Journal of Agriculture & Forestry Research

South Asian Research Publishing Organization (SARPO)

Journal of Agriculture & Forestry Research (JAFR)

Editorial message

The Journal of Agriculture and Forestry Research (JAFR) is a multidisciplinary and open access journal on agriculture and forestry published by the South Asian Research and Publishing Organization (SARPO). The journal published original articles in English. The editorial office promises to ensure quality by thoroughly reviewing the manuscript. The journal caters to the research needs of aspiring researchers from around the world on the subject of agriculture and forestry. The journal promotes scientific research through high-quality articles, systematic reviews, and rapid publication of innovative reports, perspectives, etc.

First of all, I would like to express my sincere gratitude to the editorial board members for their active cooperation. With the continued support of prominent editorial board members, potential reviewers, and active writers, we have been able to manage this journal so far. Finally, JAFR genuinely acknowledges every member single part for their significant help in this publication process.

Upcoming strategies to improve Journal:

- To improve readers for the published respective article in different social networking stages like Twitter, Linked in, etc.
- Requesting research papers from various research institutes, center laboratories, colleges, and universities around the world.
- Sending standard calls for paper for the individual country as indicated by deadlines.
- Using search engine optimization (SEO), adding significant keywords to the article makes it easier for readers to find our article on a higher page when searching for Google Keyword Planner.

Authors are warmly welcomed to submit their current research practice and result as essay science correspondence in our journal such as original research articles, review articles, expert opinion, commentary, short note communication, etc.

Editor-in-chief

Journal of Agriculture & Forestry Research

Journal of Agriculture & Forestry Research (JAFR)

Contents

Journal of Agriculture & Forestry Research
Volume no.1, Issue no. 2, Year 2021
www.sarpo.net

Research Article

Open access

Impact of Conservation Education on Zoo Tourists in Selected Zoos in Nigeria

Odunlami Samuel Sunday[1]; Osumenya Vincent Ugorji[2]

Department of Forestry and Wildlife Management, University of Port Harcourt, Nigeria

ABSTRACT

Zoo education programmes have both positive and negative impacts on zoo visitors. The paper assessed the impact of zoo education programmes on zoo visitors in three selected zoos in Nigeria. A set of structured questionnaires was purposively administered to one hundred visitors in each zoo who have paid at least a visit previously to each of the zoos, under the pre-test and post-test research design. Data obtained were analyzed by descriptive and inferential statistics. Results of zoo visitors' pre-test and post-test on conservation knowledge/awareness shows that parameter such as "I am part of the solutions to nature's problems" was negative in PH Zoo, positive in UI Zoo and negative in Kano Zoo. The t-test result shows there are significant differences in pre-test and post-test scores of tourists' knowledge about the functions of zoos in PH Zoo (-4.468, P<0.05), -2.006, P<0.05in UI Zoo and -5.391, P<0.05 in Kano Zoo. There are significant differences in pre-test and post-test scores of tourists' conservation knowledge (8.262, P < 0.05) in PH Zoo and -3.981, P < 0.05 in UI Zoo. Kruskal-Wallis' result shows that there are significant differences in tourists' test scores for knowledge about functions of zoos ($\mathcal{X}^2$ = 49.830, P < 0.05) and conservation knowledge ($\mathcal{X}^2$ = 65.716, P < 0.05) in the three zoos. It is imperative that the content of zoo education programmes and method of delivery be improved in order to strengthen the positive impacts of zoo conservation education on zoo visitors.

INTRODUCTION

Zoo's conservation education programmes have been applauded as powerful instruments for entrenching conservation knowledge in zoo visitors as well as creating awareness about conservation efforts and initiatives by different global biodiversity conservation organizations and institutions (MacDonald et al., 2016). The potential of zoos at educating and influencing millions of people to be actively involved in wildlife conservation efforts is huge (Zimmerman, 2010), and this is particularly due to the fact that over 700 million people visit global zoos and aquariums annually (Moss et al., 2014).

Zoo's conservation education programmes have been argued to have inspired many zoo visitors into active conservation actions at halting global biodiversity loss (WAZA (2005; Counsell, et al., 2020). For example, the San Diego Zoo offers, educational tours, field trips, summer camps, and many more education-related activities to visitors (San Diego Zoo, 2017). However, the effectiveness of zoo's education programmes in actively promoting conservation knowledge and attitudes among zoo visitors has been challenged by some writers (Acampora, 1998; Falk et al., 2007; Luebke and Matiasek, 2013; Godinez and Fernandez, (2019). Findings of some empirical studies on the effect of zoo education on zoo visitors by Marino et al. (2010), Dawson and Jensen, (2011) and, Moss and Esson (2013) reveal that zoos have not been able to effectively communicate conservation education to their visitors. Thus, Maynard et al. (2020) reported that zoo conservation education programmes have not been effective at changing and motivating zoo visitors into positive conservation actions. Similarly, Nygren and Ojalammi (2018), argued that the claim that zoos actually contribute to visitor's conservation knowledge and behavioural changes is inconsequential.

Moreover, the continuous and persistent loss of global biodiversity has also been considered as a measure of the ineffectiveness of zoo conservation education on zoo visitors (Bohm et al., 2013). More so, an increasing number of vertebrates are listed as threatened and endangered species annually (Hoffmann et al., 2010). Therefore, MacDonald et al., (2016), opined that the millions of dollars and staff time invested by several global biodiversity conservation organisations such as the Association of Zoos and Aquariums (AZA) at reversing the trend of global biodiversity loss is a huge failure because more vertebrates are continuously added to threatened and endanger list annually.

In addition, the education programmes of zoos have sometimes been noted to be counterproductive. For example, findings from studies conducted by Smith, (2008) and Adelman et al. (2010), revealed that zoo visitors were actually less knowledgeable about wildlife conservation and also exhibited declining pro-conservation attitudes after visiting zoos.

Similarly, some studies on zoos in Nigeria have been quick to laud zoos as conservation centres and conservation education agents, but none have critically analysed how effective zoos have been in achieving these. For example, Adams and Salome (2014) reported that the Kano Zoo supports education and scientific research, however, they fall short in portraying the effect of said education and research on attitudinal changes linked to conservation. Likewise, much of the research work on zoological gardens in Nigeria fail to determine how their conservational efforts are performing (if one exists, to begin with), and how visitation to zoos impacts visitor's perception, knowledge and understanding of conservation issues. Thus, it is important to ascertain the level of change in visitor's conservation knowledge associated with zoo visits and identify particularly, the effectiveness of conservation education efforts of zoo visitors in Nigeria.

Therefore, the objectives of this paper are to identify the effect of conservation education on zoo visitors in the selected zoos, determine the conservation education/ awareness programmes carried out by the selected zoos and determine the relationship between the socio-demographic factors of visitors and their responses to zoo education programmes in the selected zoological gardens in Nigeria.

MATERIAL AND METHODS

Study Areas

This study was carried out in three (3) selected Zoos located in three distinctive geo-political zones in Nigeria; namely Port Harcourt Zoo (PH Zoo) Rivers State, located in South-South zone, University of Ibadan Zoo (UI Zoo), Oyo State, in South-West zone and Kano Zoo (Gidan Zoo), Kano State, located in North-West zone.

Port Harcourt Zoological Garden (PH Zoo)

The PH Zoo was established in 1974, by the former military governor Alfred Diete-Spiff. It is located in the Trans Amadi district of Obio-Akpor local government area, Rivers state. Its tourist attractions include restaurants, a playground, and a museum. It is currently under the management of the Rivers State government through the Ministry of Culture and Tourism, Rivers State (Oladele and Udo, 2015, 2017). There are at least 11 different wildlife species present in the zoo with over 20 individuals (Anonymous, n.d.).

University of Ibadan Zoological Garden (UI Zoo)

The UI Zoo was founded in 1943, to aid the research and training programme for the students in the department of zoology, University of Ibadan. It became a zoo in 1974 due to an increase in the number of visitors. Its purpose is conservation, education and entertainment. Its tourist attractions include diverse wildlife species, a playground, restaurants and a museum (Sijuade, 1977; Adefalu et al., 2014).

Kano Zoological Garden (Kano Zoo)

The Kano Zoo, popularly known as Gidan Zoo, was founded by the late Military Governor of Kano state, Gen. Audu Bako. The foundation stone was laid on the 14th July 1971, however, the zoo was officially opened to the public in November 1972. The zoo was established for the purpose of conservation, education, research, and relaxation. Currently the largest zoo in Nigeria, the Kano Zoo covers a landmass of 43,000km. The zoo presently holds over 57 different species of wild animals, amounting to over 200 individual species. The zoo has received animals from Tanzania, Australia, and has both donated and received animals from other zoological gardens in Nigeria. Tourist attractions in the zoo include restaurants; children play parks, diverse wildlife species and a botanical garden. The Kano Zoo now belongs, together with the Falgore game reserve, to the Kano State Zoological Garden and Wildlife Management Agency, established in 1999. (Sijuade, 1977; Adams and Salome, 2014).

Methods of Data Collection

Data for the study was collected through the administration of 2 sets of structured questionnaires, visual observations, examination of administrative records and interviews with key personnel of the zoos. The first set was purposively administered to 100% of the management staff in the selected zoos with a minimum of three years of working experience in the selected zoos. Hence, five (5) questionnaires were administered to the management staff of the PH Zoo, but only three (3) were retrieved. In UI Zoo, nine (9) questionnaires were administered and eight (8) were retrieved. Finally, in Kano Zoo, eighteen (18) questionnaires were administered and 18 were retrieved. Thus, a total of thirty-two (32) questionnaires were administered to staff respondents and twenty-eight (28) retrieved. The second set of questionnaires, a modified version of the Association of Zoos and Aquariums (AZA) visitor evaluation toolbox on conservation attitudes adopted by Falk et al. (2007) was purposively administered randomly to one hundred (100) visitors who have paid at least a visit previously to each of the zoos under the pre-test and post-test research design. In all, a total of 300 questionnaires were administered for the study. The reflection method was employed by asking the visitors to compare their pre-visit and post-visit feelings as they entered and exit the zoos in

other to determine the changes in their knowledge about wildlife conservation and the functions of the zoos. The questionnaires retrieved and analysed for PH Zoo, UI Zoo, and Kano Zoo are ninety-one (91), one hundred (100), and ninety (90) respectively, bringing the total number of sampled visitors to 281. In all, a total of three hundred and thirty-two (332) questionnaires were administered but three hundred and nine (309) were analysed for the study.

Method of Data Analysis

The data obtained from the survey were analysed by descriptive statistics using frequencies and percentages and tables. Inferential statistics such as t-test, Spearman Rank Correlation, and Kruskal-Wallis Rank Test were also used in analysing the results. The difference between pre-and post-test results was tested for statistical significance with a t-test. Kruskal-Wallis rank test was used to test for significant differences between the scores of the three study sites. Spearman rank correlation test was used to test for a relationship between visitors' sociodemographic characteristics and their scores. The Statistical Package for Social Sciences (SPSS), version 16.0 was used to run these analyses.

RESULTS

Table 1 shows the pre-test and post-test results on the perceived functions of zoos by the visitor respondents in the three zoos. In PH Zoo, the consciousness of zoo visitors about the functions of zoos as a caring centre

for wild animals decreased (-27.45%) after the post-test but increased in both UI (3.96%) and Kano Zoos (20.24%), educating the public on conservation also decreased after post-test in PH Zoo (-53.70%) but increased in UI Zoo (5.08%) and Kano Zoo (4.62%). The function of zoos as breeding centres of wild animals decreased in PH Zoo (-16.67%), increased in UI Zoo (11.72%) and Kano Zoo (18.37%). The perception of zoos as breeding centres of endangered wildlife species decreased in PH Zoo (-22.06%), increased in UI (6.19%) and Kano Zoos (18.37%).

Results on the zoo visitors' pre-test and post-test about conservation education in the selected zoos are presented in Table 2. Parameters such as "being at the zoo are fun" decreased in PH Zoo (-43.40%), but increased in UI Zoo (11.94%) and Kano Zoo (11.94%), and "I am part of the problems with nature" was zero in PH Zoo, increased in UI Zoo (3.75%) and decreased (-7.14%) in Kano Zoo. Also, the parameters "I am part of the solutions to nature's problems" were negative in PH Zoo (-0.90%), positive in UI Zoo (6.16%) and negative in Kano Zoo (-8.62%) and "Zoos care about animals" decreased significantly in PH Zoo (-43.48%) but positive (1.66%) and (3.23%) in UI Zoo and Kano Zoo respectively. "Zoos are important for wildlife conservation" was negative (-35.71%) in PH Zoo, positive in UI Zoo (3.05%) and Kano Zoo (22.22%). The parameter "we need to help protect wildlife" increased in PH Zoo (5.63%) and UI Zoo (6.0%) but negative (-1.41%) in Kano Zoo.

Table 1: Visitor's Pre-test and Post-test results on the perceived functions of zoos by the visitor respondents in the three zoos.

Location	PH Zoo			UI Zoo			Kano Zoo		
Variables	Pre-test	Post-test	Difference (%)	Pre-test	Post-test	Difference (%)	Pre-test	Post-test	Difference (%)
Caring for animals in the zoo	510	370	-27.45	606	630	3.96	504	600	20.24

Educating the public about conservation issues such as threatened species	540	250	-53.70	551	579	5.08	455	476	4.62
Breeding animals in the zoo regardless of whether they are endangered or not	300	250	-16.67	430	480	11.63	343	406	18.37
Breeding endangered animals in the zoo	340	265	-22.06	435	486	11.72	350	399	14
Providing a fun day out for the public	575	570	-0.87	624	640	2.56	511	560	9.59
Reintroducing endangered animals into the wild that were bread in zoos	220	195	-11.36	452	480	6.19	378	336	-11.11
Carrying out and supporting conservation projects outside of the zoo to conserve wild animals	370	325	-12.16	484	512	5.79	322	364	13.04
Providing expert training for keepers/staff/conservationists	485	510	5.15	569	599	5.27	434	504	16.13
Donations to conservation organizations/projects	415	350	-15.66	456	490	7.46	329	399	21.28
Scientific research	530	570	7.55	583	608	4.29	406	525	29.31

Source: Field Survey, 2019

Table 2: Pre-test and post-test of visitor's knowledge about conservation education in the selected zoos

Location	P.H. Zoo			U.I. Zoo			Kano Zoo		
Parameter	Pre-test	Post-test	Difference (%)	Pre-test	Post-test	Difference (%)	Pre-test	Post-test	Difference (%)
Being at the zoo is fun	530	300	-43.40	561	628	11.94	532	553	3.95
I am part of the problems with nature	245	245	0	267	277	3.75	196	182	-7.14
I am part of the solutions to nature's problems	550	545	-0.90	529	564	6.16	406	371	-8.62

Zoos care about wild animals	460	260	-43.48	603	613	1.66	434	448	3.23
Zoos are important for wildlife conservation	420	270	-35.71	591	609	3.05	378	462	22.22
We need to help protect wild animals	585	615	5.13	617	645	6	497	490	-1.41
We need to help protect plants	590	615	4.24	632	633	0.16	518	490	-5.41
There is a lot I can do to conserve	455	475	4.40	475	444	-6.53	357	343	-3.92
Nature helps define Nigeria's national heritage and character	500	545	9	590	615	4.24	546	483	-11.54
Nature is a place to renew the human spirit	377	545	44.56	589	621	5.43	553	539	-2.53
We have the responsibility to leave healthy ecosystems for our families and future generations	535	555	3.74	627	651	3.83	532	497	-6.58

Source: Field survey, 2019

Table 3 shows the t-test result shows the pre-test and post-test scores for functions of zoos (t value = 4.468, P<0.05 and conservation knowledge (t value = 8.262, P < 0.05) in PH Zoo. In UI Zoo, the t-test analysis for pre-test and post-test scores for functions of zoos was (t value = -2.006, P<0.05) and conservation knowledge (t value = -3.981, P < 0.05). The t-test analysis in Kano Zoo, for both the pre-test and post-test scores for functions of zoos were (t value = -5.391, P<0.05, for the pre-test and (t value = 1, P > 0.05) as post-test scores for conservation knowledge.

Table 3: Summary of t-test analysis measuring the differences in pre and post visits knowledge of visitor respondents on the functions of zoos and conservation education in the selected zoos.

Variables	Mean	Standard deviation	Standard Error Mean	t value	Df	P Values	Significance	Inference
PH Zoo **Roles of Zoos (Pre-test scores)-(Post-test scores)**	4.66667	9.90970	1.04457	4.468	89	0.000	P <0.05	Significant
Conservation education. (Pre-test scores)-(Post-test scores)	5.16667	5.93267	0.62536	8.262	89	0.00	P <0.05	Significant
UI Zoo								
Functions of Zoos (Pre-test scores)-Post-test Scores)	-3.21000	9.90970	1.04457	-1.006	98	0.048	P < 0.05	Significant
Conservation education (Pre-test scores) - (Post-test) scores)	-2.7000	5.93267	0.62536	-3.981	99	0.00	P < 0.05	Significant
Kano Zoo								
Functions of zoos (Pre-test scores) – (Post-test scores)	-5.391	4.55955	0.53040	-10.173	73	0.000	P < 0.05	Significant
Conservation knowledge (Pre-test scores)-(Post-test cores).	1	8.33543	0.96897	1.032	72	0.305	P > 0.05	Not significant

Source: Field survey, 2019

Table 4 presents results for the Kruskal-Wallis Non-parametric analysis for the different scores amongst the three locations. The table shows that there is a significant difference amongst the test scores for conservation learning for the

three locations (X^2 = 65.716, P < 0.05), and test scores for zoo function learning ($\mathcal{X}^2$ = 49.830, P < 0.05).

Table 4: Summary of Kruskal-Wallis Non-parametric analysis for the different scores in the different zoos

Parameter	Calculated chi-square value	P value	Significance	Inference
Test scores for conservation knowledge score for the three zoos	65.716	0.000	P < 0.05	There is a significant difference in the test scores for the three zoos
Test scores for the function of zoos for the three zoos	49.830	0.000	P < 0.05	There is a significant difference in the test scores for the three zoos

Source: Field survey, 2019

Table 5 shows methods employed by the various zoos in educating their visitors about wildlife conservation. Interactive displays, is the most used method in educating visitors in PH Zoo (100%), while animal shows (94.4%) is the most used method in Kano Zoo and illustrated species talk (85.7%) is the most used method in UI Zoo.

Table 5: Conservation Education Programmes of the selected zoos as indicated by staff respondents

Variables		PH Zoo		UI Zoo		Kano Zoo	
		Frequency	Percentage %	Frequency	Percentage %	Frequency	Percentage %
Animal Shows	Yes	1	33.3	2	28.6	17	94.4
	No	2	66.7	5	71.4	1	5.6
	Total	**3**	**100**	**7**	**100**	**18**	**100**
Animal Handling	Yes	1	33.3	2	71.4	11	61.1
	No	2	66.7	5	28.6	7	38.9
	Total	**3**	**100**	**7**	**100**	**18**	**100**
Keeper Talks	Yes	2	66.7	2	28.6	9	50.0
	No	1	33.3	5	71.4	9	50.0
	Total	**3**	**100**	**7**	**100**	**18**	**100**
Guided Tours	Yes	2	66.7	4	57.1	13	77.8
	No	1	33.3	3	42.9	4	22.2
	Total	**3**	**100**	**7**	**100**	**18**	**100**
Illustrated Species Talk	Yes	1	33.3	1	14.3	6	33.3
	No	2	66.7	6	85.7	12	66.7
	Total	**3**	**100**	**7**	**100**	**18**	**100**

Interactive displays	Yes	0	0	2	28.6	6	33.3
	No	3	100	5	71.4	12	66.7
	Total	3	100	7	100	18	100

Source: Field Survey, 2019

Table 6 shows the number of students from elementary to tertiary levels of education school pupils educated in Kano Zoo from 2009 to 2018. The peak months for all the years were March and July. On average, 36,594 students have been trained by the zoo every year since 2009.

Table 6: Number of students educated in Kano Zoo between 2009 to 2018

Variables	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018*
Jan	1274	259	150	0	928	559	276	1202	2195	1574
Feb	3525	1684	1267	463	4696	3592	1975	9430	8799	9872
Mar	3236	4715	4174	1850	5248	8340	2606	17090	18119	21110
Apr	1724	2469	1357	484	3238	2642	296	5564	6568	4159
May	1305	301	1024	863	1531	3831	4432	5144	5085	4480
Jun	4891	1980	4136	3355	5876	9386	11667	2782	434	813
Jul	4838	5891	6913	5375	2895	122	414	4479	4451	0
Aug	3350	2702	963	412	0	0	1877	607	9316	0
Sep	24	80	178	317	211	55	2537	0	362	0
Oct	285	841	1177	7643	1369	121	1478	1542	885	0
Nov	1161	66	2182	2283	3813	1089	4243	5079	9806	0
Dec	556	1052	792	1843	3537	993	2237	4586	3887	0
Total	27179	22040	24313	24888	33342	30730	34038	57505	69907	42008

Source: Field Survey, 2019

*Incomplete

Socio-demographic characteristics and its influence on visitors' conservation learning and zoo function learning

Table 7 shows the result for spearman's rank correlation for the test of a significant relationship between socio-demographic characteristics and conservation learning and function learning. In UI Zoo, there is no significant relationship between sex and conservation learning, sex and function learning, age and function learning, education and function learning, occupation and conservation learning, and occupation and function learning (P > 0.05). However, there were significant relationships between Age and Conservation learning, education and conservation learning (P < 0.05). Amongst visitor respondents of the Kano Zoo, sex and conservation learning, sex and function learning, and occupation and function learning had no significant relationship P > 0.05, but age and conservation learning. Age and function learning, education and conservation learning, education and function learning,

occupation and conservation learning, age and conservation learning all had significant relationships. In P.H. zoo, there was no significant relationship between sex and conservation learning, sex and function learning, age and function learning, education and conservation learning, occupation and conservation learning, occupation and function learning (P > 0.05), while age and conservation learning, education and function learning had significant relationships (P < 0.05).

Table 7: Summary of Spearman's rank correlation analysis testing for a relationship between demographic and pre-test post-test scores amongst visitor respondents in the three zoos.

Location	Variables	Correlation coefficient	P values	Significance	Inference
UI Zoo	Sex and Conservation learning	-0.005	0.958	P > 0.05	Not significant
	Sex and Function learning	-0.113	0.264	P > 0.05	Not significant
	Age and Conservation learning	-0.276	0.005	P≤ 0.05	Significant
	Age and Function learning	-0.014	0.893	P > 0.05	Not significant
	Education and Conservation learning	0.202	0.043	P < 0.05	Significant
	Education and function learning	0.077	0.446	P > 0.05	Not significant
	Occupation and Conservation learning	0.044	0.664	P>0.05	Not significant
	Occupation and Function learning	0.017	0.863	P>0.05	Not significant
Kano Zoo	Sex and Conservation learning	-0.135	0.203	P> 0.05	Not significant
	Sex and Function learning	0.000	1.0	P>0.05	Not significant
	Age and Conservation learning	-0.314	0.002	P < 0.05	Significant
	Age and Function learning	0.281	0.007	P < 0.05	Significant
	Education and Conservation learning	0.671	0.000	P < 0.05	Significant
	Education and function learning	0.331	0.001	P < 0.05	Significant
	Occupation and Conservation learning	-0.374	0.000	P < 0.05	Significant
	Occupation and Function learning	-0.064	0.547	P > 0.05	Not significant
PH Zoo	Sex and Conservation learning	0.187	0.077	P > 0.05	Not significant

Sex and function learning	0.055	0.606	P > 0.05	Not significant
Age and conservation learning	-0.303	0.004	P < 0.05	Significant
Age and function learning	0.024	0.824	P>.05	Not significant
Education and conservation learning	-0.106	0.318	P > 0.05	Not significant
Education and Function learning	0.364	0.000	P < 0.05	Significant
Occupation and Conservation learning	0,189	0.074	P > 0.05	Not significant
Occupation and function learning	-0.192	0.070	P > 0.05	Not significant

Source: Field survey, 2019
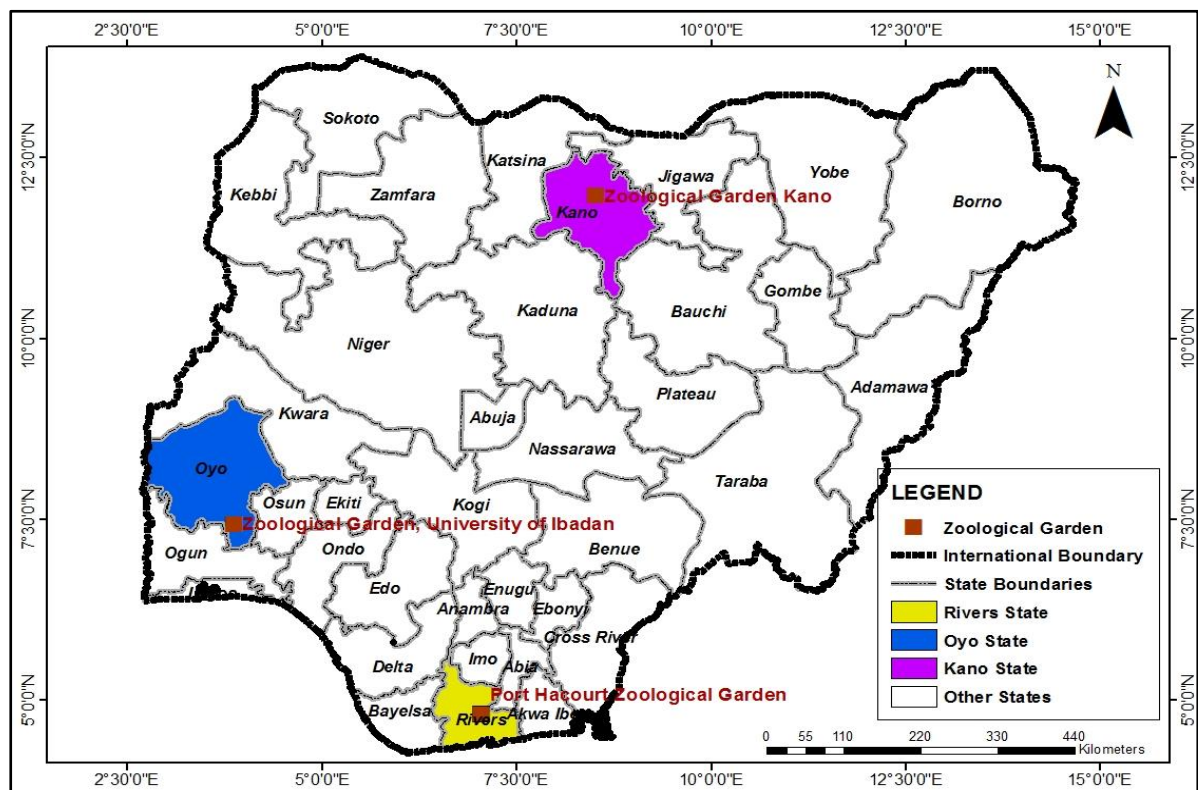
Figure 1: Map of Nigeria showing the study sites

DISCUSSION

Effect of zoo conservation education on Zoo visitors' knowledge

Results show that visit to the zoos have quantifiable positive and negative impact on zoo visitor's understanding of conservation issues and the roles zoos in wildlife conservation. Port Harcourt Zoo visitors experienced reduction in their knowledge about the functions of zoos and conservation knowledge after visiting the zoo (Tables 1 and 2). The level of satisfaction of zoo visitors especially concerning the state of the animal, the manner they are display and overall welfare of zoo animals have serious impact

on visitors' perception of zoos. Packer (2018), similarly noted that visitors often make judgements on whether the animals in the zoo are well cared for through ratings of the animal's perceived health conditions. PH Zoo has the highest levels of dissatisfaction in all the three zoos as 50% of the visitors claimed they were unsatisfied while 16.7% were highly unsatisfied (Figure 1). Visitor's individual action messages such as "Zoos care about animals" "zoos are important for wildlife conservation", reduced considerably as a consequence of their visit (Table 2). Also, there is a significant decrease in the visitor's perception of the functions of the zoo. Visitors to the Port Harcourt zoo felt that caring for animals, educating the public about conservation issues, breeding of endangered animals, and reintroduction of species into the wild are not important functions of the zoo (Table 1). This can be attributed to poor zoo education programme and poor zoo experience. The zoo may have been considered a poor leaning environment about environmental education by the visitors because of the condition of the zoo. Consequently, this shows that a poor performing zoo can reduce visitors' positive orientation towards zoos. Nevertheless, this may also have buttressed the fact that zoo visitors care so much about entertainment rather than learning about zoo and zoo animals as reported by Carr and Cohen, 2011) as well as Roe and McConney (2015). The results of their studies show that visitors were usually concerned primarily with viewing animals and not show poor interest in learning about them. There was an increase in the acceptance that "we need to help protect the animals, and leave a healthier ecosystem for our family and future generations" (Table 2). The poor status of the zoo could also have heightened the need for biodiversity conservation in the minds of the zoo visitors which was reflected in their responses. Decrease in action messages such as "There is a lot I can do to conserve nature" and "I am part of the solution to nature's

problem" for visitor's in Kano Zoo as shown in table 2 reveals that zoo visitors can learn about conservation in a zoo, without learning about the role they can play and actions they can take to help conserve biodiversity. However, in UI Zoo, visitor's knowledge and attitude towards conservation, and the functions of the zoo significantly improved due to their visit (Table 1 and Table 2). Visitors experienced increase in their Pro conservation thoughts such as "I am part of the problems with nature", "I am part of the solutions", "zoos are important for wildlife conservation", and "we need to protect the animals (Table 2). This corroborates the findings of Nickels (2008) and Falk et al. (2007) that visitors to the zoo leave with a significantly increased conservation attitude post visiting, becoming more aware of their role in environmental problems. Results also show that visiting zoos strengthened their knowledge of the functions of zoos, with significant increase in their perception that "Caring for animals in the zoo is good", "Educating the public about conservation issues such as threatened species", "Breeding endangered animals in the zoo", are important functions of the zoo (Table 1). There was no statistically significant change in visitors understanding of conservation due to their visit in Kano Zoo (Table 3). As observed by Falk et al., (2007), some zoo visitors have a broader understanding of biodiversity than realized, and as such, changes ascribed to their visits are intangible and not statistically different. Nevertheless, visits to the zoo still strengthens the values of the visitors, as in the case of Kano Zoo where visitors experienced 3% and 22.2% increase in their perception that zoos care about animals, and that zoos are important for wildlife conservation, respectively (Table 2). Nevertheless, t-test (Table 3) and Kruskal-Wallis analysis measuring the differences in the pre-test and post-test scores of visitors' zoo function and conservation knowledge test scores for visitors in the three zoos (Table 4) show significant differences. The

results of the study clearly reinforced the perception that zoo visitors often become less knowledgeable about the functions of zoos after zoo visit. The result of the study further shows that many zoo visitors are usually less interested in learning about animals on display in various zoos because they visit zoos primarily for entertainment which was similarly reported by Luebke et al. (2016). The result of this study agrees with the findings of Marino et al. (2010) on their review of impact of zoo visit on the attitudinal changes of American zoo visitors. Their study revealed that knowledge about zoo animals and environmental conservation attitudes actually decline after zoo visits. Since many zoo visitors are in the zoos primarily to be entertained by the captive zoo animals. Hence, they concentrate on the entertainment and funny antics of captive animals which often captivate their attention rather than the zoo conservation education efforts as affirmed by Ludwig (1981).

Conservation education/ training programmes in the Selected Zoos

The result of the study revealed that the three zoos employed animal shows, animal handling, keeper talks, guided tours, illustrated species talk and interactive displays to educate their visitors as shown in Table 5. The study also shows that interactive displays, is the most used method in educating visitors in PH Zoo, while animal shows and illustrated species talk are the most used methods in Kano and UI Zoos. These methods differ from the one employed by the San Diego Zoo (San Diego Zoo, 2017). The selected zoological gardens educate students from primary to tertiary institutions on visit to the zoo. Majority of the zoo staff respondents in the three zoos indicated that visitors on excursion trips to the zoos are educated on conservation education through guided tours. In Kano Zoo, an average of 36,594 students have been educated on conservation and the role of zoos, annually since 2009 till 2019 (Table 6). However, it is

very clear from the responses of the zoo visitors that these methods are not really effective at achieving the actual goals of entrenching conservation awareness in zoo visitors towards influencing them into taking conservation actions. It could also suggest that the programmes were poorly delivered such that visitors might perceived these programmes as part of the entertaining programmes of the zoos.

Effect of socio-demographic Factors on visitors learning

In all the three zoos, visitors' gender was not found to be significantly related to their conservation knowledge learning or function of zoo learning. This is contrary to the findings of Powell and Bullock (2014) who reported that female visitors had stronger emotional experiences in the zoo than their male counterparts. In all the three zoos, Spearman's rho showed significant weak negative linear relationship between visitor's age and their conservation learning (P≤ 0.05) (Table 9). This implies that as the visitor's ages across the zoos increased, their conservation learning decreased. Younger adults tend to explore zoos more, read animals tags, and spend more time viewing each animal. This disagrees with the work of Powell and Bullock (2014) where young adults were observed to have reduced positive emotional response than elderly participants. Education was seen to have a significant weak positive linear relationship with function learning in UI Zoo and in PH Zoo (P< 0.05) (Table 7). However, the relationship between education and conservation learning in UI Zoo was strongly positive. This implies that conservation knowledge and zoo function learning are related to visitor's educational qualification. Similarly, visitors to Dundee's Discovery Point Exhibition shows that zoo visitors with higher educational qualification had higher learning index (Prentice et al., 1998). This implies that the higher the educational level of visitors,

the higher their conservation knowledge (Table 7).

CONCLUSION

This study has given insight into the effect of conservation education on zoo visitors in the three selected zoos in Nigeria. The study revealed that the conservation education of the selected zoos has both positive and negative impacts on the conservation knowledge of zoo visitors and the functions of zoos. The positive effect on the conservation knowledge among zoo visitors in UI and Kano Zoos is slim. However, the study shows that PH Zoo visitors experienced serious negative changes in their knowledge about conservation and functions of zoos after their visit to the zoo. Visitor unsatisfied with the welfare and state of the zoo and its animals, may experience a reduction in their perception of the role zoos have to play in the conservation of wildlife. This was the case in PH Zoo as visitors moved from thinking zoos are important for wildlife conservation before visit, to rejecting that belief after visit. It is therefore important that further research into factors responsible for the widening gap between pre-visit and post-visit scores of zoo visitors be conducted. The study also revealed that the selected zoos actually have conservation education programmes, though ineffective at encouraging pro-conservation actions among zoo visitors who often become less knowledgeable about conservation knowledge after zoo visit. This perhaps may be a reflection of what is happening in other zoos in Nigeria. It is also very important that the content of education programmes of Nigerian Zoos and method of delivery be investigated in order to improve and strengthened the positive impacts of zoo education on zoo visitors in Nigeria. This will help in contributing to positive conservation attitudes and pro-conservation actions among many zoo visors in Nigeria. Other findings of the study showed that

educational qualification of zoo visitors have significant implications on their appreciation of conservation education programmes of the zoos.

REFERENCE

Acampora, R. R. Extinction by Exhibition: Looking at and in the Zoo. 1998, *Human Ecology Review.*1998, 5 (1):1-4.

Adams, A.; Salome, A. A. Impacts of zoological garden in schools: a case study of zoological garden, Kano State Nigeria. *Open J. Ecology.* 2014, 4(10): 612.

Adefalu, L. L.; Aderinoye-Abdulwahab, S. A.; Olabanji, O. P.; Tijani, A. Socio-economic Characteristics of Tourists in University of Ibadan Zoo, Ibadan, Nigeria. *Int'l J. Advan. Agric. Environ. Eng*. 2014,1(*2*):2349-1531.

Adelman, L. M.; Falk, J. F.; and James, S. Impact of national aquarium in Baltimore on visitors' conservation attitudes, behavior, and knowledge. 2010, *Curator* 43:33–41.

Anonymous. (n.d.). *Port Harcourt Zoo.* Retrieved from https://en.m.wikipedia.org/wiki/Port_har corut_zoo Accessed December 6th, 2019.

Ballantyne R.; Packer J.; Hughes K.; Dierking L. Conservation learning in wildlife tourism settings: lessons from research in zoos and aquariums. *Envital. Edu. Research.* 2007, 13(3), 367–383.

Bohm, M.; Collen, B.; Baillie, J. E.; Bowles, P.; Chanson, J.; Cox, N.; Rhodin, A. G. The conservation status of the world's reptiles. *Biol. Conserv.*2013, 157, 372–385.

Carr, N.; Cohen, S. The Public Face of Zoos: Images of Entertainment, Education and Conservation. *Anthrozoos.* 2011, 24(2), 175-189. DOI:10.2752/175303711X129986322576 20

Counsell, G.; Moon, A.; Littlehales, C.; Brooks, H.; Bridges, E; Moss, A. Evaluating an in-school zoo education programme: an analysis of attitudes and learning. *J. Zoo and Aquarium Rese.* 2020, 8(2), 99-106.

Dawson, E.; Jensen E. Towards a 'contextual turn' in visitor studies: evaluating visitor segmentation and identity-related motivations. *Visitor Studies.* 2011, 14, 1–14.

Falk, J. H.; Reinhard, E. M.; Vernon, C. L.; Bronnenkant, K.; Deans, N. L.; Heimlich, J. E. *Why zoos and aquariums matter: Assessing the impact of a visit to a zoo or aquarium*. Silver Spring, MD. Association of Zoos and Aquariums. Pp1-24. www.aza.org. Accessed July 10th 2021.

Godinez, A. M.; Fernandez, E. J. What Is the Zoo Experience? How Zoos Impact a Visitor's Behaviors, Perceptions, and Conservation Efforts. *Front. Psychol*. 2019, 10:1746. doi: 10.3389/fpsyg.2019.01746

Hoffmann, M.; Hilton-Taylor, C.; Angulo, A.; Bohm, M.; Brooks, T. M.; Butchart, S. H.; Darwall, W. R. The impact of conservation on the status of the world's vertebrates. *Science*, 2010, 330(6010), 1503–1509.

Luebke, J. F.; Matiasek J. An Exploratory Study of Zoo Visitors' Exhibit Experiences and Reactions. *Zoo Biology,* 2013, 32, 407–416.

Luebke, J. F.; Watters, J. V.; Packer, J.; Lance J.; Miller, L. J.; David, M.; Powell, D. M. Zoo Visitors' Affective Responses to Observing Animal Behaviors, *Visitor Studies.* 2016, 19(1), 60-76, DOI: 10.1080/10645578.2016.1144028. Accessed 20th September 2020.

Ludwig, E. G. People at zoos: A sociological approach. *Int'l J. for the study of animal problems.* 1981. 2 (6), 310-316.

Mac Donald, E.; Milfont, T.; Gavin, M. Applying the elaboration likelihood model to increase recall of conservation messages and elaboration by zoo visitors. *J. Sustainable Tourism*. 2016, 24(6), 866-881.
doi:10.1080/09669582.2015.1091464

Marino, L.; Lilienfeld, S.O.; Malamud, R.; Nobis, N.; Broglio, R. Do zoos and aquariums promote attitude change in visitors? A critical evaluation of the American zoo and aquarium study. *Soc Ani*. 2010, 18, 126–138.

Maynard, L.; Monroe, M. C.; Jacobson, S. K.; Savage, A. Maximizing biodiversity conservation through behavior change strategies. *Cons. Scie. Pract.* Retrieved from https://doi.org/10.1111/csp2.193. on August 15th 2020.

Moss, A.; Esson, M. The educational claims of zoos: where do we go from here? *Zoo Biol*. 2013, 32(1), 13-18.

Moss, A.; Jensen, E.; Gusset, M. Zoo visits boost biodiversity literacy. *Nature*. 2014, 508:186.

Nygren, N. V.; Ojalammi, S. Conservation education in zoos – a literature review. *Finnish Journal for Human-animal Studies*, 2018, 4, 62-76.

Nickels, A. L. An exploration of visitors' conservation attitudes, expectations, and motivations at three informal education institutes in Newport. 2008. Oregon.

Oladele A. T.; Udo N. E. Ecosystem services and mapping of amenity trees in Port Harcourt Zoo, Nigeria. *African Journal of Agriculture Technology and Environment*. 2017, 6(1), 106-117.

Packer, J.; Ballantyne, R.; and Luebke, J. F. Exploring the Factors That Influence Zoo Visitors' Perceptions of the Well-Being of Gorillas: Implications for Zoo Exhibit Interpretation. *Visitor Studies*. 2018, 21(1), 57-78.

Powell, D. M.; Bullock, E. V. W. Evaluation of factors affecting emotional responses in zoo visitors and the impact of emotion on conservation mindedness. *Anthrozoos*. 2014, *27*(3), 389–405.

Prentice, R.; Guerin, S.; McGugan, S. Visitor learning at a heritage attraction: a case study of discovery as a media product. *J. of Tour. Mgt.* 19(1), 5-23.

Roe, K.; McConney, A. Do zoo visitors come to learn? An internationally comparative, mixed-methods study. *Environmental Education Research*. 2015, 21(6), 865-884. DOI: 10.1080/13504622.2014.940282.

San Diego Zoo. *Education.* http://www.sandiegozoo.org/zoo/education/. Accessed 23**th** June 2021.

Sijuade, A. Zoos in Nigeria: problems of management and development and some suggested solutions. *International Zoo Yearbook*. 1977, *17*(1), 200-205.

Smith, L.; Broad, S.; Weiler, B. A closer examination of the impact of zoo visits on visitor behavior. *J. Sust. Tourism.* 2008, 16(5), 544-562.

WAZA. *Building a Future for Wildlife: The World Zoo and Aquarium Conservation Strategy.* Bern, Switzerland. The World Association of Zoos and Aquariums Executive Office. 2005, 1-72 pp.

Zimmermann, A. *Wild Mammals in Captivity: Principles and Techniques for Zoo Management.* 2nd ed.; Chicago University Press, Chicago, (USA). Chapter 23, The role of zoos in contributing to in situ conservation, 2010, 281-287 pp.

Journal of Agriculture & Forestry Research

Research Article

Open access

Assessing Hospitality Services in Obudu Mountain Resort, Nigeria

Odunlami Samuel Sunday; Wali Chinedu Nyedika[2]

Department of Forestry and Wildlife Management, University of Port Harcourt, Nigeria

ARTICLE INFORMATION

ABSTRACT

Hospitality services and efficient service delivery play vital roles in enhancing tourist experiences at tourist destinations. This study assessed the Hospitality services in Obudu Mountain Resort (OMR). Data for the study were obtained through in-in-depth interviews personal observations, and administration of two sets of self-structured questionnaires. The first set of questionnaires was administered to thirty-five hospitality staff of the resort with a minimum of three years of working experience. The second set was administered to randomly selected 120 tourists who have spent a minimum of two nights in the accommodation facilities of the resort. Findings from the study show that services provided by the hospitality unit of Obudu Mountain Resort include accommodation as noted by 100% of the staff respondents, food and beverages (100%), entertainment (92.0%), and laundry (84.0%). Also, accommodation service was rated good by most respondents (72.7%), 18.2% rated it poor and 9.1% rated it excellent. Also, laundry service was rated good by the majority of tourist respondents (67.3%) while 32.7% rated it poorly. Similarly, the Food/beverage service was rated good by the majority of the respondents (62.5%), 30.5% rated the service excellent while laundry service was rated poor by 16.5% of the tourist respondents. For effective hospitality service delivery in the resort, it is important to strengthen areas of weaknesses while improving further on the areas of strength.

INTRODUCTION

Man, regardless of race, culture, tribe and economic status always craved for pleasure, comfort, happiness, freedom and privacy. The hospitality industry readily provides an avenue to meet these needs (Enemuo *et al.,* 2016). The industry provides specialized services which enhanced tourist's experiences at tourist destinations. Hospitality services include all services and products provided by the accommodation sector which include hotels, boarding houses, motels, tourist camps, holiday centres, resorts and others. Similarly, the International Labour Organisation (ILO),

stressed that hospitality services also include those rendered by restaurants, bars, cafeterias, snack bars, pubs, nightclubs, and other similar establishments for the comfort of both local and international tourists (ILO, 2010). Hence, the services provided by the hospitality sector can greatly influence tourist's experiences and can create amazing memories about the visited destination. Hospitality services and the manner they are rendered to tourists could encourage or discourage future visitation by tourists. Besides enhancing tourist's experiences, it also contributes significantly to the image of the destination.

The Organisation for Economic Co-operation and Development also stressed that the incredible growth in both domestic and international global travel in recent times has also resulted in a corresponding increase in global demand for hospitality services by both local and international tourists (OECD, 2008). Therefore, the industry is experiencing profound investment in new facilities and equipment in order to meet the rapidly increasing needs. The United Nations World Tourism Organisation (UNWTO) similarly reported that there is an increase in global demand for hospitality services attributed to a sharp increase in global travel with an astounding rise from 674 million international tourist arrivals recorded in 2010 to over 1.4 billion in 2019 (UNWTO, 2020). This sharp increase also includes travel to global eco-destinations which have similarly resulted in a corresponding increase in demand for hospitality services in protected areas globally. Hospitality services in eco-destinations likewise involve services in relation to food, drink, and accommodation. Tourists to eco-destinations will normally patronize destinations that meet their needs and avoid those that did not just like tourists to other destinations. Therefore, the hospitality sector of eco-destinations always strives to satisfy their guests in other to gain their loyalty and sustain patronage. Additionally, because satisfaction is a subjective issue and reflects personal feelings or experiences as a result of consumption of services. Hence, it could strongly influence individual tourists' rating of, length of stay, repeat visit, and choice of eco-destination (Mihaela, 2014; Manhas and Tukamushaba, 2015). Availability of varied services and efficient service delivery at a destination promote and sustain patronage while poor service delivery is harmful to sustaining patronage and loyalty as well as the survival of eco-destination. Moreover, good patronage is the goal of every service-oriented industry. Therefore, the objectives of this paper, are to identify different hospitality services available in the resort, determine the maximum length of stay by tourists and evaluate the level of tourist satisfaction with the services rendered to them by the hospitality unit of the resort.

METHODOLOGY

Description of the Study Area

The study was carried out in Obudu Mountain Resort, Cross River State, Nigeria. The Obudu Mountain Resort (OMR), formerly known as Obudu Cattle Ranch, is a cattle ranch and resort in the highlands of Cross River State in the South Eastern part of Nigeria (Figure 1). Obudu Mountain Resort is located in Obaliku Local Government Area of Cross River State. It lies between longitude 6° 21^{1} 30^{11} and 6^{0} 22^{1} 30^{11} N and latitude 9° 22^{1} 0^{11} and 9^{0} 22^{1} 45^{11} E, with an approximate area of 104sqm, and a height of about 1576m above sea level (Cross River State Tourism Bureau, 2010). Cross River State shares a boundary with Benue State to the North, Enugu and Abia States to the West, Cameroon Republic to the East and Akwa-Ibom State and the Atlantic Ocean to the South. OMR is situated on a relatively flat Plateau on the Oshie Ridge of Sankwala Mountains. It is an area of idyllic tranquilliy,

beautiful scenery and breathtaking views. It has 22 U- bends that consist of the most exciting "the Devil's Elbow" which is halfway through the stretch. OMR enjoys a climate typical of the temperate regions of the world. It has a temperature of between 26°C to 32°C between November and January and the low-temperature range of 4°C to 10°C between June and September (Okojie and Ijaola, 2011).

Data collection

A two-stage sampling technique was employed for the study. The first stage involves a simple random selection of staff with a minimum of three years of working experience in the resort. In the second stage, hospitality staff who have worked in the hospitality sector of the resort for a minimum of three years were selected and the first set of questionnaires to elicit information on available hospitality services and facilities was administered to all the thirty-five staff who fell into this category. Thus, no hospitality staff and hospitality staff with less than three years of working experience were excluded from the study. The second set of questionnaires that provided information on tourist's satisfaction was administered to

one hundred and twenty (120) randomly selected tourist respondents who have stayed for at least two nights in the resort. Therefore, tourists who have not spent at least two nights previously in the resort were similarly excluded from the study. In all, a total of one hundred and fifty-five questionnaires was administered for the study. However, one hundred and fifty (150) were retrieved and used for the analysis. The Likert 3-point scale was used for scoring and rating tourists' level of satisfaction ranging from excellent (1), good (2), and poor (3).

Method of Data analysis

The data obtained from the survey were analysed by descriptive statistics using frequencies and percentages, pie charts and bar tables. Inferential statistics such as Chi-square analysis was used to test for association between socio-economic characteristics of tourists and their perceived satisfaction of hospitality services in the resort. The Statistical Package for Social Sciences (SPSS), version 16.0 was used for the analysis.
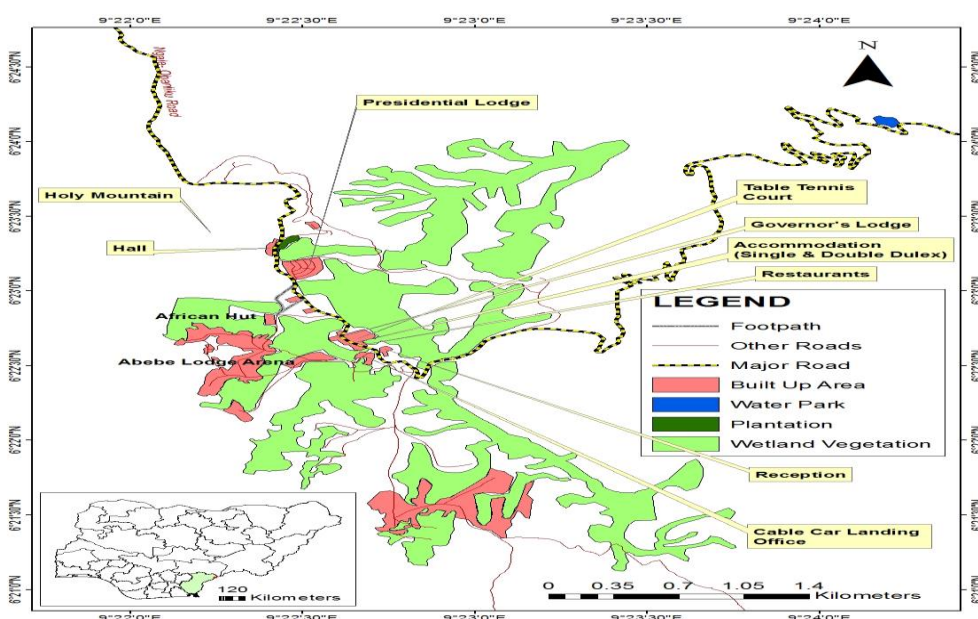
Figure 1: Showing the Map of Obudu Mountain Resort (OMR)
Source: Field Survey, 2018

RESULTS

Table:1 shows the services provided by the hospitality unit of Obudu Mountain Resort which include accommodation as noted by 100% of the staff respondents, food and beverages (100%), entertainment (92%), and laundry (84%).

Table 1: Types of services provided by the hospitality unit of OMR according to staff respondents

Services	Frequency	Percentage
Accommodation	35	100
Food and Beverage	35	100
Entertainment	32	92.0
Laundry	30	84.0

Source: Field Survey (2018)

Table 2 shows the level of tourists' satisfaction and the rating of the services by the hospitality unit of Obudu Mountain Resort by tourist respondents. Accommodation service was rated good by most respondents (72.7%), 18.2% rated it poor and 9.1% rated it excellent. Also, laundry service was rated good by the majority of tourist respondents (67.3%) while 32.7% rated it poorly. Similarly, Food/beverage was rated good by the majority of the respondents (62.5%), 30.5% rated the service excellent while laundry service was rated poor by 16.5% of the tourist respondents.

Table 2: Perceived efficiency and rating of hospitality services in OMR by tourist respondents.

Services	Perceived Rating	Frequency	Percentage
Accommodation	Poor	20	18.2
	Good	80	72.7
	Excellent	10	9.1
Total		110	100
Laundry	Poor	36	32.7
	Good	74	67.3
	Excellent	0	0
Total		110	100
Food and Beverages	Poor	18	16.5
	Good	69	62.5
	Excellent	23	30.5
Total		110	100
Entertainment	Poor	17	15.5
	Good	77	70.0
	Excellent	16	14.5
Total		110	100

Table 3 shows the chi-square analysis which elicits the association between socio-economic characteristics of tourists and their perceived efficiency and rating of hospitality services in the resort. The analysis revealed that age, education, sex and annual income have significant relationships with the perceived level of satisfaction and rating of hospitality services in the resort. The analysis shows that age significantly influences the perception of efficiency and rating of hospitality services. Age has P-value = 0.001, educational level = 0.014, annual income 0.004 and purpose of visit 0.047 respectively.

Table 4 shows the number of previous visits by tourist respondents to OMR. The table shows that tourists who have visited the eco-destination twice were the highest (41.7%) and those who have paid 3 visits previously accounted for 26.1% of tourist respondents. Also, those who have visited four times were 13.0% while 10.5% of the respondents have visited the resort more than five times previously.

Table 3: Summary of chi-square tests of association between socio-economic characteristics of tourists and their perceived satisfaction of hospitality services in Obudu Mountain Resort

Parameter	Chi-square (x^2)	P value	Inference
Age of tourists and perceived satisfaction of hospitality service	9.461	0.005	Significant association
Education qualification of tourists and perceived satisfaction of hospitality service	12.544	0.014	Significant association
Sex of tourists and perceived satisfaction of hospitality service	26.470	0.001	Significant association
Occupation of tourists and perceived satisfaction of hospitality service	14.664	0.066	No Significant association
Annual income and perceived satisfaction of hospitality service	25.739	0.004	Significant association

Source: Field Survey, 2018

Table 4: Number of previous visits by tourist respondents to OMR

Number of times	Frequency	Percentage %
2	48	41.7
3	30	26.1
4	15	13.0
5	12	10.5
>5	10	8.7
TOTAL	115	100

Source: Field Survey, 2018

Length of the previous stay in OMR by tourists as indicated by tourist respondents

The study revealed that the maximum length of the previous stay by most tourist respondents (39.1%) in the resort was 2 nights and 30.0% claimed they have spent 3 nights previously. Similarly, those who have stayed for 4 and 5 nights before this study accounted for 15.7% and 12.1% respectively. Additionally, those who have stayed for more than 5 nights previously were 6.1% of the total sampled tourists (Figure 2).

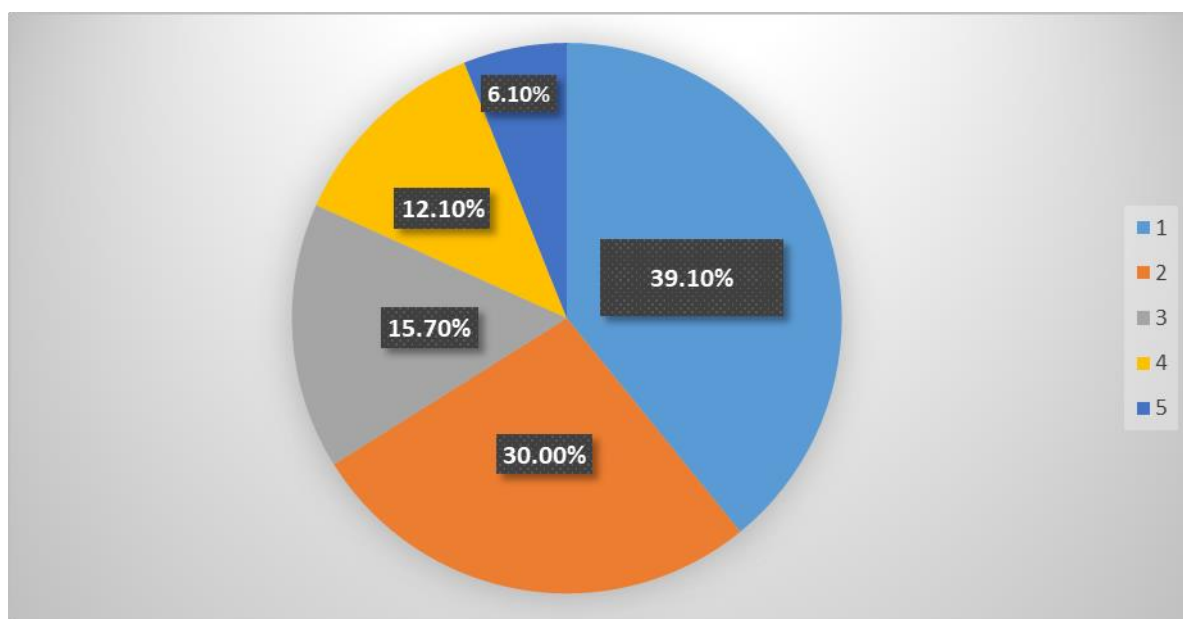**Figure 2: Showing the Average length of the previous stay by tourists in OMR**

Source: Field Survey, 2018

Table 5 presents tourist's inflow to Obudu Mountain Resort from 2013-2017. The table shows that the majority (67.2%) of the 35,691-total number of tourists that visited the resort for five consecutive years preceding this study were domestic tourists while international tourists accounted for 32.8%.

Table 5: Tourist Inflow to Obudu Mountain Resort from 2013-2017

Years	Domestic Tourists		International Tourists		Total
	Frequency	Percentage %	Frequency	Percentage %	
2013	7,927	58.0	5,741	42.0	13,668
2014	8,343	72.1	3,230	27.9	11,573
2015	8,025	75.2	2,643	24.8	10,668
2016	5,758	63.4	3,220	36.6	8,978
2017	5,638	68.4	2,601	31.6	8,239
Total	35,691	67.2	17,435	32.8	53,118

Source: Obudu Mountain Resort, 2018

DISCUSSION

Services provided by the hospitality unit of Obudu Mountain Resort

Findings from the study revealed that the hospitality unit of Obudu Mountain Resort offers various customer-centric services which include guest rooms of varying categories such as Single, Double, Deluxe and Family Chalet. The provision of different and decent accommodation facilities that meet different tourist needs is very important for tourist destinations to attract patronage and loyalty. Similarly, the majority of visitors to the resort (67.2%) for more than five years preceding this study were domestic tourists. This agrees with the global report where domestic tourists formed the bulk of tourists in some tourist destinations as reported by UNWTO (2017) and from the findings of Amalu et al. (2016). Additionally, findings from the study also revealed that there are 160 different accommodation facilities in the resort and these varied in terms of size, interior furnishings and capacity. Hence, many tourists were able to find desirable accommodation facilities that meet their needs without necessarily compromising their choice. The hospitality unit also provides different types of meals and drinks in the restaurant and bar to meet the needs of different categories of tourists. The unit serves local, continental, inter-continental well as special meals. The hospitality unit also serves different alcoholic and non-alcoholic drinks. These findings agree with that of Enemuo and Iredia (2013), who also noted

that food and drinks, as well as accommodation facilities, are the key features that are generally associated with hospitality service. The hospitality department of tourist destinations usually plays important role in making tourists feel warm and welcome to their temporary home for the duration of their stay. Moreover, the experiences created by the hospitality department via meals, accommodation, drinks and entertainment can overwhelm tourist's experiences beyond recreational activities or any other purpose for visiting the destination.

Perceived tourist satisfaction and efficiency of services

The result of the study clearly shows that on average, most tourist respondents (72.7%) were satisfied with the accommodation facilities and other services offered by the hospitality units of the resort. This could suggest that the accommodation facilities in Obudu Mountain Resort are tastefully furnished and of high quality, thus, could meet the demand of many tourists who have visited other eco-destinations in Nigeria with poor room furnishings and dilapidated accommodation facilities. This agrees with the findings of Manhas and Tukamushaba (2015) who reported that the ambience of guest rooms provide feelings of satisfaction to tourists and could influence tourists to pay a repeat visit. Also, Brunner-Sperdin et al. (2012), affirms that the destination environment can affect tourist's emotions and consequently influence their overall perception of the service delivery at tourist

destinations. Similarly, the result of the study indicates that the Food and Beverage service was satisfactory to the majority of the tourists (62.5%) who rated it well while 30.5%% rated it excellent. This also agrees with Nield et al. (2000) who argued that quality food and good food service contribute to tourist satisfaction. It could therefore be reiterated that the quality of food and excellent food service can be considered important marketing tools for tourist destination managers. Also, the result of the study further shows that the majority of the tourist respondents (70.0%) were pleased with the entertainment services in the resort, hence, they rated it good.

Previous visits and the average length of stay by tourists

Findings from the study also revealed that the majority of tourists to the resort (68.7%) are short-stay tourists who spent between two (2) and (3) nights and have similarly visited the resort between two (2) and (3) visits in the past. This agrees with the findings of Odunlami and Ijeomah (2016) who similarly reported that the average length of stay of the majority of visitors in Yankari Game Reserve, another eco-destination in North-Eastern Nigeria, was between two (2) and three (3) nights. It is apparent that the good rating of the services in the resort by tourists did not translate into an increase in the number of tourist's repeat visits and length of stay. These could be attributed to the cost of travel and stay in the resort. For example, the cost of accommodation alone (besides meals and drinks) in the resort is between twenty-five thousand nairas (₦25,000:00) and forty-seven thousand nairas (₦47,000:00) per night. This is beyond the reach of an average civil servant in Nigeria, except a very senior civil servant. Nevertheless, making tourists feel comfortable such that they want to come back again is an indicator that their aim for visiting the destination is a fulfilled one. It is therefore very important for the

management of the resort to regularly assess and check that every single service rendered meets the desire and the aspiration of tourists. The tourists' destinations are in business because of tourists; however, good and efficient services are key to sustaining tourists and hospitality business operations at tourist destinations.

CONCLUSION

The hospitality unit of Obudu Mountain Resort offers different services to tourists including food and drinks, accommodation, entertainment as well as laundry services, and the majority of the tourists were satisfied with the services rendered to them but tourist visitation to the resort declined after three visits, and the majority of the visitors only stay for three nights which clearly indicate the need to develop an effective strategy that will encourage tourists to pay more repeat visits and spend more than three nights in the resort.

ACKNOWLEDGEMENT

REFERENCES

Amalu, T. E.; Duluora, E. I.; Otop, O. O.; Omeje, V. U.; Emeana, K.S. Assessment of tourists' patronage of Obudu Mountain Resort, Cross River State, Nigeria. *J. Hosp. Mgt. Tourism.* 2017, 8(4), 32-41. DOI: 10.5897/JHMT2013.0096

Brunner-Sperdin, A.; Peters, M.; Strobi, A. It is all about the emotional state: Managing tourist experiences. *Int. J. Hosp. Mgt.* 2012, 21: 23-30. DOI: 10.1016/j.ijhm.2011.03.004

Cross River State Tourism Bureau. Tourism in Cross River, the journey so far, 2012. Calabar: Tempo Project Report.

Enemuo, O. B.; Edward, Ejikeme, J. N. U. C. I. The role of customer satisfaction and maintenance culture in the sustainability of hospitality industries in Umuahia North and South Local Government Areas of Abia State. *J. Hosp. Manage. Tourism.* 2016, 7(1):1-10. DO:10.5897/JHM2015.0164.

Enemuo, O. B.; Iredia, C. Repositioning the hospitality industry in Etsako West Local Government Area for profit maximization through Information and Communication Technology.2013, *Int. J. Humanities Soc. Sci Invention.*2013, 1 (2), 55- 62.

ILO. International Labour Organisation. Sectoral activities Programme. Development and challenges in the hospitality and tourism sector. 2010. Issues paper for discussion at the Global Dialogue Forum for the Hotels, Catering and Tourism Sector. November 23rd -24th 2010. Geneva.

Manhas, P. S.; Tukamushaba, E. K. Understanding Tourist Experience and its impact on brand image in Hospitality sector. 2015, *Int. J. Hosp. Mgt*. 2020, 45, 77-87. https://doi.org/10.1016/j.ijhm.2014.11.010. Accessed January 25th 2020.

Mihaela, P. R. Customer Satisfaction in Tourism. How to Measure it? *Cact. Tsm J.* 2014, 10 (2), 30-35.

Nield, K.; Kozaak; Le Grys, G. The role of Food Service in Tourist satisfaction. *Hosp. Mgt*, 2000, 19, 375-384. https://doi.org/10.1016/S0278-4319(00)00037-2. Accessed January 29th 2021.

Odunlami, S. S.; Ijeomah, H. M. Preference of recreational activities and wildlife species by tourists in Yankari Game Reserve, Nigeria. 2016, *Int. J. Agric. Rural Develt.* 19(2), 2647-2654.

OECD. Organisation for Economic Co-operation and Development, 2010: Tourism Trends in the OECD Area and beyond, in Tourism trends and policies (Paris). https://doi.org/10.1787/tour-2010-en. Accessed December 24th 2020.

Okojie, L. O.; Ijaola, A. A. Ecotourism Values and Sustainability of Obudu Cattle Ranch. *Nig. J. Humanities. Soc. Scie. Creative Arts.* 2011, 6(1), 36-47.

UNWTO. United Nations World Tourism Organization. UNWTO Tourism Highlights, 2017 Edition, Madrid Spain. DOI: https/doi.org/10.18111/9789284419029. Accessed June 30th 2021.

UNWTO. United Nations World Tourism Organization. UNWTO Tourism Highlights, 2020 Edition, Madrid Spain. DOI: https://doi.org/10.18111/9789284422456. Accessed July 10th 2021.

Journal of Agriculture & Forestry Research

Research Article

Open access

An Intervention Study of Deltamethrin Impregnation of Lower Efficacy of Used Llins and Local Mosquito Nets in Ohnpinkone Ward, Nant Nhyin Village, Banmauk Township, Sagaing Region in Myanmar

Maung Maung Mya[1]; Myat Phone Kyaw[1]; Kyaw Thu Soe[2]; Pyae Linn Aung[2]; Than Tun[3]; Nwe New Aye[3]; Ye Kyaw Thu[2]; Swan Htet Aung[2]; Kyaw Kyaw Linn[4]

[1] Department of Medical Research Yangon, MOGH
[2] ICEMR Project
[3] Vector Borne Diseases Control DOH
[4] Township Medical Officer Banmauk Township Sagaing Region

ARTICLE INFORMATION

ABSTRACT

Long-Lasting Impregnated bed nets have been distributed in all villages in Myanmar. The insecticide efficacy should last for 3 years and re-distribution is necessary, but re-distribution was not covered to all townships in 2019. An intervention study was conducted in Ohnpinkone as test ward and Bwedarkone as control ward of Nant Nhyin village, Banmauk township, from December 2019 to October 2020. In the Ohnpinkone ward, all used LLINs with low efficacy of insecticide and traditional nets from households were impregnated with Deltamethrin at the rate of 55mg/meter square and compared with non-intervention ward Bwedarkone for 10 months. There were 10 *P. falciparum* cases in Ohnpinkone and 1 *P. falciparum* case in the Bwedarkone ward in the 2019 before intervention. After intervention in Ohnpinkone, the malaria cases were going down to 0. There were 3 malaria-positive cases were found in the control ward Bwedarkone, 66.67% higher up. Main vector *An. minimus* was found higher number in both Ohnpinkone (137) and Bwedarkone (109) wards by outdoor and indoor light trap catch methods. Moderate number of *An. Barbirostris* (126) and *An. Vagus* (104) were observed in the test ward and *An. vagus*, *An. philippinensis* in the control ward. After intervention, no malaria cases and vectors were caught up by indoor bedroom light traps in the test ward, showing 100% recovery till October, although malaria vectors were observed in the indoor light trap in the control ward. Therefore, Deltamethrin impregnation to used LLINs nets with expiry or lower efficacy, become higher bio-efficacy again. It is a very useful and cost-effective tool to control malaria transmission and man vector contact as well as reduced vector mosquitoes

---

in malaria-endemic areas. The National Malaria Control Program may consider implementing this intervention in resources limited settings and or emergencies with supply chain shortages.

INTRODUCTION

Malaria is one of the major communicable disease-causing high mortality and morbidity among the population. Previously malaria is a main public health problem in Myanmar. Although now morbidity and mortality of malaria are reducing from 4% to 1% by 100000 population 2011 to 2018 (Health in Myanmar, 2019). Out of which, about half of the cases were *Plasmodium vivax* (*Pv*). *Plasmodium vivax* is gradually rising in Myanmar (Myint Oo et al., 1999). But malaria is endemic in hard-to-reach areas and border areas (MOHS, 2018). This disease is transmitted by biting the female *Anopheline* mosquito species. Out of 37 Anopheline species found in Myanmar, *An. dirus* and *An, minimus* are major vectors of malaria and *An. annularis* is a local vector of malaria in Rakhine State and *An. sundigus* is a vector of malaria in coastal areas in Myanmar (Khin Mung Kyi 1970). Although *An. annularis, An. maculatus, An. aconitus* and *An. philippinensis* are secondary vectors of malaria in Myanmar. In India the six species viz., *Anopheles culicifacies, An. stephensi, An. minimus, An. sundaicus, An. fluviatilis* and *An. dirus* are major vectors of malaria and three species viz., *An. annularis, An. philipinensis* (nivipus) and *An. varuna* are minor vectors of malaria (Sharma, 1999).

There has been a renewed emphasis on preventive measures at community and individual levels. Insecticide-treated nets (ITNs) are the most prominent malaria preventive measure for large-scale deployment in highly endemic areas (Schellenberg et al., 2002; Lengeler, 2004). Most research about the efficacy of net bed impregnation has been done in Africa and Asia (Kroeger et al., 1997). The study by Choi et al. (1995) showed a reduction of the malaria incidence rate by 50%. Also, the overall mortality and morbidity attributed to malaria in children aged 1-4 years were reduced by 63% and 70%, respectively, in areas in the Gambia where insecticide-treated nets were used (Alonso et al., 1991). The controlled trials carried out so far thus showed a reduction not only of malaria-related morbidity but also of child mortality (Lengeler, 2004).

In India on a pilot-scale study was done in 100 highly endemic districts under the Enhanced Malaria Control Programme. This is the first time ITNs have been incorporated into the malaria control programme to replace insecticide indoor residual spraying in India at Primary Health Centre (PHC)/district level (Jambulingam et al., 2008). In diverse social and epidemiological settings, the efficacy of the ITNs alone may not be the crucial determinant for the effective implementation of this community-based intervention measure (Binka and Adongo, 1997).

Nant Nhyin village is a remote and hard-to-reach area; it is 40-50 miles away from Banmauk City. There is a total of four wards, Ohnpinkone and Bwedarkone wards are included in Nant Nhyin village. The total population is about 5000 populations in the village. Most of the population are farmers remaining are health staff, school teacher and some are working in Gold mines. One monastery and one middle school are situated. The area of the Nant Nhyin is a hilly area and there are no pucker roads. One creek is across the village. So many creeks cross between Bunmouk and Nant Nhyin village. Malaria morbidity is found every month in this area. Therefore, there is a need to control malaria morbidity as well as the main vector. Long-lasting insecticide-treated nets have been distributed in all villages and

insecticide efficacy should last for 3 years and re-distribution is necessary, but re-distribution was not covered to all townships in 2019. The study determined monthly malaria vectors occurrence in Ohnpinkone ward after impregnation of mosquito nets and Bwedarkone wards data was used as a control in Nant Nhyin villages because we have found 10 *Plasmodium falciparum* malaria cases in Ohnpinkone. Therefore, the study aims to determine the malaria prevalence rate and indoor malaria vector entrance rate after impregnation of Deltamethrin insecticide to mosquito nets.

MATERIALS AND METHODS

Study areas

The study was conducted in Ohnpinkone and Bwedarkone wards in Nant Nhyin village Banmauk Township Sagaing Region in Myanmar, where the morbidity of malaria is high.

Study period

The study period was one year, conducted from December 2019 to November 2020.

Study design

An intervention study design was used.

Malaria parasite detection

Sample collection: Before to after the intervention period, monthly finger-prick blood samples were taken from all the population in both Ohnpinkone and Bwedarkone words. Thick and thin blood films were made on greases free glass slides and dried in the air in shad in the room. Dried Thin films were fixed with absolute alcohol and dried at room temperature. Thick and thin blood slides were stained with 10 % Giemsa's stain for 5 minutes. Stained slides were washed with buffer water. Washed slides were dried at room temperature. Malaria parasites were diagnosed under an oil emersion lens (100X).

Identification of malaria parasites

Malaria parasites in thick and thin films were identified under an oil emersion lens. Malaria parasite was counted against 200 WBC.

Mosquitoes collection

Anopheles mosquitoes were collected by using CDC light traps such as Indoor light traps, Indoor bedroom light traps, and outdoor light traps collection methods from 18:00 hour to 00:06 hour in randomly selected households in before and after intervention period in both Ohnpinkone (Test) and Bwedakone (control) wards.

Larval surveys

Larval survey for breeding sites, susceptibility, and bio-efficacy tests: larval surveys were conducted in and around three kilometers away from the study villages. Water pools, domestic wells, streams, creeks, and pools, and all different types of water holding places were examined by 3 Dips /water holding places for larval detection (WHO, 1975). In and around the villages, water pockets, coconut shells, discarded tins and utensils, bamboo stumps including footprints of animals were examined. The captured larvae and pupae were put in labeled plastic bags and brought back to the laboratory for species identification and colonization.

Mosquito species identification

Collected *Anopheles* mosquitoes by light traps and adults emerged from larval survey were identified according to different identification keys (Harrison, 1980; Raid, 1967; Myo Paing, 1990b)

Insecticide susceptibility test

Insecticide susceptibility tests (WHO test kit): Collected F1 generation of adult female *Anopheles* mosquitoes from the larval survey were tested for measurement of insecticide susceptibility level using WHO test kits and standard procedures (WHO 1975). The efficacy of insecticides (which are commonly used for vector control in malaria-endemic areas) as Permethrin 0.75%, Cyfluthrin 0.15%, and Deltamethrin 0.05% impregnated

paper with WHO test kits (WHO 1993) were provided to determine the susceptibility of mosquitoes and Bio-efficacy of deltamethrin impregnated nets.

Procedure

Ten F1 generations of *Anopheles* mosquitoes were introduced in WHO insecticide-impregnated paper attached plastic tube (WHO test kit) by sucking tube and exposed for 1 hour. After one hour of exposing the mosquitoes were then removed from the plastic tubes and placed in clean plastic tubes without paper with 10% glucose soak cotton and moisture was maintained by water soak damp towel. Percentage of knockdown was measured after 60 minutes of exposure and effective mortality was assessed after 24 hours exposure. Two replicate testing was done to confirm the susceptibility of mosquitoes. If the number of collected mosquito adults emerged from the larval survey was not more than ten while we used pool mosquito samples to test insecticides susceptibility. The susceptibility of mosquitoes was determined according to WHO (1993).

Bio-efficacy Test (Cone test)

Determination of insecticide persistence – Bioassays were carried out using the World Health Organization cone test method (WHO, 2013) after 3, 6, and 9 months of impregnation of mosquito nets in the Ohnpinkone wards to monitor the persistent effect of the insecticide treatment. Ten deltamethrin impregnated nets were randomly collected and bioassays were conducted. For comparison, tests were conducted in parallel on one untreated net obtained from the villagers. Ten sets of 10 F1 female *Anopheles* mosquito adults from the larval survey were exposed to the treated nets for 3 min and the mortality was recorded after 24 hours. *Anopheles minimus* and secondary vectors were used for the bioassay test. The same test was done for another randomly collected 20 ITNs for two days.

Data analysis

Data entry and collected monthly malaria and mosquito were analyzed by using Microsoft Excel software. Mosquito density, the main vector of indoor and outdoor light traps, mosquito susceptibility, and mortality, were calculated in percent.

RESULTS

Table 1 shows that 84 different types of mosquito nets were impregnated with deltamethrin at the rate of 55mg/meter squire. Of this used long-lasting insecticide nets (LLINs) (n=54), Cotton nets (n=6), Cylon nets (n=8), Traditional nets (n=16).

Table 1. Deltamethrin impregnation of different types of mosquito nets in Ohnpinkone ward.

Type of Mosquitoes nets	Number of nets	Good net	Tattered nets	% of good nets
Used LLINs nets	54	51	3	94.44
Cotton nets	6	6	0	100
Cylon nets	8	8	0	100
Traditional nets	16	16	0	100
Total nets	84	81	3	96.43

Table 2. shows that Indoor and Outdoor light traps collection in Ohnpinkone (Test ward) and Bwedarkone (control wards) and found that the highest number of vector *An. minimus* was found (n= 72) in indoor light traps collection followed by n=65 in the

outdoor collection in Ohnpinkone ward. In Bwedarkone ward, the highest number of main vector *An. minimus* was found n=67 in outdoor light traps collection followed by n=36 in the indoor collection and lowest *An. minimus* was observed n=5 in bedroom Light traps catch. Although *An. barbirostris* was abundantly found n= 126 in Ohnpinkone and n=21 in Bwedarkone wards followed by *An. willmori* n=40 in Bwedarkone and n=21 in Ohnpinkone wards. Other secondary vectors such as *An. aconitus* (n= 40, 25)*, An annularis* (17, 14), *A culicifacies* (n=10, 2) *An. maculatus* (27, 9) and *An. kochi* (19, 9) were found in both areas. In bedroom light traps catch, has not collected any *Anopheles* mosquitoes in Test area of Ohnpinkone ward although in Bwedarkone wards n= 11 *Anopheles* mosquitoes were collected by bedroom light traps.

Table 2. *Anopheles* mosquitoes were collected by Light traps methods in two selected control and test wards in Nant Nhyin village.

Species	Ohnpinkone Ward (Test ward)				Bwedakone (Control ward)			
	Outdoor	Indoor house	Indoor bed room	Total	Outdoor	Indoor house	Indoor bed room	Total
An. kochi	5	14	0	19	3	6	0	9
An. barbirostris	42	84	0	126	10	11	0	21
An. hyrcanus	7	7	0	14	0	1	0	1
An. splendidus	31	10	0	41	28	10	0	38
An. minimus	65	72	0	137	36	67	5	109
An. varuna	11	40	0	51	11	18	1	30
An. maculatus	11	16	0	27	4	4	1	9
An. Jamesi	32	2	0	34	2	2	0	4
An. aconitus	16	24	0	40	10	15	0	25
An. stephensi	1	18	0	19	0	0	0	0
An. candidiensis	7	3	0	10	4	4	0	8
An. pallidus	2	10	0	12	1	0	1	2
An. theobaldi	0	0	0	0	0	0	0	0
An. Annularis	8	9	0	17	7	7	0	14
An. philippinensis	33	41	0	74	20	17	1	38
An. gigus	0	0	0	0	0	0	0	0
An. vagus	24	90	0	114	17	20	2	39
An. dirus	2	8	0	10	0	0	0	0
An. culicifacies	3	7	0	10	0	2	0	2
An. willmori	0	21	0	21	0	40	0	40
An. tesselatus	0	4	0	4	1	0	0	1
An. subpictus	1	4	0	5	0	1	0	1

Total	301	484	0	785	154	225	11	390

Tabe 3 shows that detailed *Anopheles* larvae breeding site and abundances in study areas. The highest number of *Anopheles* larvae were collected from Rice fields n=1392(23.48%), followed by Sand pools and Creeks n=1171(19.75) and1156 (19.50%) and the lowest was observed in water well n=182(3.07%). *Anopheles minimus* larvae were abundantly found in. Rice fields (n=153), Sand pools (n=127), and Valley (n=129). Main vector *An. dirus* was found lowest number (n=22) in water wells in Ohnpinkone ward. The Secondary vector is *An. aconitus, An. maculatus, An. aconitus, An. annularis*, *An. philippinensis*, *An. culicifacies* and non-vectors *An. vagus, An.kochi, An. barbirostris* were abundant found in different water holding places.

Table 3. Different species of *Anopheles* larvae collected from different breeding places from Ohnpinkone and Bwedarkone wards

Species	16 Water well	8 sites of Valley	30 of Water pools	29 sites of Sand pool	45 sites of Rice field	38 sites of Creeks	Total	Density %
An. minimus	89	129	83	127	153	56	637	10.75
An. dirus	18	4					22	0.37
An. maculatus	32	79	89	105	168	99	572	9.65
An. aconitus	43	78	132	54	152	87	546	9.21
An. annularis		108	142	97	107	97	551	9.29
An. philippinensis		123	96	76	107	138	540	9.11
An. culicifacies		108	79	136	147	123	593	10.00
An. kochi		60	130	158	145	98	591	13.67
An. barbirostris		82	61	95	166	137	541	9.13
An varuna		67	59	98	69	78	371	6.26
An vagus		87	95	153	92	105	532	8.97
An willmori		65	71	72	86	138	432	7.29
Total	182	990	1037	1171	1392	1156	5928	100.00
Percent density %	3.07	16.70	17.49	19.75	23.48	19.50	100.00	

Red =primary vectors, Blue= Secondary vectors, Black= Non=vectors

Table 4. shows that all collected main vector *An. minimus* and *An. dirus*, Secondary vector *An. aconitus, An. varuna, An. annularis, An. philippinensis, An. maculatus, An, kochi. An. vagus* were found susceptible to WHO recommended insecticides as Deltamethrin 0.05%, Permethrin 0.75% and Cyfluthrin 0.15% impregnated paper.

Table 4. Susceptibility status of collected main and secondary vectors of Anopheles mosquitoes in test area

Species	Number of mosquitoes	WHO recommended insecticides impregnated paper	susceptible
An. minimus	30		susceptible

An. dirus	9	Deltamethrin 0.05% Permethrin 0.75% Cyfuthrin 0.15%	"
An. aconitus	30		"
An. varuna	30		"
An. annularis	30		"
An. philippinensis	30		"
An. maculatus	30		"
An. kochi	30		"
An. vagus	30		"

Table 5. shows that bio-efficacy of before deltamethrin impregnation of mosquito nets in Ohnpinkone and Bwedarkone were found 6(20%) and 19(63.33%). Three months later, after impregnation of deltamethrin to mosquito nets in Ohnpinkone wards, the bio-efficacy was found 100% and in control ward Bwedarkone (non -impregnated with deltamethrin) the bio-efficacy was reduced from 63.33 to 43.33%. During intervention after 6 months later, the bio-efficacy of impregnated mosquito nets in Ohnpinkone and non-impregnated nets in Bwedarkone was found 100% sensitive in Ohnpinkone and 36.67% sensitive in Bwedarkone. After intervention in Ohnpinkone wards, the bio-efficacy of impregnated nets was found 96.67% sensitivity and in the control ward, the sensitivity of non-impregnated nets was found to be 16.67% in Bwedarkone ward.

Fig. 1. shows that before intervention 10 *P. falciparum* malaria cases were found in Ohnpinkone wards although the main vectors of *An. minimus* was collected in high number in March, April and July and 2 *An. dirus* was collected in June in indoor light traps catch. There were no malaria cases found during and after intervention period. But 1 *P. falciparum* positive cases was observed in pre-intervention months December and three malaria cases (2 Falciparum and 1 Vivax malaria cases) were found after intervention month in control ward Bwedarkone and main vector *An. minimus* was gradually increased from February to June and declined to October.

Table 5. Bio-efficacy of impregnated mosquito nets during and after intervention periods by the cone test method

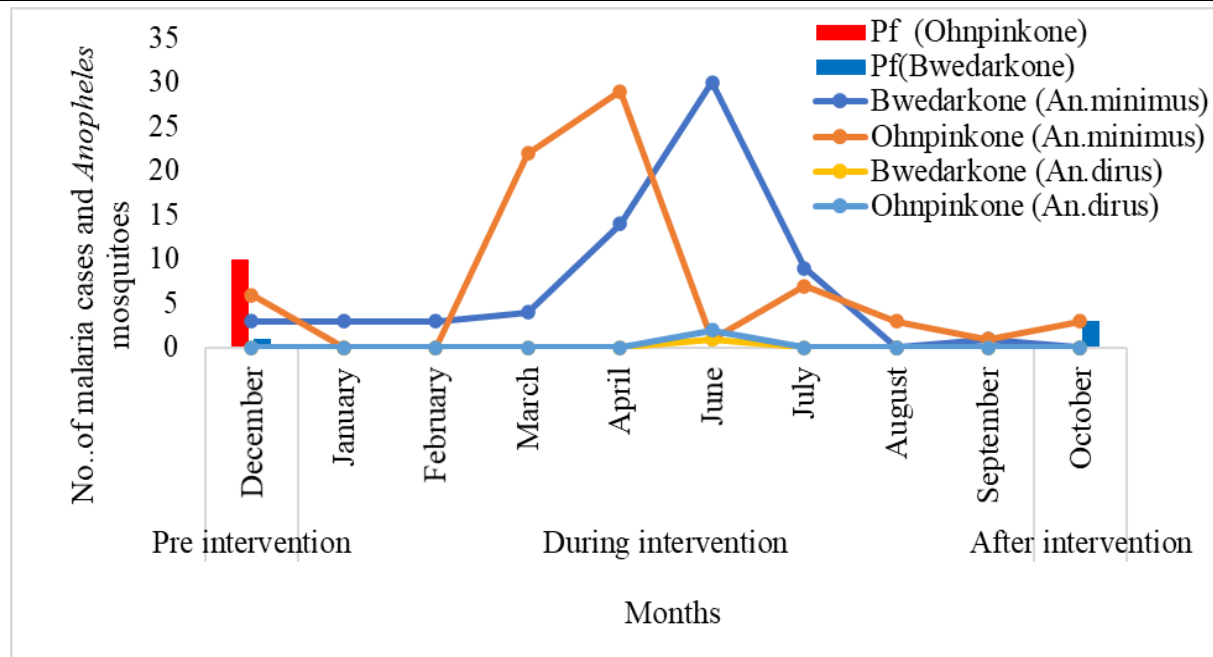| Periods	(Ohnpinkone Test)		Bwedarkone (Control)	
	Tested nets	Bio-efficacy	Tested nets	Bio-efficacy
Pre-intervention (Before deltamethrin impregnation to nets)	30	6 (20%)	30	19 (63.33%)
During intervention (3 months later)	30	30(100%)	30	13 (43.33%)
During intervention (6 months later)	30	30(100%)	30	8 (36.67%)
After intervention (9 months later)	30	29(96.67%)	30	5 (16.67%)

Fig. 1. Malaria cases and indoor main vectors collected by Light traps in study period.

Table 6. shows a 100% reduction of malaria cases were found after intervention periods. After deltamethrin impregnation of mosquito nets, the positive malaria cases were reduced to 0% during intervention month January to after intervention month (October). Although in the control ward as Bwedarkone was found, 66.67% of positive malaria cases were increased in the after-intervention period.

Table 6. Percentage reduction of malaria cases in after intervention period

Place	Pre-intervention	After intervention	Percentage
Ohnpinkone ward	10 malaria cases	O malaria cases	100% reduction
Bwedarkone ward	1 malaria cases	3 malaria cases	66.67 % increased

DISCUSSION

Malaria is a public health problem in Myanmar now due to the morbidity is high in hard-to-reach areas. Malaria morbidity is found every month in this area due to migrants, gold mine workers and rubber plantations (Maung Maung Mya et al., 2020a; Maung Maung Mya et al., 2014). *Plasmodium vivax* cases were found high prevalence in some areas and found Chloroquine resistance in Myanmar (Myint Oo et al., 1999, Myat Phone Kyaw et al., 1993). Therefore, there is a need to control malaria morbidity as well as man vector contact. We selected Ohnpinkone as the Test ward and determined monthly malaria morbidity and vectors occurrence in the Ohnpinkone ward after impregnation of mosquito nets. Bwedarkone wards data was

used as a control because we have found 10 malaria cases in Ohnpinkone and one malaria case was found in the Bwedarkone ward in the preintervention period. Before the intervention period, a total of 84 used mosquito nets (Used LLINs nets 54, Cotton nets 6, Cylon nets 8, and Traditional nets 16) were collected and impregnated with Deltamethrin at the rate of 55mg/meter square. There are 4 kinds of mosquito nets in Ohnpinkone ward as LLINs nets, cotton nets, polyester nets and traditional nets; of this highest number of used LLINs nets were impregnated due to low bio-efficacy (20%). In the pre-intervention month, December 10, Falciparum malaria cases were found in Ohnpinkone wards and one *P. falciparum* case was found in Bwedarkone wards. During intervention months (January to September),

no positive malaria cases were found till after intervention months (October) in the Ohnpinkone ward. In the control ward 3 malaria cases (2 *P. falciparum* and 1 *P. vivax*) were found after-intervention month (October). Other researchers revealed that malaria morbidity was high in Katinehtit village Kamamaung Township Kayin State, where Vivax malaria cases were found more prevalent (Maung Maung Mya et al., 2019b). In Bwedarkone and Ohnpinkone wards, a total of 785 and 390 *Anopheles* mosquitoes were collected within pre, during and post-intervention periods (December to October) of this n=484 by indoor and 301 by outdoor light traps were caught in Ohnpinkone wards and 386 *Anopheles* were collected by outdoor and 225 by indoor light traps were collected in Bwedarkone ward. A total of 22 *Anopheles* mosquito species were collected, *An. minimus* and *An. barbirostris* was found highest number in Ohnpinkone Ward and main vector *An. minimus* was found to be higher in indoor and outdoor than indoor and outdoor of Bwedarkone. In Ohnpinkone ward, *Anopheles* mosquitoes were had not collected in indoor bedroom catch. However, 11 *Anopheles* mosquitoes were collected by the indoor light trap method in Bwedarkone. *An. minimus* is a main vector of malaria in Myanmar (Khin Maung Kyi, 1970), and is abundantly found in Pyin Oo Lwin Township Mandalay Region (Maung Maung Mya et al., (2018). The very small number of *An. dirus* was observed from both study and control areas. *Anopheles dirus* is a main vector of malaria and found high density in Bago Yoma Mountain range, Mon State and Taninthayi Region (Tun Lin et al., 1995, Htay Aung et al., 1999). In India *An. dirus, An. minimus, An. culicifacies, An. stephensi, An. philippinensis* and *An. flivitellis* are the main vector of malaria (Sharma, 1999). In Thail and *An. dirus, An. minimus, An. maculatus* and *An. philippinensis* are the main vector of malaria (Tananchai et al., 2019). *Anopheles sinensis* is a main vector of malaria in China (Jia-Yun Pan et al., 2012) *Anopheles darlingi* has an endophilic behaviour and is the main vector of malaria in the Amazon region. The *Anophelines* exhibited a peak of activity in the evening and morning twilight and continued their activity throughout the night in this region (Suarez-Mutis et al., 2009). In Costa Marques, State of Rondonia, Brazil, a decreased number of anophelines collected intra-domiciliary was observed (Santos et al., 1999). In the present study, main vector *An. minimus* was found higher in indoor than outdoor catch by Light traps collection in both study areas.

Anopheles minimus larvae were abundantly collected from Rice field and valley followed by Sand pools and *An. dirus* were found in water wells and valley. *An. minimus, An. maculatus* and *An. aconitus* were found co-breeders of *An. dirus* in domestic water wells. The same result has been found in a water well in Ye Township, Mon State (Maung Maung Mya et al., 2020a). *An. minimus* larvae were abundantly found in slowly running water, foothill areas and rice field (Tun Lin et al., 1995; Pe Than Htun et al., 2005; Maung Maung Mya et al., 2019a). Only 2 *An. dirus* in Ohnpinkone and 1 *An. dirus* in Bwedarkone were collected by Indoor light traps. *An. dirus* is a main vector of malaria and abundantly found in Bago Yoma mountain range and larvae were found rock pools, domestic water wells in Mon, Kayin State and Tanintharyi Region (Tun Lin et al., 1995; Maung Maung Mya et al., 2018; Htay Aung et al., 1999).

In the present study F1 generation of *An. minimus* and *An. dirus*, were susceptible to WHO-recommended insecticides as Deltamethrin 0.05%, Permethrin 0.75% and Cyfluthrin 0.15% impregnated paper. All collected secondary vector *An. aconitus, An. varuna, An. annularis, An. philippinensis, An. maculatus, An. kochi* and *An. vagus* were found susceptible to above insecticides. The same result has been observed by other researchers in Taikkiy Township Yangon Region and other parts of Myanmar (Maung

Maung Mya et al., 2002; Maung Maung Mya et al., 2019a).

Before deltamethrin impregnation, the bio-efficacy of mosquito nets was found very low sensitivity in Ohnpinkone and Bwedarkone was found over 60 % sensitivity. After deltamethrin impregnation for three and six months, the bio-efficacy test was found to be 100% sensitive. After 9 months later the bio-efficacy was slightly reduced to 96.67% sensitivity in the Ohnpinkone ward due to 10-15 times of washing with Fuji detergent cream. Although in control ward Bwedarkone, the bio-efficacy of ITN nets was gradually fallen down to 16.67% sensitivity because collected mosquito nets were washed 20 to 25 times washed and bio efficacy of all mosquito nets were expired their insecticide activity. The use of LLINs has been shown to be a highly cost-effective strategy for malaria prevention, and it has contributed to a significant reduction in disease morbidity and mortality in recent years (WHO, 2011). Same result has been found in the present study, deltamethrin impregnation to old, used and lower efficacy LLINs net were cost affected and gained higher bio-efficacy. All collected LLINs nets were more than 3 years duration of usage. Other researchers revealed that In Brazilian Amazon: Regarding the duration of use LLINs net, most participants in the interventional group used LLINs for≤5 years in all the surveyed years, whereas most participants in the control group used the LLINs for>10 years (Sousa et al., 2019). Some studies that specifically evaluated the use of mosquito nets have found between 15 and 50% of distributed LLINs remain unused (Baume and Marin 2007, Baume et al., 2009, Githinji et al., 2010). A present study found that both Ohnpinkone and Bwedarkone used their LLINs nets for 3 to 4 years; only 3 LLINs net have not been used and kept in showcase in Ohnpinkone.

In the present study, before intervention 10 *P. falciparum* malaria cases were found in the Ohnpinkone ward and one *P. falciparum* malaria case was found in Bwedarkone. After impregnation of used, old and low bio-efficacy LLINs nets, malaria cases were reduced to 0 cases till October it means that 100% reduction in Ohnpinkone was after intervention and very low number of main vector *An. minimus* was observed in January, February. Although main vectors of *An. minimus* was collected in high number in March, April and July and 2 *An. dirus* was collected in June in indoor light traps catch in Ohnpinkone ward. In Brazilian Amazon area, malaria is a seasonal disease with the highest number of cases occurring at the end of the rainy season when there is a greater presence of Anophelines (Sousa et al., 2019). There were no malaria cases found during and after the intervention period in the test ward. But 1 *P. falciparum* positive case was observed in pre-intervention months December and 3 malaria cases (2 Falciparum and 1 Vivax malaria cases) were found after intervention month in control ward Bwedarkone. Main vector *An. minimus* was gradually increased from February to June and declined to October in both test and control wards. The bedroom light traps result in Ohnpinkone were clearly inform that main vectors and other *Anopheles* were no entrance in the bedroom where ITN nets were used, it may be due to the fact that result could reflect the repellent action of the LLINs to vector mosquitoes. The same result has been found in different parts of Myanmar (Maung Maung Mya et al., 2020b). After intervention periods, 100% reduction of malaria cases were found in after deltamethrin impregnation of mosquito nets the positive malaria cases were reduced to 0% in during intervention month January to after intervention month (October). Although in the control ward, Bwedarkone was found 66.67% of positive malaria cases were increased in the after-intervention period. A study in Thanphyuzayet Township revealed that malaria parasite positive rates were significantly reduced when deltamethrin impregnation to cloths in Raber

plantation workers. (Maung Maung Mya et al., 2014). A study in 2016 in sub-Saharan Africa, 54% of the at-risk population slept under an LLIN, which is a substantial increase from 30% in 2010 (WHO, 2017). It has already been demonstrated that LLINs are important for protecting all individuals in a community, including those who do not sleep under a mosquito net [Kilian et al., 2010].

CONCLUSION

Before intervention there were 10 *P. falciparum* cases in Ohnpinkone and 1 *P. falciparum* case in the Bwedarkone ward. After intervention in Ohnpinkone, the malaria cases were going down to 0. There were 3 malaria-positive cases were found in the control ward Bwedarkone, 66.67% higher up. Main vector *An. minimus* was found higher number in both Ohnpinkone (137) and Bwedarkone (109) wards by outdoor and indoor light trap catch methods. After intervention, no malaria cases and vectors were caught up by indoor bedroom light traps in the test ward, showing 100% recovery till October, although malaria vectors were observed in the indoor light trap in the control ward. Therefore, Deltamethrin impregnation to used LLINs nets with expiry or lower efficacy, become higher bio-efficacy again. Insecticide Treated Nets (ITN) are more effective and hygienic as well as they reduce the mosquito density in the bedroom and indoor as well as reduce the men vector contact. They could either complement or replace some of the preventive measures against the mosquito compare to other mosquito control techniques. Based on the present study, it is apparent that ITN based intervention technique is effective and cost-effective as well as appropriate for the control of malaria transmission and vector mosquitoes that they abundantly present in intervention and non-intervention areas. The bio-efficacy was a decrease of 20 % in Test Ward Ohnpinkone and efficacy persist over 60% in the use of these nets. The bio-efficacy results suggest a significant difference between Test and control wards. WHO revealed that below 80% of bioefficacy of LLINs nats need reimpregnation with insecticides. Therefore, it is necessary to impregnate used and low bio-efficacy mosquito nets if in short supply of new LLINs for the prevention of malaria transmission and the entrance of the main vector of *Anopheles* mosquitoes in the bedroom and in the indoor guest room in the test ward. Study suggested that the strategies used must be permanent in areas of high epidemiological risk and difficult geographical access, where people live at low socio-educational levels and that it is necessary to search for new intervention technues to ensure that the knowledge acquired results in a permanent modification of attitudes and behaviors.

ACKNOWLEDGMENTS

REFERENCES

Alonso, P. L.; Lindsay S. W.; Armstrong, J. R. The effect of insecticide-treated bednets on mortality of Gambian children. *Lancet* 1991, 337, 1499-1502.

Baume, C. A. and Marin M. C. Intra-household mosquito net use in Ethiopia, Ghana, Mali, Nigeria, Senegal, and Zambia: are nets being used? Who in the household uses them? *Am. J. Trop. Med. Hyg*. 2007, 77, 963–971.

Baume, C. A. and Reithinger, R.; Woldehanna S. Factors associated with use and non-use of mosquito nets owned in Oromia and Amhara Regional States, Ethiopia. *Malar. J.* 2009, 8, 264.

Binka, F. N.; Adongo, P. Acceptability and use of insecticide impregnated bednets in northern Ghana. *Trop Med Int Health*. 1997, 2: 499-507.

Chatchai, T.; Manguin, S.; Michael, J.; Bangs, Theeraphap Chareonviriyaphap. Malaria Vectors and Species Complexes in Thailand. *Trends in Parasitol.* 2019, 35(7), 544-558.

Choi, H. W.; Breman, J. G.; Teutsch, S. M.; Liu, S.; Hightower, A. W.; Sexton, J. D. The effectiveness of insecticide-impregnated bed nets in reducing cases of malaria infection: A meta-analysis of published results. *Am. J. Trop. Med. Hyg*. 1995, 52, 377-382.

Githinji, S.; Herbst, S.; Kistemann, T.; Noor, A. M. Mosquito nets in a rural area of Western Kenya: ownership, use and quality. *Malar. J.* 2010, 9, 250.

Harrison, B. A. Medical Entomology Studies: XIII. The Myzomyia series of Anopheles (Cellia) in Thailand, with emphasis on intra-interspecific variation (Diptera: Culicdae). *Am. Entomology Inst*. 1980, 17:1-195.

Health in Myanmar. Annual Report. *Health in Myanmar* 2019.

Htay, Aung.; Sein Minn.; Sein Thaung.; Maung Maung Mya.; Sein Maung Than.; Thaung Hlaing Soe Soe.; Druilhe Quecuche, P. Well breeding *Anopheles dirus* and their role in malaria transmission in Myanmar. *South east Asian J. Trop Med Pub Health*. 1999, 30, 447-453.

Jambulingam, P.; Mohapatra, S. S. S.; Govardhini, P. Micro-level epi- Micro-level epidemiological variations in malaria and its implications on control strategy. *Ind. J. Med. Res.* 1991, 93: 371-378.

Jia-Yun Pan.; Shui-Sen Zhou.; Xiang Zheng.; Fang Huang.; Duo-Quan Wang.; Yu-Zu Shen.; Yun-Pu Su.; Guang-Chao Zhou.; Feng Liu.; Jing-Jing, Jiang. Vector capacity of *Anopheles sinensis* in malaria outbreak areas of central China. *Para. & Vec.* 2012, 5, 136-143.

Khin Maung, Kyi. Malaria vectors in Burma *Anopheles balabacensis balabacensis* Baisas, 1936. *Union Bur J. Life Sci.* 1970, 3, 217-225.

Kilian, A.; Koenker, H.; Baba, E.; Onyefunafoa, E. O.; Selby, R. A.; Lokko, K. Universal coverage with insecticide-treated nets applying the revised indicators for ownership and use to the Nigeria 2010 malaria indicator survey data. *Malar J.* 2013, 12, 314.

Kroeger, A.; Meyer, R.; Mancheno, M.; Gonzalez, M.; Pesse, K. 1997. Operational aspects of bednet impregnation for community-based malaria control in Nicaragua, Ecuador, Peru and Colombia. *Trop Med Int Health*. 1997, 2, 589-602.

Lengeler, C. Insecticide-treated bed nets and curtains for preventing malaria. *Cochrane Database Syst. Rev*. 2004, 2, CD000363.

Maung Maung Mya.; Saxena, R. K. and Paing Soe. Study of malaria in a village of lower Myanmar. *Ind. J. Mal*.2002, 39(3-4), 96-102.

Maung Maung Mya.; Myat Phone Kyaw.; Tin Oo.; Phyo Zaw Aung.; Aung Kyaw kyaw.; Thu Yan.; Thaung Hlaing. Deltamethrin treated clothes for personal protection on malaria among temporary migrant workers in rubber plantation, Mon State, Myanmar. *Myan. Helth. Sci. Res. J.* 2014, 26(1), 64-72.

Maung Maung, Mya.; Myat Phone, Kyaw.; Sein, Thaung.; Tin Tin, Aung.; Yan Naung Maung, Maung. Occurrence of *Anopheles* mosquitoes, potential vector, sibling species and susceptibility in malaria endemic areas of Kamamaung Township, Kayin State. *Myan. Helth. Sci. Res. J*. 2017, 29(2), 165-166.

Maung Maung, Mya.; Myat Phone, Kyaw.; Sein, Thaung.; Tin Tin, Aung.; Yan Naung Maung, Maung. Potential vectors of malaria in Kamamaung, Myanmar and their bionomic. *Ind. J. Ento.* 2018, 80(4), 1-8. DOI: 10.5958/0974-8172.00245.6.

Maung Maung, Mya.; Phyo Wai, Win.; Aye Mya, Thandar.; Maung Maung, Gyi.; Myint

Zu, Min.; Yan Naung, Maung. Breeding habit and habitat of *Anopheles* mosquitoes in forest frinch and plain areas in Myanmar. *Inter. J. Edu. Res. and Stu*. 2019, 1(1), 30-37.

Maung Maung, Mya.; Sein, Thaung.; Yee Yee, Myint.; Thu Zar Nyein, Mu.; Yan Naung, Maung.; Moh Moh, Tun.; Khin Saw, Aye.; Kyaw Zin, Thant. Bio-efficacy of Long Lasting Insecticidal Mosquito Nets (LLINs) on Malaria Vector Anopheles Mosquitoes in Malaria-Endemic Areas of Myanmar. *J. Biol. Eng. Res. and Rev*. 2019, 6(1), 21-28.

Maung Maung, Mya.; Sein, Thaung.; Nyan, Sint.; Yee Yee, Myint.; Sai Zaw Min, Oo.; Pae Phyo, Kyaw.; Di Lone.; Yan Naung Maung, Maung. Vector bionomics, potential vectors and insecticide efficacy in malaria endemic areas, Ye Township, Mon State Myanmar. *Sci. Res. J. (SCIRJ).* 2020a, 8(7),31- 43.

Maung Maung, Mya.; Sein, Thaung.; Yee Yee, Myint.; Thu Zar Nyein, Mu.; Chit Thet, New.; Zar Zar, Aung.; Sai Zaw Min, Oo.; Yan Naung Maung, Maung.; Moh Moh Tun. Innovative personal protection of malaria vector *Anopheles* mosquitoes in malaria endemic areas of Myanmar. 2020b; *48th Myan. Helth. Res. Cong.* (13.01.2020- 17.01.2020) P 61.

MOHS, Malaria report. *Ministry of Health and Sports* 2018.

Myat-Phone-Kyaw.; Myint-Oo.; Myint-Lwin.; Thaw-Zin.; Kyin-Hla-Aye.; New-New-Yin. 1993. Emergence of chloroquine-resistant Plasmodium vivax in Myanmar (Burma). *Trans. R. Soc. Trop. Med. Hyg*.1993, 87, 687.

Myint, Oo.; Than, Swe.; Ye, Htut.; Tin, Shwe.; Nyunt, Win.; Aung, Khin.; Khin Hla, Aye.; Thi The, Aye. The changing incidence of *Plasmodium vivax* infection in subjects with malaria. *Myan. Helth. Sci. Res. J.* 1999, 1, 61-63.

Myo, Paing.; Thi Thi, Naing.; Sein, Min.; Zaw, Myint. *Anopheles* mosquitoes of Myanmar. III. *Anopheles (*Cellia) *philippinensis* Ludlow 1902 & *Anopheles*

(Cellia) *nivipes* Thebald 1903 in Myanmar and their differentiating characters. *Myan. Helth. Sci. Res. J.*1990b, 2, 32-38.

Pe Than, Tun.; Yan Naung Maung, Naing.; Sein, Min.; Sein, Thaung.; Sai Zaw Min, Oo.; Maung Maung, Mya. Vector surveillance and insecticide efficacy in malaria endemic areas. *Myan. Helth. Res. Cong*. 2013, 72-73.

Raid, J. A. Two Forms of *Anopheles philippinensis* malago. *J. Med. Entomol.* 1967, 4, 175-179.

Santos, J. B.; Dos Santos, F.; Macêdo, V. Variação da densidade anofélica com o uso de mosquiteiros impregnados com deltametrina em uma área endêmica de malária na Amazônia Brasileira. *Cad. Saude. Publica*. 1999, 15, 281–92.

Schellenberg, J. A.; Minja, H.; Mponda, H. L. Re-treatment of mosquito nets with insecticide. *Trans. R. Soc. Trop. Med. Hyg.* 2002, 96, 368-369.

Sharma, V.; P. Current scenario of malaria in India. *Parassitologia*. 1999, 41(1-3), 349-353.

Sousa, J. de. O.; Albuquerque B. C. de.; Coura J. R.; Suárez-Mutis M. C. Use and retention of long-lasting insecticidal nets (LLINs) in a malaria risk area in the Brazilian Amazon: a 5-year follow-up intervention. *Malar. J.* 2019, 18:(100), 1-9. https://doi.org/10.1186/s12936-019-2735-9.

Suárez-Mutis, M. C.; Fé, N. F.; Alecrim, W.; Coura, J. R. Night and crepuscular mosquitoes and risk of vector-borne diseases in areas of piassaba extraction in the middle Negro River basin, state of Amazonas, Brazil. *Mem. Inst. Oswaldo. Cruz.* 2009, 104, 11–7.

Tun Lin, W.; Myat Myat, Thu.; Sein Maung, Than.; Maung Maung, Mya. Hyper-endemic malaria in a forested hilly Myanmar village. *J. Ame. Mosq. Con. Asso*. 1995, 11(4), 401-407.

World Health Organization (WHO), Roll Back Malaria. Continuous long-lasting insecticidal net distributions: a guide to

concepts and planning. Geneva: *WHO*. 2011.

World Health Organization (WHO). Guidelines for laboratory and feld-testing of long-lasting insecticidal nets. Geneva: *WHO*. 2013.

World Health Organization (WHO). Vector resistance to pesticides: fifteenth Report of the WHO Expert Committee on Vector Biology and Control. *WHO. Tech. Rep. Ser*. 1992, 818.

World Health Organization (WHO). Manual on practical entomology in malaria part II. Geneva: *WHO,* 1975.

World Health Organization (WHO). World Malaria Report 2017. Geneva: *WHO*; 2017. 1–196 p.

Research Article

Open access

Contribution of Cocoa-Based Agroforest to Household Livelihood in Emure Local Government Area Ekiti State

Odiaka, I. E.; Kolade, D.; Adebisi-Fagbohungbe, T. A.; Ganiyu, O. A.; Abdulazeez F. I.; Haastrup, N. O.; Oladipupo-Alade, E. O.; Oyedele, M. D.

Forestry Research Institute of Nigeria, Jericho, Ibadan

ARTICLE INFOORMATION

ABSTRACT

This study assesses the contribution of cocoa-based agroforestry to household livelihood in Emure Local Government Area, Ekiti State. The study was carried out in six farm settlements that were purposively selected in the Local Government. One hundred and twenty pre-tested questionnaires were randomly administered to respondents for the collection of data in the study. The study revealed that 44.17% of the respondents are within the age bracket of 51-70 years while only 5.83% are above 70 years. The majority (41.67%) of respondents have primary education while only 10% are graduates of higher institutions. The result also revealed that 34.17% of respondents operate farm sizes of between 16-20 hectares of land followed by those with over 20 hectares of land (20.83 %). 76.67 % of respondents have farming experience of 11 years and above, while 70.73% of respondents acquired their land through inheritance. The result on agroforestry practices revealed that 29.34% of the respondents are involved in mixed cropping, perennial crop combination, and shifting cultivation respectively. Tree species retained by cocoa agroforestry farmers in the order of preference among others are *Terminalia superba* (6.76 %), *Glicidia sepium* (6.17%), *Milicia excelsa* (5.90%), *Terminalia ivorensis* (5.57%), and *Antiaris africana* (5.04%). While species such as *Mangifera indica*, *Cola nitida*, *Citrus* spp., *Elaeis guniness* and *Cola acuminate* are the fruit trees mostly planted or retained. Food crops mostly cultivated by the respondents are *Colocasia esculenta*, *Musa paradisiaca* and Musa spp. Natural products usually harvested in the cocoa plantation include among others *Archantina marginata*, *Agaricus* spp., *Thaumatococcus daniellii*, *Senecio biafrae* and *Aframomum melegueta*. The result also revealed that farmers retain trees on their farms for the following reasons; provision of shade, timber.

INTRODUCTION

Cocoa is an economic crop cultivated in the humid tropics of West Africa, Southeast Asia, South America, and the Caribbean. It is estimated that about 5-6 million smallholder farmers earn most or all of their cash income from cocoa production (Clay, 2004). In Ghana, the cocoa sub-sector accounts for over 20.5% of its export earnings, 3.3% of GDP, and employs 24% of labour force (FASDEP, 2002). It also serves as a major source of livelihoods to smallholder farmers and accounts for 55% of the total household income (IITA, 2002; Asamoah and Baah, 2003). The cocoa sub-sector in Nigeria has benefited immensely from the implementation of several Government policies over the years in an effort to increase production.

Cocoa-based agroforestry system (CAFS) ranks high as a viable way of diversifying land use to improve smallholder farmers livelihoods and conservation of natural resources (Rice and Greenberg, 2000; Duguma et al., 2001; Leakey and Tchoundjeu, 2001; Schroth et al., 2004; Franzen and Borgerhoff, 2007; Smith and Martino, 2007). Cocoa-based agroforestry system contributes to the self-sufficiency of smallholder families through a diversified production of food and cash crops thereby reducing financial and commercialization risk (Ramirez Leakey *et al.*, 2005; Degrande et al., 2006; Steffan-Dewenter *et al.*, 2007).

The adoption of environmentally sound and suitable cocoa production through cocoa agroforestry system has been suggested as a useful technology to improve crop yield in many cocoa-producing countries where marginal lands are increasingly been brought under cultivation (Asare, 2005; Boateng, 2008). The cocoa agroforestry system is the intercropping of cocoa trees with fruits, commercial timber, or fast-growing and high-value timber trees (Duguma et al., 2001). Apart from the additional income to farmers through the sale of other products, cocoa agroforestry provides food, minimizes risk through diversification, and provides shade for cocoa plants (Duguma et al., 2001; Isaac et al., 2007).

Cocoa agroforestry is also regarded as environmentally preferable for biodiversity conservation to other forms of agricultural activities in tropical forest regions (Power and Flecker, 1998). Research conducted in Latin America indicates that the capacity of cocoa plantations to conserve birds, ants, and other wildlife is greater than in any other anthropogenic land-use system (Rice and Greenberg, 2000; Jimenez and Beer, 1999). In areas like Southwest Nigeria and Eastern Brazil, cocoa agroforests are credited with conservation of the biological diversity of the humid forest zone (Ruf and Schroth, 2004) and the Atlantic forest (Rolim and Chiarello, 2004), compared to farming activities that produce food crops like maize and cereals. In Ghana, Conservation International has had success in using cocoa agroforests as a buffer zone around protected areas (The Kakum National Park Project) in the central region to reduce forest encroachment. Also, in Western Nigeria farmers have been able to increase the diversity of forest trees in cocoa farms by retaining economically valuable timber species such as *Milicia excelsa*, *Triplochiton scleroxylon,* and *Terminalia superba.*

It is important to recognize, however, that even though research suggests that cocoa agroforest is generally environmentally friendly compared to other forms of agriculture, cocoa agroforest does not equate with primary forests (Donald, 2004). According to Rolim and Chiarello (2004), cocoa agroforestry not only supports relatively lower species richness but also impairs natural species succession and gap dynamics compared to floristically and climatically similar sites of secondary or primary rain forest in Nigeria and as a result, tree species of late successions are becoming

rare while pioneer and early secondary species are becoming dominant. This shift in succession pattern is attributed to management practices, which involve the clearing of undergrowth twice a year that eliminates most regeneration, except in a few trees which escape cutting or are deliberately spared.

Acknowledging these limitations, however, does not change the fact that the cocoa agroforestry system provides a real opportunity, compared to other agricultural systems, to conserve biodiversity by providing niches for a variety of faunal and floral species (Noble and Dirzo, 1999; Rolim and Chiarello, 2004). Beyond simple conservation, cocoa agroforest may have positive environmental effects in landscapes already impoverished by human disturbances (Estrada et al., 1997; Reitsma et al., 2001).

In spite of the purported potentials and abilities of the cocoa-based agroforestry system and the various recommendations from researchers and development agencies, there have been a few attempts to use cocoa agroforest on a large scale as a conservation instrument in tropical countries (Parrishe et al., 1998). Furthermore, up to date, there is limited information on biological diversity in cocoa-based agroforestry ecology (Greenberg et al., 2000). More so it has been argued that there is only a limited amount of work that upholds the notion that cocoa farms with diverse shade canopies support greater biodiversity, especially of forest-dependent organisms as compared to other cash crop systems in the low-land tropics (Rice and Greenberg, 2000).

The general objective of this study is to access the contribution of cocoa-based agroforestry to the household livelihood in Emure local government in Ekiti State.

METHODOLOGY

Study Area

The study area (Emure Local Government area) is a municipal local government area that comprises, Emure–EkitiTownship surrounded by some farm settlements. It is located in the southern part of Ekiti State, Southwest Nigeria. Emure-Ekiti is located between longitude 5º 46' east and latitude7º 44' north. It comprises a total population of 90,645 inhabitants. The estimated terrain elevation above sea level is 378 meters. The rainy season normally starts from late March through October with occasional strong wind and thunderstorms, usually at the onset and the end of the rainy season. The annual rainfall ranges from 1,200mm to 1,500mm. Temperature ranges from 21 ^{0}C to 31 ^{0}C with little variation throughout the year.

Data collection

This experiment was carried out in Emure local government. Six farm settlements were purposively selected. In each of the settlements, cocoa plantation farms were visited where a pre-tested questionnaire containing both structured and unstructured questions was administered. The questionnaire which sought questions on social-economic characteristics of the respondents, agroforestry practices, and contribution to respondents' household livelihood, were administered to twenty (20) randomly selected cocoa agroforestry farmers in each of the settlements visited. The administration of the questionnaire was by personal interview. This method affords the researcher to retrieve the entire questionnaire for analysis. Since the interview was done right on the farm, the researcher's observation was used to deduce the applicable answer to a question like the distance of the village to the farm.

Table 1. Distribution of respondents in the study area.

Farm settlements	No. of respondents
Oge	20
Ajebamidele	20
Akeye	20
Owode	20
Eporo	20
Sasaye	20
Total 6	**120**

RESULTS

Socio-economic characteristics of the respondents

The distribution of respondents by age shows that 44.17% of the respondents are within the age bracket of 51-70 years while only 5.83 % are above 70 years (Table 2). The result on age revealed that 66.67%are male while 33.33 % are female. The result on educational background revealed that the majority (41.67%) of respondents have primary education while only 10% are graduates of higher institutions. The result on family size shows that 33.33% of respondents have a household size of 6-10 members while 12.5% of respondent's have a household size of more than 20 members.

Table 2. Distribution of respondents by socio-economic characteristics.

Age	Frequency	Percentage
<30 years	17	14.17
31-50 years	43	35.83
51-70 years	53	44.17
>70 years	7	5.83
Sex		
Male	80	66.67
Female	40	33.33
Educational background		
No formal education	23	19.16
Primary	50	41.67
Secondary	35	29.17
Tertiary	12	10.00
Household size		
1-5	30	25.00
6-10	40	33.33
11-15	35	29.17
>20	15	12.5
Total	**120**	**100**

Source: field work (2018)

To cite this article: Odiaka, I. E.; Kolade, D.; Adebisi-Fagbohungbe., T. A.; Ganiyu, O. A.; Abdulazeez, F. I.,; Haastrup, N. O.; Oladipupo-Alade, E. O.; Oyedele, M. D. Contribution of Cocoa-Based Agroforest to Household Livelihood in Emure Local Government Area Ekiti State. *J. Agric. For. Res.* 2021, 1 (2), 40-52.

Respondents farming practices

Results in Table 3 revealed that 34.17% of respondents operate farm sizes of between 16-20 hectares of land followed by those with over 20 hectares of land (20.83 %). Table 4 shows that 76.67 % of respondents have farming experience of 11 years and above. While table 5 revealed that 70.73% of respondents acquired their land through inheritance. The result in table 6 revealed that self and family members accounted for 31.83% of respondents 'sources of labour while 14.32% are through group labour.

Table 3. Distribution of respondents by farm size.

Farm size	Frequency	Percentage (%)
<1-5 hectares	9	7.50
6-10 hectares	21	17.50
11-15 hectares	24	20.00
16-20 hectares	41	34.17
>20 hectares	25	20.83
Total	**120**	**100**

Source: Fieldwork (2018)

Table 4. Distribution of respondents by farming experience

Farming experience	Frequency	Percentage (%)
1-5 years	10	8.33
6-10 years	18	15.00
11-15 years	44	36.67
>15 years	48	40.00
Total	**120**	**100**

Source: Fieldwork (2018)

Table 5. Distribution of respondents by land ownership

Land ownership	Frequency	Percentage (%)
Inheritance	116	70.73
Gift	15	9.15
Leasehold	5	3.05
Purchase	28	17.07
Total	**164***	**100**

Source: Fieldwork (2018)
*Multiple responses

Table 6. Distribution of respondents by sources of labour.

Sources of labour	Frequency	Percentage (%)
Self	120	31.83
Family member	120	31.83
Hired labour	83	22.02
Group labour	54	14.32
Total	**377***	**100**

Source: Fieldwork (2018) *Multiple responses

Agroforestry practices in the study area

The result in Table 7 shows that 29.34% of the respondents are involved in mixed cropping, perennial crop combination, and shifting cultivation while 11.98% of respondents are involved in mono-cropping. The result on tree species retained (Table 8) shows that *Terminalia superba* has the highest frequency (6.76 %) followed by *Glicidia sepium* (6.17 %), *Milicia excelsa* (5.90%), *Terminalia ivorensis* (5.57 %) and *Antiaris africana* (5.04 %) respectively. While the least tree species retained by the respondent's is *Ceiba petandra* with 1.33 %. The result in Table 9 revealed that species such as *Mangifera indica*, *Cola nitida, Citrus* spp., *Elaeis guniness,* and *Cola acuminate* are the fruit trees mostly planted or retained by respondents in the study area.

The result on food crops planted by the respondents in Table 10 shows that *Colocasia esculenta, Musa paradisiaca,* and *Musa* spp. with 15 % each are the crops mostly cultivated by the respondents these were followed by *Ananas comosus* and *Diascorea cayenensis* with 14.38 % and 12.75 % respectively. Table 11 shows other natural products harvested by the respondents in the cocoa plantation. These products include among others *Archantina marginata*, *Agaricus* spp., *Thaumatococcus daniellii, Senecio biafrae,* and *Aframomum melegueta.* Table 12 shows the reason why the respondent's plant /retain trees in their cocoa plantation. The result revealed that provision of shade has the highest value (15.38 %) followed by timber production (14.87 %), firewood (11.92 %), and fruit production (10.77 %) respectively.

Table 7. Distribution of respondents by the farming system

Farming system	Frequency	Percentage (%)
Mono-cropping	49	11.98
mixed-cropping	120	29.34
Perennial crop-combination	120	29.34
Shifting cultivation	120	29.34
Total	**409***	**100**

Source: Fieldwork (2018)
*Multiple responses

Table 8. Distribution of respondents by trees species retained

Local name	Scientific name	Frequency	Percentage (%)
Isin	Bligha sapida	40	2.65
Iroko	*Milicia excels*	89	5.90
Araba	*Ceiba petandra*	20	1.33
Agbalumo	*Chrysophllum albidum*	25	1.66
Oganwo	*Khaya* spp.	42	2.78
Arere	*Triplochyton schleroxylon*	68	4.51
Igba/Iru	*Parkia biglobosa*	30	1.98
Agunmaniye	*Glicidia sepium*	93	6.17
Ahun	*Alstonia boonei*	35	2.32
Omo	*Cordia milleni*	47	3.12
Afara	*Terminalia superba*	102	6.76
Idi	*Terminalia ivorensis*	84	5.57

Oriro	*Antiaris africana*	76	5.04
Osun	*Pterocarpus osun*	22	1.46
Ira	*Bridelia ferruginea*	31	2.05
Oporoporo	*Pterygota macrocarpa*	58	3.84
Oriri	*Vitex doniana*	13	0.01
Epin	*Ficus exasperate*	44	2.91
Elemi	*Dacryodes* edulis	23	1.52
Akomu	*Pycnanthus africana*	58	3.84
Agbonyin	*Piptadenastrum africanum*	61	4.05
Ofun	*Mansonia altissima*	66	4.37
Opepe	*Nauclea diderrichii*	28	1.86
Iyeye	*Spondias mombin*	53	3.51
Iya	*Daniella oliveri*	62	4.11
Awewe	*Margaritaria discoideus*	22	1.46
Ayere	*Albizia glaberrima*	47	3.12
Ijebo	*Entandrophragma utile*	68	4.51
Ita	*Celtiss zenkeri*	60	3.97
Ito	*Landolphia* spp.	41	2.72
Total		**1,508***	**100**

Sources: Fieldwork (2018)

*Multiple responses

Table 9. Distribution of respondents by fruit trees planted/retained in the plantation

Local name	Scientific name	Frequency	Percentage (%)
Mango	*Mangifera indica*	120	12.83
Obi gbanja	*Cola nitida*	120	12.83
Oro	*Irvingia garbonensis*	36	3.85
Agbalumo	*Chrysophllum albidum*	73	7.81
Orogbo	*Garcinia kola*	46	4.92
Osan	*Citrus* spp.	120	12.83
Kaju	*Anacardium occidentalis*	114	12.19
Ope	*Elaeis guinensis*	120	12.83
Obi abata	*Cola acuminate*	120	12.83
Awusa	*Plukenetia conophorum*	66	7.02
Total		**935***	**100**

Sources: Fieldwork (2018)

*Multiple responses

Table 10. Distribution of respondents by food crops planted in cocoa plantation

Local name	Scientific name	Frequency	Percentage (%)
Isu (Alo)	*Diascorea cayenensis*	102	12.75
Ege	*Manihot esculenta*	85	10.63
Koko	*Colocasia esculenta*	120	15.00
Ata	*Capsicum* spp.	68	8.50
Opeoyinbo	*Ananas comosus*	115	14.38

Ogedewewe	*Musa* spp.	120	15.00
Ogedeagbagba	*Musa paradisiaca*	120	15.00
Ibepe	*Carica papaya*	85	10.63
Anomo	*Ipomoea batatas*	53	6.63
Total		**800***	**100**

Source: Fieldwork (2018)

*Multiple responses

Table11. Natural products in cocoa-agroforest and their uses

Local name	Scientific name	Uses/Benefits
Igbin	*Archantina marginata*	Meat, income, medicinal
Osu/Olu	*Agaricus* spp.	Spices, income
Oyin	*Apis mellifera*	Sweetener, income, medicinal
Etu	*Sylvicarpra graminia*	Meat, income
Iyere	*Piper guineense*	Spice, income, medicinal
Ewuro	*Vernonia amygdalina*	Vegetable, medicinal
Eriru	*Xylopia aethiopica*	Medicinal, income
Atale	*Zinginber officinale*	Medicinal, income, cultural
Rorowo	*Senecio biafrae*	Vegetable, medicinal, income
Ewe iran	*Thaumatococcus daniellii*	Wrapping, income, Roofing
Arindan	*Tetrapleurate traptera*	Medicinal, cultural, income
Atare	*Aframomum melegueta*	Medicinal, cultural, income, spice
Ario	*Monodora myristica*	Income, medicinal

Source: Fieldwork (2018)

Table 12. Respondents' reason for planting /retaining tree in the cocoa plantation.

Reasons	Frequency	Percentage (%)
Fruit production	84	10.77
Shading	120	15.38
Soil fertility	75	9.62
Medicinal uses	67	8.59
Timber production	116	14.87
Fire wood	93	11.92
Wind control	48	6.15
Boundary demarcation	56	7.18
Staking/support	45	5.77
Biodiversity conservation	32	4.10
Erosion control	44	5.64
Total	**780***	**100**

Source: Fieldwork (2018)

*Multiple responses

Contribution of cocoa agroforest to household livelihood

The result on the average annual income from cocoa agroforest farm (Table 13) shows that 45 % of the respondents generate over ₦1,000,000 annually while 32 % made ₦501,000 - ₦1,000,000. Only about 4.17 % of the respondents made less than ₦100,000 per annum. The result in Table14 shows that income generation is the greatest benefit of

cocoa agroforest to the respondents with 29.27 % followed by the provision of food (25.61 %), the economy of labour (23.41 %), and insurance against crop failure (21.71 %) respectively.

Table 13. Distribution of respondents by average annual income from cocoa agroforest

Average annual income (₦)	Frequency	Percentage (%)
<100,000	5	4.17
100,000-250,000	12	10.00
251,000-500,000	17	14.16
501,000-1,000,000	32	26.67
>1,000,000	54	45.00
Total	**120**	**100**

Source: Fieldwork (2018)

Table 14. Benefits of cocoa-agroforest to respondents

Benefits	Frequency	Percentage (%)
Economy of labour	96	23.41
Insurance against crop failure	89	21.71
Income generation	120	29.27
Provision of food	105	25.61
Total	**410***	**100**

Source: Fieldwork (2018)
*Multiple responses

DISCUSSION

Results from this study revealed that thirty (30) different tree species were either planted or retained by farmers in their cocoa plantations in the study area. Some of the tree species retained or planted in order of preference include *Terminalia superba, Glicidia sepium*, *Milicia excelsa*, *Terminalia ivorensis* and *Antiaris africana*. The high number of trees retained by farmer's shows that they acknowledge the importance of trees to their livelihood. Observation from this study revealed that trees are planted or retained for different purposes Some of the reasons mentioned by farmers for retaining these trees include the provision of shade, provision of food (fruit), boundary demarcation, firewood, and income generation among others. The provision of goods and services observed in this study is in agreement with the submission of ICRAF (1997) who reported that trees were cherished for their social, economic, and environmental benefit. *Giliricidia sepium* is particularly planted for staking and later serve as a shade tree for protecting the young cocoa tree from excessive heat. Also, trees like Terminalia and Milicia are retained for timber production to generate income when sawn into the log. This observation further proves that cocoa agroforestry is a system that gives room for the diversification of products from a piece of land. This assertion agrees with the submission of Cerda et al., 2014 that cocoa agroforest plantation is a dependable source of timber production in Central America.

Agroforestry practices in the study area

Results obtained in this study revealed that mixed cropping, perennial crop combination, and shifting cultivation are the dominant farming practices in the study area. This farming practice allows the integration of both crops and trees simultaneously on the same piece of land. Under this system, farmers plant various kinds of crops on the same piece of land to provide a wide range of products for their immediate household needs (Olujobi and Oke, 2005). The preponderance of these farming systems indicates that farmers in the study area have long been involved in agroforestry practice whereby farmers intercropped both tree crops with other crops. This was evident in the types of fruit tree crops such as *Mangifera indica, Cola nitida, Citrus* spp., *Elaeis guniness,* and *Cola acuminata* that were intercropped with food crops like *Colocasia esculenta, Musa paradisiaca, Ananas comosus,* and *Diascorea cayenensis.* The cultivation of these sets of crops by farmers in their cocoa plantations has given rise to an agroforestry practice known as perennial tree/crop combination which is another form of simultaneous agroforestry.

Contributions to household livelihood in the study area

The result on the average annual income from cocoa agroforestry farms revealed that the majority of the respondents generate over ₦ 1,000,000 annually. The result from this study revealed that money generated from cocoa agroforestry farms has contributed immensely to household livelihood in terms of income generation. Other benefits derived by farmers from their cocoa agroforestry farm are the provision of food, insurance against crop failure, and economy of labour. The contributions of cocoa agroforestry to household livelihood and its environmental benefit cannot be over-emphasized especially in the area of food security. Households with poor food access and or poor food utilization tend to suffer more illness or other physical debilitations thereby impairing their productivity. Food production constitutes one of the most basic livelihood activities and can be a critical situation especially in rural households (Woller, 2018). Other natural products such as *Archantina marginata, Agaricus* spp., *Thaumatococcus daniellii, Senecio biafrae,* and *Aframomum melegueta* harvested by the respondents in the cocoa plantation ensure regular supplies of the household needs of the agroforestry farmers in and out of cocoa season (Edusah, 2011).

CONCLUSION

The study revealed that the majority of the respondents in the study area are full-time farmers who operate on a large scale with a long year of farming experience. The study has also revealed that mixed-cropping, shifting cultivation and perennial crop-combination are the major agroforestry systems practiced by farmers in the study area. Moreover, it has been revealed that the cocoa agroforestry system has greatly benefited the farmers in terms of a wide range of products derived from the system. The study also revealed that the system has contributed greatly to the socio-economic wellbeing of the people in terms of income generation, provision of food, insurance against crop failure, and biodiversity conservation.

Consequent to the results in the study it is recommended that since farmers in the study area are already aware of the benefits derived from cocoa-based agroforestry, Government should encourage the farmers by giving them incentives in form of loans and farm input.

REFERENCES

Asare, R. Cocoa Agroforest in West Africa: A look at activities on preferred trees in the

farming systems. Danish centre for forest, landscape, and planning. 2005, 77pp.

Asamoah, M.; Baah, F. Improving research-farmers Linkage: The roles of CRIG. Conferences paper (4th international seminal on cocoa-pest and diseases) (INCOPED), Accra, Ghana.19th– 21st October 2003.

Bailis, R.; Ezzati, M.; Kammen, D.M. Mortality and greenhouse gas impacts of biomass and petroleum energy future in Africa. *Science.* 2005, 308, 98-103.

Boateng, I. Impact of agroforestry on livelihoods: A case study of a selected community of OFFINSO, Afigyasekyere and Atiwa Districts. Kwama Nkrumah University of Sciences and Technology, Department of Agroforestry. 2008, 15-17 pp.

Brouwer, I. D.; Hoorweg, J. C.; Ivan Liera, M. J. When households run out of fuel: responses of rural households to decreasing fuelwood availability, Ntcheu District, Malawi. *World Development.* 1997, 25, 255-266.

Clay, J. World Agricultural and the Environment. Island Press, Washington. 2004.

Clement, C. R. Fruits: In GT France, M Nesbitt (eds.) The cultural history of plants. London Routledge. 2004, 77-95 pp.

Conklin, H. C. Hanunoo Agriculture, Rome Italy. Food and Agriculture Organisation. 1957.

Degrande, A.; Schreckenberg, K.; Mbosso, C. H.; Anegbeh, P.; Okafor, V.; Kanmegne, J. Farmers fruit tree-growing strategies in the humid forest zone of Cameroon and Nigeria. *Agroforestry system. 2006*, 67, 159-175.

Donald, P. F. Biodiversity impact of some agricultural production systems. *Conservation Biology*. 2004, 18, 17-37.

Duguma, B.; Gockowski, J.; Bakala, J. Smaller Cacao (*Theobroma Cacao* Linn) cultivation in agroforestry systems of West and Central Africa: Challenges and opportunities. *Agroforestry systems*. 2001, 51:117-118.

Edusah, S. E. The impact of forest reserve on livelihoods of fringe communities in Ghana. *Journal of Sciences and Technology* 2011. 31 (1), 10-22.

Estrada, A.; Coates-Estrada, R.; Meritt, D. A. Anthropogenic landscape changes and avian diversity at Los Tuxtlas, Mexico. *Biodiversity and Conservation*. 1997, 6, 19-43.

FAO. The state of food and agroforestry. Biofuels: prospects, risk and opportunities. Rome. 2008.

FAO. Global forest resources assessment. FAO Forestry Paper assessment. Rome 2011, 163 pp.

Food and agricultural sector development policy. Ministry of food and Agriculture, Government of Ghana, Accra. 2002, 57 pp.

Faye, M. D.; Weber, J. C.; Abasse, T. A.; Boureima, M.; Larwanou, M.; Bationo, A. B. Farmer's preferences for tree functions and species in the West. *African Sahel. Forests, Trees and Livelihood*. 2011, 20, 113-136.

Franzen, M.; Borgerhoff, M. Ecological economic and social perspectives on cocoa production worldwide. *Biodiversity Conservation*. 2007, 16, 3835-3849.

Frison, E. A.; Cherfas, J.; Hodgkin, T. Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. *Sustainability*. 2011, 3, 238-253.

Garrity, D. P. Agroforestry and achievement of the Millennium Development Goals. *Agroforestry systems*. 2004, 61, 5-17.

Garibaldi, L. A.; Steffan-Dewenter, I.; Winfree, R.; Aizen, M. A.; Bommarco, R.; Cunninghan, S. A. Wild pollinators enhance fruit set of crops regardless of honey bee abundances. *Sciences*. 2013, 339, 1608-1611.

Greenberg, R.; Bichier, P.; Cruz Angon, A. The conservation valve of birds of cacao plantations with diverse planted shade in

Tabasco, Mexcico. *Animal Conservation*. 2011, 3, 105-112.

Hagen, M.; Kraemer, M. Agriculture surrounding support flower-visitor networks in an Afrotropical rainforest. *Biological Conservation*. 2010, 143, 1654-1663.

Hailey, L. An African Survey. Oxford University Press, UK. 1957, 10-14 pp.

International Institute of Tropical Agriculture. Summary of findings from the child labor surveys in the cocoa sector of West Africa: Cameroon Cote d'ivoire, Ghana, and Nigeria. 2002

International Centre for Research in Agroforestry (ICRAF) Medium Term Plan 1998-2001, 1-5 pp.

Isaac, M.; Timber, V.; Quashie-Sam, S. Shade tree effects in an 8-year-old cocoa agroforestry system: biomass and nutrients diagnosis of Theobroma Cacao by vector analysis' nutrient cycling in an agroecosystem. *Ecosystem*. 2007, 78, 155-165.

Jamanadass, R. H.; Dawson, I. K.; Franzel, S.; Leakey, R. R. B.; Mithofer, D.; Akinnifesi, F. K.; Tchoundjeu, Z. Improving livelihoods and nutrition in sub-Saharan Africa through the promotion of indigenous and exotic fruit production in smallholder's agroforestry systems: *A review*. 2011, 13, 338-354.

Jimenez, F.; Beer, J. Multistrata Agroforestry systems with perennial crops proceeding of the international symposium on Multi-strata Agroforestry Systems with perennial crops, 22-27 Feb. Turrialba, Costa Rica. 1999.

Kings, K. F. S. The history of Agroforesry. *In*: Steppler, H. A. and P.K.R (Eds.) Agroforestry a Decade Decade of Development, Nairobi, Kenya. 1987. 1-11 pp.

Kristjanson, P.; Neufeldt, H.; Gassner, A.; Mango, J.; Kyazze, F. B.; Destas, A. Are food insecure smallholder households making changes in the farming practices? Evidence

for East Africa. *Food Security*. 2012, 4, 381-397.

Klein, A. M.; Vaisslere, B. E.; Cane, J. H.; Steffan-Dewenter, I.; Cunningham, S. A.; Krene, C. Importance of pollinators in changing landscapes for the world crops. Proceeding of the Royal Society of London 2007, Series B 274:303-313.

Leakey, R. R. B.; Tchoundjeu, Z. Diversification of trees crops: domestication of companion crops for poverty reduction and environmental services. *Expl Agric*. 2001, 37, 279-278.

Leakey, R. R. B. Agroforestry: a delivery mechanism for multi-functional agriculture. In: LR Kellimore, ed. Handbook on agroforestry: management practices and environmental impact. Environmental sciences, Engineering and Technology series. Nova science Publishers. 2010, 461-471 pp.

Malezieux, E. Editorial. Underutilized fruit trees in Africa Special Issue. Revne fruits. 2013.

Nair, P.R.K. An Introduction to Agroforestry. The Netherlandfs, Klewer Academic Publishers 1993, 499 pp.

Nair, P.K.R. Intensive multiple Cropping with coconut in India, Berlin, Germany. Verlagpaul parley. 1979.

Noble, I. R. Dirzo, R. Forests as human ecosystems. *Science*. 1999, 277, 522-525.

Ojo, G. J. A. Yoruba Culture London, UK, University of Ife and London press 1966, 7-10 pp.

Olujobi, O. J. Oke, D. O. Assessment of existing agroforestry practices in Ondo State. Nigeria. In: L. Popoola, P. Mfon and P.I. Oni (eds). Proceeding of the 30th Annual Conferences of the Forestry Association of Nigeria, held in Kaduna, Kaduna State.Nigeria. 07th-11th November 2005, 110-118.

Parrish, J.; Reitsma, R.; Greenberg, R. Cacao as crop and conservation tools. Paper from the workshop on Shade Grown Cocoa held in Panama, 3/30-4/2, 1998.

Power, A. G.; Flecker.; Ander. S. Agroecosystem and biodiversity. Paper from a workshop held in Panama, 3/30-4/2, 1998, Smithsonian Institution. Washington, DC.

Reitsma, R.; Parrish, J. D.; Mc Larney, W. The roles of cacao plantations in maintaining forest avian diversity in southeastern Costa Rica. *Agroforestry systems* 2001, 53, 185-193.

Rice, R. A.; Greenberg, R. Cacao cultivation of biological diversity. *Ambio* 2000, 29, 81-87 pp.

Rolim, S. G.; Chiarello, A. G. Slow death of Atlantic forest in cocoa agroforest in southeastern Brazil. *Biodiversity and Conservation*. *2004,* 13, 2679-2694.

Roshetko, J. M.; Lasco, R. D. Delos Angeles M.S. Smallholder agroforestry systems for carbon storage. Mitigation and Adaptation Strategies for Global Change 2007a, 12, 219-242.

Ruf, F.; Schroth, G. Agroforestry and biodiversity conservation in a tropical landscape. Island Press, Washington DC 2004, 523 pp.

Schroth, G.; Gustavo, A. B.; da Fonseca, C. A.; Havey, C.; Gascon, H. L.; Vasconcelos, A.; Lzac, M. N. (eds.). Agroforestry and biodiversity conservation in a tropical landscape. Island Press, Washington DC 2004, 523 pp.

Smith, P.; Martino, D. Agriculture in climate change. Fourth IFCC Agricultural Report, IFCC Geneva. 2007, 50 pp.

Steffan-Dewenter, I.; Priess, J. A.; Mimler, M.; Klein, A. M.; Schwarze, S. Tscharntke, T. Linking Deforestation Scenarios to pollination services and economic returns in Coffe agroforestry systems. *Ecological Applications*. 2007, 17, 407-417.

Sunderland, T. C. H. Food security: Why is biodiversity important? *International Forestry Review*. 2011, 13, 265-274.

Thorlakson, T.; Neufeldt, H. Reducing subsistence farmer' vulnerability to climate change: Evaluating the potential contribution of agroforestry in western Kenya. *Agricultural and Food Security* 2012, 1:15. http://www.agriclture and food security.com/content/1/1/15.

Torquebiau, E. Man-made dipterocarp forest in Sumatra. *Agroforestry System*. *1984,* 2, 103-127.

World Bank. Wood-based biomass energy development for sub-Sahara Africa: issues and approach. Washington DC, 2011.

Wilken, G. C. Integrating forest and small scale farm system in Middle America. *Agroecosystem*. 1977, 3, 291-302.

Demonstration of Fungicides for Management of Faba Bean Gall (*Olipidium viciae* Kusano) Disease in North Shwa Zone of Central Ethiopia

Sisay Argaye; Belachew Bekele*

Ethiopian Institute of Agricultural Research, Holeta Agricultural Research Center, P.O.box 31, Holeta, Ethiopia

ARTICLE INFO

ABSTRACT

Faba bean (*Vicia faba* L.) is the most important legume crop in Ethiopia and the most single subsistence crop after the staple cereals. However, its production is hampered by various biotic, abiotic, and socio-economic factors. Among the biotic constraints, a newly emerging disease known as Faba bean gall (*Olpidium viciae*) has become a serious threat to faba bean production in the country. Thus, a field experiment was conducted to demonstrate effective fungicides to manage faba bean gall under natural infection. Two fungicides viz; Noble 25 WP and Ridomil 80 WP were demonstrated alongside the control plot. The result revealed that the use of Noble 25 WP and Ridomil 80 WP reduces fava bean gall explained by reducing AUDPC and percentage severity index (PSI) as well as higher yield. Noble 25 WP recorded the lowest faba bean gall PSI (15%) and AUDPC (855%/days). A higher yield of 58.04% Noble 25 WP and 18.43% Ridomil 80 WP sprayed plots were recorded compared to control. A marginal rate of return of 681.90% and 678.16% were obtained from plots sprayed with Nobble 25WP and Ridomil 80 WP fungicides. Thus, those fungicides will be used as a component in the integrated management of this disease.

INTRODUCTION

Faba bean (*Vicia faba* L.) is grown in many countries as a rain-fed and irrigated crop for human food and animal feed and plays important roles in the national economy and agricultural production in various ways. It is one of the most important pulse crops as it has high yield potential and protein-rich grains and hence serves as human consumption and animal feed. In many developing countries it is the major source of protein in their feeding culture. Likewise, in Ethiopia, faba bean is the leading protein source for the rural people and used to make various traditional dishes (Senayit and Asrat, 1994), which otherwise includes mainly

cereals or root crops. It also plays a fundamental role in sustaining agricultural production and productivity through nitrogen fixation and crop rotation (Torres et al., 2006, Braich et al., 2016).

Ethiopia is one of the largest faba bean producers ranked second after China. In highland areas of Ethiopia, faba bean is a major staple food crop among pulses and the most vital legume crop after the staple cereals (Teklay et al., 2018). It is a dominant legume crop in area coverage and production than the other pulses in the country (CSA, 2020). Despite the availability of high-yielding varieties, the average national yield of faba beans is 2.16 tonnes/ha (CSA, 2020). Its production and productivity are adversely affected by biotic factors (insect-pests, parasitic weeds, and mainly foliar diseases), abiotic factors (drought, heat, and acidity), and poor agronomic practices causing a steady reduction in many countries. Among the fungal diseases, chocolate spot (*Botrytis fabae*), root rots (*Fusarium* spp.), rust (*Uromyces viciae fabae*), downy mildew (*Peronospora viciae*), and Ascochyta blight (Ascochyta fabae) is the most destructive constraints to the crop (Beyene et al., 2016; Maalouf et al., 2019). Diseases are among the most important biotic factors, causing faba bean yield reduction. More than 17 pathogens have been reported so far on faba bean, from different parts of the country and the most important yield-limiting diseases are chocolate spot (*Botrytis fabae*), rust (*Uromyces vicia fabae*), black rot (*Fusarium solani*), ascochyta blight (*Ascochyta fabae*) and faba bean necrotic yellows virus (FBNYV) (Dereje and Tesfaye, 1994). Nowadays the crop is threatened by new gall-forming disease (*Olpidium* spp.) with typical symptoms of, green and sunken on the upper side of the leaf, bulged at the backside of the leaf and finally develops light brownish color lesion, chlorotic galls which progressively broaden to become uneven circular or elliptical spots (Endale et al., 2014) which is

causing yield losses as high as 100% (Chala et al., 2017). The pathogen is now becoming a priority biosecurity threat for the production of the crop in the country (Wulita et al., 2019). The disease was first recorded in Japan in 1912 as faba bean galls (*Olpidium viciae* Kusano), and also it is a key disease in the highlands of Songpan, Xiaojin, Maekang Sichuan Gansu, Tibet, and Shanxi provinces of China (Xing, 1984; Li-juan et al., 1993).

So far, little has been known about Faba bean galls management and only fungicidal management recommendations have been recommended for the growers. Spraying of Ridomil fungicide reduces the disease severity and gives better yields than other fungicides applied and control plots (Bitew et al., 2016). Applications of Bayleton 25 WP and Ridomil gold reduced disease severity and gave higher yields than control/unsprayed plots (Teklay et al., 2018). Thus, the objectives of this study were to demonstrate effective fungicides for the management of faba bean gall disease.

MATERIALS AND METHODS

This experiment was conducted at Degem (hot spot area for the disease) in the 2019 main cropping season. A local faba bean variety was used to execute the experiment and seed rate was applied as a recommendation in row planting. Two fungicides; Ridomil Gold and Noble 25 MZ were demonstrated. Plot sizes of 10m x 10m with a spacing of 1.5 m between plots were used. The foliar spray fungicides were applied three times using a knapsack sprayer starting from the first appearance (at the vegetative stage of the crop) of the disease and water was sprayed on control plots. Fungicides were applied as manufacturers' recommendations. Spraying was applied three times at the time of disease's appearance (seedling) and repeated two times before the start of the flowering and

podding stage. Date of seedling emergence and first date of bean
gall disease appearance was recorded. Also, disease severity, Plant height, Number of pods per plant, thousand seed weight, and seed yield (grain yield) were recorded.

Data collection

Disease severity: Disease severity was recorded on 20 randomly selected plants in the two central rows of each plot starting from the onset of the disease and repeated after every 10-day intervals. A 0-9 scale was used where 0 = no disease symptom observed, 1 = < 2% plant parts infected, 2 = 2 - 5% plant parts infected, 3 = 6 - 10% plant parts infected, 4 = 11 - 25% plant parts infected, 5 = 26 - 50% plant parts infected, 6 = 51 – 75% plant parts infected, 7 = 76 - 90% plant parts infected, 8 = 91 - 99% plant parts infected, 9 = 100% plant parts infected (Ding et al., 1993).

Disease severity scores were converted into a percentage severity index (PSI) for analysis (Wheeler, 1969).

$$PSI = \frac{Snr}{Npr\ x\ Msc} X100$$

Where Snr is the sum of numerical ratings, Npr is the number of plants rated, Msc is the maximum score of the scale. Means of the severity from each plot were used in data analysis.

The area under disease progress curve (AUDPC):

AUDPC was calculated for each plot using the formula of Shanner and Finney (1977) and expressed in %-dp $DPC = \sum_{i=1}^{n-1} 0.5(Xi + 1 + Xi)(ti + 1 - ti)$
Where Xi is the cumulative disease severity at the ith observation; the independent variable 'x' indicates the AUDPC level in percentage; t^i is the time (days after planting) at the ith observation and n is the total number of observations.

Crop Parameters

Plant height (cm): The height of the plant was measured from the ground to the tip of five randomly taken plants at maturity.
A number of pods per plant: The average number of pods per plant was determined from five randomly taken plants.
Hundred seed weight (g): The weight of 100 randomly taken seeds was recorded from each plot.
Total grain yield (t h^{-1}): The grain yield per plot was then converted into yield per hectare basis.
Percent relatve grain yield loss (RYL) was calculated as follows:

$$RYL\ (\%) = \frac{(Yp-Yt)}{Yp} x100)$$

Where, RYL = relative yield loss in percent, Yp = yield from the maximum protected plots and Yt = yield from other plots

Cost-Benefit Analysis

Prices of faba bean seed (Birr ton^{-1}) from a local market and total sales from one hectare were computed. Price of fungicides, labor costs for chemical application, and equipment were also recorded. Partial budgeting was used to assess the profitability of any new technologies to be imposed on the agricultural business (CIMMYT, 1988).
To measure the increase in net return associated with each additional unit of cost (marginal cost), the marginal rate of return (MRR) was calculated as:

$$MRR = \frac{\Delta NI}{\Delta IC}$$

Where, MRR is the marginal rate of returns, ΔNI – change in net income compared with control, and ΔIC – change in input cost compared with control.
The following points were considered during cost benefit analysis using a partial budget.

- Costs for all agronomic practices were uniform for all treatments within sites.
- Costs of labor and spray equipment were taken.

- Costs, returns and benefit were calculated per hectare basis.

RESULTS AND DISCUSSION

Disease severity: The newly emerged faba bean disease "faba bean gall" was first observed at the vegetative stage at cropping. At the initial assessment dates, fungicides sprayed and unsprayed plots didn't show variation from each other (Table 1). On the other hand, at the final disease assessment date, fungicide application plots showed high differences in disease severity. Throughout the season the highest disease severity was recorded from unsprayed control plots. Also, in the last disease recording date (64%) highest final percent severities were recorded from those plots (Table 1). In contrast, Noble 25 WP sprayed plots showed the lowest disease severity (15%) also Ridomil 80 WP sprayed plots recorded lower diseases severity (25%) than unsprayed plots. This finding coincides with the result of (Wulita et al., 2019); Alemu and Tadele (2017) who reported that foliar-applied fungicides reduced the severity of faba bean galls on faba beans compared to the unsprayed control plots. In general, fungicide application didn't completely control the development of newly emerged disease "faba bean gall" epidemics but reduced the disease's severity and the loss incurred by the pathogen.

The area under disease progress curve (AUDPC):

Both demonstrated fungicides showed the lowest AUDPC value than control plots. As control plots recorded the highest disease score throughout the season also, the highest (1955%) AUDPC value was recorded followed by (1380%) plots receiving Redomil 80 WP fungicide (Table 2). In contrast, Noble 25 WP sprayed plots recorded the lowest AUDPC (825%) value. Belachew et al., (2018) fungicides have been also recorded as highly effective in reducing the area under the disease progress curve of faba bean gall disease. Control plots recorded the highest disease score throughout the season with an AUDPC value of 1955%.

Plant height: Plant height was shown differences among the demonstrated fungicides and control treatments. The shortest (111.0) plant heights were obtained from the unsprayed control plots in the cropping season. On the other hand, the tallest (138.0) plant heights were obtained from plots sprayed with Noble 25 WP fungicide. This result is in line with the finding of DBARC (2015), which reported that faba bean gall diseases significantly reduced the height of the faba bean crop (Table 1).

Numbers of pod per plant: The number of pods per plant showed highly significant variations among the fungicides and the control. The lowest (20.00) and the highest (21.8) mean numbers of pod per plant were obtained from the unsprayed control plots and Ridomil 80 WP sprayed fungicides. Also, the same result, the highest numbers of pods per plant was recorded on Chlorothalonil and Redomoil sprayed plots (Bitew et al., 2016) (Table 1).

Grain yield and hundred seed weight: Both demonstrated fungicides were given better grain yield and hundred seed weight than unsprayed control plots (Table 1). Grain yield was significantly increased by fungicide sprays. The lowest (1.07 t. ha^{-1}) grain yield was recorded from unsprayed control plots, while the highest (2.55 t. ha^{-1}) yields were obtained from Noble 25 WP sprayed plots. Generally, both fungicide-treated plots gave a higher grain yield than the unsprayed control plot. Highest hundred seed weights of 46.8g followed by 43.0 g was obtained from Noble 25 WP and Ridomil 80 WP fungicides sprayed plots respectively, whereas, the lowest (37.1 g) were recorded from unsprayed control plots.

Table 1. Effect of fungicides on disease severity and yield and yield components of faba bean

Fungicides	Final DS (%)	PH (cm)	AUDPC%	Pod/plant	Yield ton ha^{-1}	HSW(g)
Noble 25 WP	15	138	825	20.2	2.55	46.8
Ridomil 80 WP	25	133	1380	21.8	2.08	43.0
Control	64	111	1955	20	1.07	37.1

Where,

DS: Disease Severity, PH: Plant Height, AUDPC: Area Under Disease Progress Curve, HSW: Hundred Seed Weight

Relative Yield Loss in Grain (RYL)

The untreated plot notably recorded the highest relative yield losses (58.04%) and hundred seed weight losses (20.73) (Table 2). On Ridomil 80 WP sprayed plots also recorded 18.43% relative yield loss and 8.12% hundred seed weight losses as compared to plots received Noble 25 WP fungicide as the order mentioned in 2019/20 cropping season.

Table 2. Effect of fungicide application on yield and hundred seed weight of faba bean

Fungicides	Yield ton ha^{-1}	RYL (%)	Hundred Seed Weight (g)	RHSWL (%)
Control	1.07	58.04	37.1	20.73
Ridomil 80 WP	2.08	18.43	43.0	8.12
Noble 25 WP	2.55	0.00	46.8	0.00

Where; RYL: Relative Yield Loss, RHSWL: Relative Hundred Seed Weight Loss

Cost-benefit Analysis

Results from the assessment of economic returns in this study indicated that fungicide application for faba bean gall disease management demonstration was profitable. Maximum of (ETB 21,826.02) followed by (ETB 18,030.64) net benefits were obtained from plots sprayed Noble 25 WP and Ridomil 80WP as compared to unsprayed control plots (ETB 9,892.69) in the 2019 cropping season (Table 3). Beyene and Abiro (2016) also reported application of bayleton and mancozeb fungicides against faba bean gall disease was more profitable than unsprayed control plots. Also, Belachew et al., (2018) reported that three times spraying of Ridomil fungicide resulted in the maximum marginal rate of returns as compared to unsprayed control plots. Also, Rechcing (1997) stated that fungicides are used because they provide effective and reliable disease control, deliver products in the form of crop yield and quality at an economic price, and can be used safely.

Table 3. Partial budget analysis of fungicide application

Fungicides	Yield ton ha⁻¹	Price (ETB ton⁻¹)	Sale revenue	Marginal cost (ETB ha⁻¹)	Net profit (ETB ton⁻¹)	Marginal benefit (ETB ton⁻¹)	Marginal rate of return (%)
Noble 25 WP	2.55	9,245.50	23,576.02	1,750.00	21,826.02	11,933.33	681.90
Ridomil 80 WP	2.08	9,245.50	19,230.64	1,200.00	18,030.64	8,137.95	678.16
Control	1.07	9,245.50	9,892.69	0.00	9,892.69	0.00	0.00

CONCLUSION

It was concluded that spraying of Noble 25 WP and Ridomil 80 WP reduced "faba bean gall" disease severity and AUDPC. Application of these fungicides gave higher yield and net profit than control plots. Also, applications of both fungicides were economical and profitable. Thus, it is recommended that these fungicides can be used as one component of disease management. Thus, variety with the supplement of both fungicides with some cultural practices will increase crop production.

ACKNOWLEDGMENTS

REFERENCES

Alemu, G. Y.; Tadele, Y. A. Management of Faba bean gall disease through the use of host resistance and fungicide foliar spray in northwestern Ethiopia. *Adv Crop Sci Tech.* 2017.

Belachew, B.; Woubit, D.; Bekele, K.; Selvaraj, T. Management of Faba bean gall disease using cultivars and fungicides in north Showa zone of central Ethiopia. *IJRAS.* 2018, 5 (1), 6–33.

Beyene, B.; Abiro, T. Management of faba bean gall disease (Kormid) in north Shewa highlands, Ethiopia. ACST, (4), 225 pp.

Beyene, B. Survey and identification of new faba bean disease (Qormid) in the highlands of North Shewa, Ethiopia. *CRMB*, 2016, 3(1), 561-563.

Braich, S.; Sudheesh, J.; Paull.; Kaur, S. Construction of genetic linkage map and QTLs identification for Ascochyta blight (AB) resistance and flowering time in Faba bean (*Vicia faba* L.), in proceedings of the Australian pulse conference, Tamworth, Australia, September, 2016.

Chala, D.; Abraham, N.; Zerihun, A.; Meseret, T. Assessment of the occurrence and prevalence of Faba bean gall (*Olpidium viciae*) in Western highlands of Oromiya, Ethiopia. *JNSR.* 2017, 7(5), 63–67.

CIMMYT (International Maize and Wheat Improvement Center). From agronomic data to farmers' recommendations: Economic training manual. 1988, l, 79.

Central Statistical Agency report on area and production of major crops (private peasant holdings, meher season). *Statistical Bulletin.* 2020, 1, 10–17.

Dereje, G.; Tesfaye, B. Faba bean disease in Ethiopia. *In.* Asfaw Telaye.; Geletu Bejiga; Mohan C.; Saxena; Mahmoud, B (Eds.), cool-season food Legumes of Ethiopia. Proceedings of first National Cool-season Food legume Review Conference, Addis Ababa, Ethiopia, December 16-20, 1994, ICARDA/IAR.ICARDA, 328-345.

Ding, G.; Xung, L.; Oifang, G.; Pingxi, L.; Dazaho, Y.; Ronghai, H. Evaluation and

screening of Faba bean germplasm in China. *FN. 1992*, 32, 8–10.

Endale, H.; Gezahegne, G.; Tadesse, S.; Negussie, T.; Beyene, B.; Anteneh, B.; Daniel, K.; Tamene, T. Faba Bean Gall; a New Threat for Faba Bean (*Vicia faba*) Production in Ethiopia. *ACST*, 2014, 2, 144.

Li-juan, L.; Zhao-hai, Y.; Zhao-jie, Z.; Ming-shi, X.; Han-qing, Y. Faba Bean in China: State-of-the-art Review Special Study Report (English Translation). International Center for Agricultural Research in the Dry Areas (ICARDA). 1993, P.O. Box 5466, Aleppo, Syria.

Maalouf, F.; J. Hu, D. M.; O'Sullivan. "Breeding and genomics status in faba bean (Vicia faba)," *Plant Breeding.* 2019, 138(4), 465–473.

Rechcing, N. A.; Rechcing, J. E. Environmentally safe approaches to Crop disease control. *CRC. Lewis Publisher*, New York, 1997.

Senayit, Y.; Asrat, W. Utilization of cool season food legumes in Ethiopia. *In*: Asfaw, T.; Saxena, M.; Solh, M.; Geletu, B. (eds.). Cool season food legumes of Ethiopia. 16-20 December, 1993, Addis Ababa, Ethiopia. ICARDA/Institute of Agricultural Research, 1994.

Shanner, G. Finney R. Inheritance of slow-mildewing resistance in wheat proceedings. *American Phytopathological Society*. 1977, 2, 49.

Teklay, A.; Gurja, B.; Gemechu, K.; Taye, T. Fungicidal management of the newly emerging Faba bean disease gall (*Olpidium viciae* Kusano) in Tigray, Ethiopia. *Crop protection*. 2018, 107, 19–25.

Torres, M.; Roman, B.; Avila, M. Faba bean breeding for resistance against biotic stresses: towards application of marker technology. *Euphytica*, 2006, 147(1-2), 67–80.

Wheeler, E. J. An Introduction to plant diseases. Wiley and Sons, London. 1969, 374 pp.

Wulita, W.; Mashila, D.; Nigussie, T.; Seid, A. Fungicide management of Faba bean gall (*Olpidium viciae*) in Ethiopia. *TJAFST*. 2019, 7(7), 1075–1081.

Xing, Z. Faba bean gall disease caused by *Olipidium* and its control. *Acta Phytopathological Sinica. 1984,* 14 (3), 165-173.

Research Article   **Open access**

Lead, Cadmium and Arsenic Contamination Levels of Crops Produced at Kasavubu Vegetable Perimeter/Saio "The Case of *Amaranthus hybridus*"

Ngadi Nsandji Ruffin[1], Kanda Mwamba Aloys[2], Mulaja Kyela Crispin[3], Idrissa Assumani Zabo[4], Mukala Wa Muluaba Célestin[5], Buluku Ekwakwa Alain[6], Mukendi Mukendi Clément[7]

[1] Senior Lecturer and PhD student attached to Université Pédagogique Nationale at faculty of science, Chemical department, Kinshasa in the Democratic Republic of Congo. U.R. Développement et santé

[2] Emeritus Professor attached to Université Pédagogique Nationale at Faculty of science. Chemical Departement. Kinshasa in the Democratic Republic of Congo.

[3] Professor attached to Université de Kinshasa at Faculty of science. Chemical Departement. Kinshasa in the Democratic Republic of Congo.

[4] Professor attached to Université Pédagogique Nationale at Faculty of science. Biology Departement. Kinshasa in the Democratic Republic of Congo.

[5] Professor attached to Université Pédagogique Nationale, Agricultural Faculty. Kinshasa in the Democratic Republic of Congo.

[6] Ordinary Professor attached to Université Pédagogique Nationale at Faculty of science, Chemical Departement, Kinshasa in the Democratic Republic of Congo.

[7] Professor attached to Université Pédagogique Nationale at Faculty of science. Chemical Departement. Kinshasa in the Democratic Republic of Congo.

ARTICLE INFORMATION	ABSTRACT
	The study aims at evaluating the level of vegetable crops' contamination located along high-frequency motorized roadways. The useful area for a secure culture will be determined according to the threshold of toxic metal traces. The findings show that: the level of vegetable crops contamination varies according to the distance separating the roadways from the cultivated plants; the lead rate is inversely proportional to the distance which separates the vegetable crops from Kasavubu and Saio roadways. In the soil, lead concentrations are higher than in vegetables and irrigation water. The non-soil renewal after the harvest period could justify

the accumulation of lead in the soil. Cadmium is only detected in soil samples taken less than 3 m away from the road. Tire wear could be the real cause, the kinetic Cadmium differential and Arsenic is zero, while an inverse correlation was observed between the physicochemical parameters (pH, OM, and TOC) and the metals under study. The correlation between lead in soil and vegetables is justified by the same source of contamination. This is not the case for trace metals in irrigation water and vegetables. The useful area for safe cultivation is set at 50 m away from the frequent motorized road.

INTRODUCTION

According to the estimates of Institut National de Statistique (National Statics Institute of Statistics) in the DRC, the city of Kinshasa had 6,062,000 inhabitants in 2000. Referring to the the1973 statistics which report the figure of 1,198,720 inhabitants, the demography recorded an exponential growth (Flouriot, 1975; Lelo, 2008; Wagemakers et al., 2010). Currently, the population is estimated at over 10 million (Musibono et al., 2011).

Due to the increase sharp of the world population in general, and urban in particular, food for cities has become a basic problem (Bricas and Seck, 2004; Mougeot, 2005). This urban population growth concerns both capitals and secondary cities (Aubry et al., 2010).

The population of the City of Kinshasa consumes around 155,500 tons of vegetables a year, with an increase of 3 to 5% per year. In order to meet this need, the population resorts to urban agriculture. This activity is a response to poverty and food insecurity (FAO, 2007).

Ignored for a long time, urban agriculture is increasingly seen by urban planners as one of the means to tackle food inequality. It provides income to urban populations (Dubbeling, 2009, Musibono et al., 2011).

Growingin cities, edible plants involve exposure to constraints such as optimizing the available space and controlling the exposure of populations to pollutants often observed in different environments (soil,

water, air). As cities are densely populated, the likelihood of human exposure to the present pollutants is relatively high. Scenarios of human exposure to pollutants commonly observed in urban areas are particularly the ingestion of water from polluted wells or the consumption of vegetable plants grown on polluted soils (Shahid et al., 2016) or having intercepted enriched atmospheric particles in metals (Schreck et al., 2014; Xiong et al., 2016).

Environmental pollution is still widely observed in urban areas following historical pollution of lead, Cadmium, or very persistent mercury in soils (Leveque et al., 2015, Dumat et al., 2016) or atmospheric deposition of particulate pollutants. Over long distances (Schreck et al., 2013). Many chemicals can circulate or accumulate in garden soils (Schwartz, 2013), and finally, vegetables (Uzu et al., 2014; Clinard et al., 2015; Xiong et al., 2016).

Air pollution by heavy metals is riffed in urban areas, not only because of industry concentration and domestic households but also because of the density of motor vehicle traffic (Hanane et al., 2015). The main metallic pollutants emitted in the road environment come from fuels, tires, linings, and brakes (Pagotto, 1999; Deletraz, 2002). The use of lead in gasoline, however, is still common in developing countries (Menkes and Fawcett, 1997). The entry of lead into the manufacture of batteries and fuels led to an increase in its atmospheric concentration (Rhue et al., 1992).

Pollutants from automobile traffic or district heating can be deposited on plants or soil or even be absorbed by plant roots (Wieczorek et al., 2005; Kalavrouziotis et al., 2007). On the one hand, trace metallic elements (Pb, As, Hg, Cd, Zn, Cu, Ni, and Cr) accumulate as circulation increases. On the other hand, hydrocarbons, oils, rubbers constitute polycyclic aromatic hydrocarbons (PAHs) (Barriusto et al., 1996, Barbaste et al., 2004). Regardless of road traffic, contaminants from fertilizers, pesticides, and nature are absorbed by vegetation and then end up in the trophic chain (Atidegla et al., 2011).

An assessment of the air pollution of crops and the use of untreated urban solid waste, fertilizers, and pesticides are needed to improve the quality of vegetables grown in market gardening sites in Kinshasa.

The curves obtained for the trace metals will make it possible to distinguish two zones:

- Red zone characterized by a high rate of contamination compared to standards;
- Useful area where contaminants in crop plants are at the minimum acceptable trace level.

If the circumcised area is red, the municipal or urban authority will have to draw up legislation on urban agriculture.

The study aims at evaluating the quality of vegetables grown near Kasavubu and Saïo roadways and consumed in Kinshasa.

Site

Located on the crossroads of KASAVUBU and SAIO avenues in KASAVUBU municipality, this site is frequently used by motorized vehicles. It is also used as a house for street children who discharge excrement and urine there.

Figure 1. Cultivation site

Market gardeners cultivate amaranth (*Amaranthus hybridus*), spinach (*Basella alba*), sweet potato (*Ipomoea batatas*), and sorrel (*Hibiscus acetocella*). Market gardeners use well water for watering. Regarding fertilization, they use litter, poultry droppings, or other chemical fertilizers (NPK, urea, etc.) and untreated household waste to optimize yield. The choice of *Amaranthus hybridus* cultivation is justified by the fact that it represents 90% of

market gardening activities in Kinshasa (Wekole, 2018).

MATERIALS

Soil and plant samples were retrieved according to the distance separating them from the road (between 3m and 100m). After removal of plant debris and roots, soil samples collected from organo-mineral horizons (0-10cm) of the soil were dried at room temperature, then crushed and sieved

through the 2mm mesh. The vegetable samples were dried out of direct sunlight and then crushed. The sauce was used for the analysis of the cooked vegetables. The water sample was taken from the wells selected on the basis of their position relative to the road.

During the rainy season, the sampling took place between April 10 and15, 2019, i.e. 25 days later. The second phase took place during the dry season (July 2019).

METHODS

The physicochemical parameters: total organic carbon and Organic matter of the soil were deduced using the weight difference method before and after kiln incineration (Abderrazak (2012). The physicochemical parameters of the well water were determined in situ using the HACH HQ 40d brand multi-parameter probe. The soil pH was determined using a pH meter with "combined pH electrodes". The pH (H$_2$O) is measured in a soil-water suspension while the pH-KCl is determined in a 1N soil-KCl suspension using the ST 10 0HAUS brand pH meter.

The analyzes of the trace metals (Pb, Cd, and As) were carried out by molecular absorption spectroscopy using the DR 2000 spectrophotometer with digital reading applying the Beer-Lambert law, the detection limit of which is 0.02 mg/L.

The heavy metals transfer to plants was evaluated using the transfer factor according to Tangou (2016):

$$F = \frac{Plant\ metal\ concentration}{metal\ concentration\ in\ soil}$$

To evaluate the relationship that exists between different analyzed parameters, a statistical correlation study by PEARSON was used to find out if these parameters have the same origin or if the observed difference is due to chance. The ORIGIN 8 software was used for this assessment.

The Student's Test was applied to assess the variability of the parameters (distance between red zone and useful zone) during the two seasons. It was calculated on the basis of a Microsoft Excel program (Ancelle, 2008).

RESULTS

Physicochemical parameters for well water

a. pH

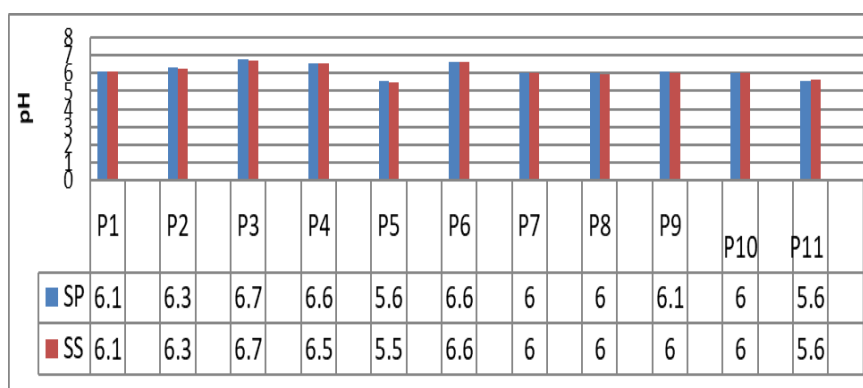|	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
SP	6.1	6.3	6.7	6.6	5.6	6.6	6	6	6.1	6	5.6
SS	6.1	6.3	6.7	6.5	5.5	6.6	6	6	6	6	5.6

Figure 2. pH of well water

This figure shows the pH of the different wells used for watering the vegetables for both seasons. In well P3, the high pH (6.74) and well P5 a low pH compared to the other wells.
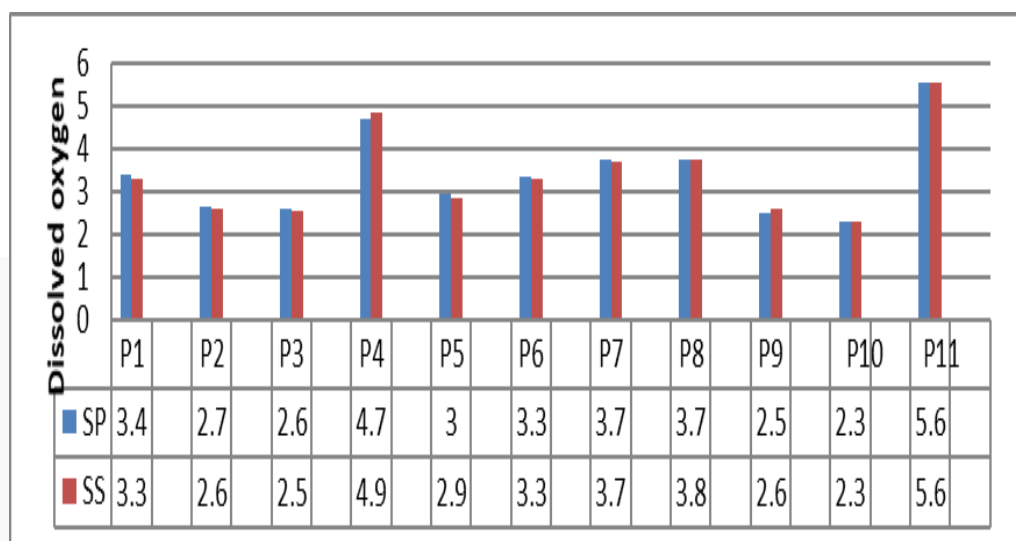
a. Dissolved oxygen

Figure 3. Evolution of dissolved oxygen in different water wells

This Figure reveals that the dissolved oxygen values in the different wells used for watering the vegetables during the two seasons vary between 2.28 (P10) and 5.58 (P11).
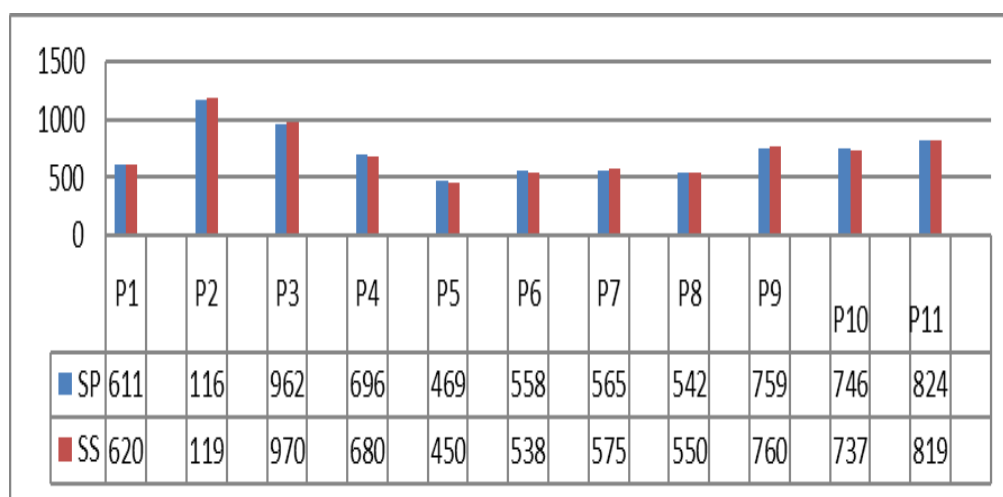
a. Conductivity

Figure 4. Conductivity values in different water wells

This Figure shows the different conductivity values in the wells used for watering vegetables. Thus, whatever the season, the P2 well has a high value (1164) and the P5 well has a lower value compared to the other wells.

To cite this article: Ruffin, N. N.; Aloys, K. M.; Crispin, M. K.; Zabo, I. A.; Célestin, M. W. M.; Alain, B. E.; Clément, M. M. Lead, Cadmium and Arsenic Contamination Levels of Crops Produced at Kasavubu Vegetable Perimeter / Saio "The Case of Amaranthus hybridus. *J. Agric. For. Res.* 2021, 1 (2), 60-77.
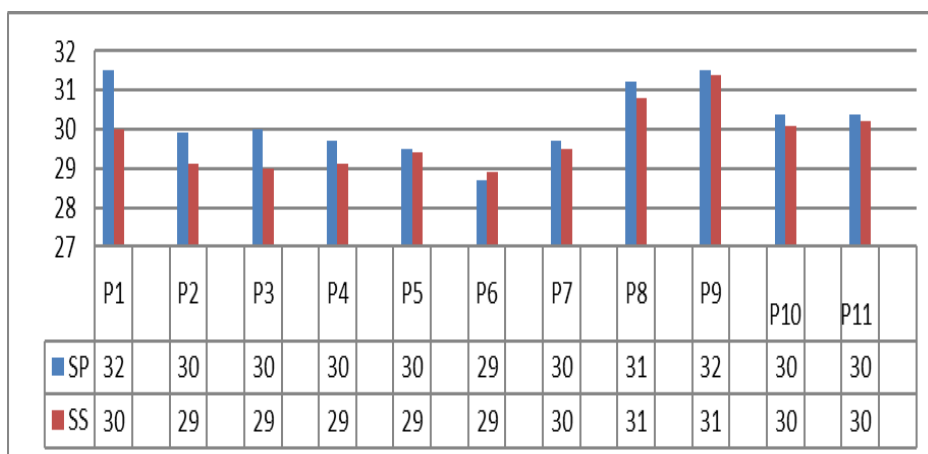
a. Temperature

Figure 5. Different temperature values in different water wells

This figure shows different temperature values in water wells used for watering vegetables. Whatever the season, wells P1 and P9 have high-temperature values (31.5 ° C) while well P6 (28.9 ° C) a low value compared to the other wells.

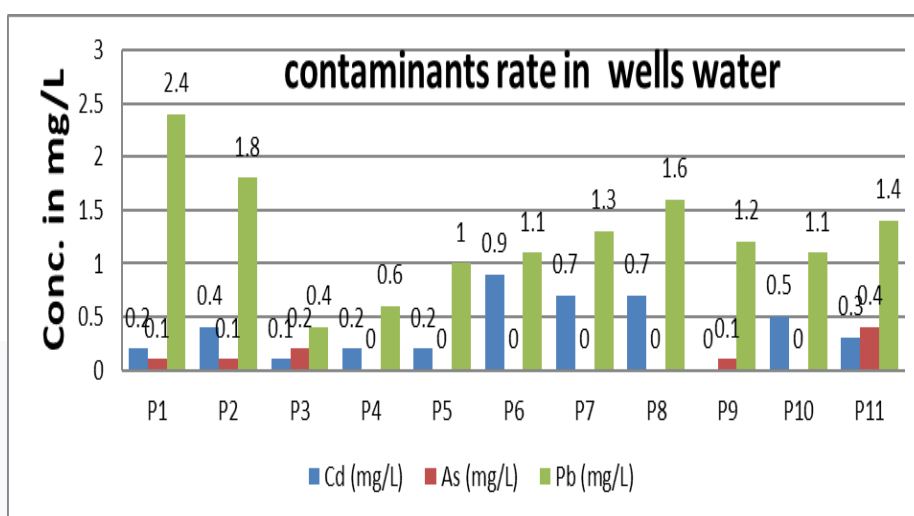### a. Heavy metals in well water (Pb, Cd and As)

Figure 6. Contaminant rates (Pb, Cd, and As) in different water wells

The results of this Figure indicate that:
- The arsenic values are zero for wells P4 to P8 and P10. But from P1 to P3, P9 and P11 vary between 0.1 to 0.4 mg / L.
- A high value of Cadmium in wells 6 (P6) and 12 (P12) and low in wells 3 (P3). It was found that in wells 9 (P9), the cadmium value is almost zero compared to the analysis method used;
- Lead values are considerable in wells P1 and P2 near the road compared to wells P3 to P11 which are further away from the road.

Soils

a. Organic substances in the soil
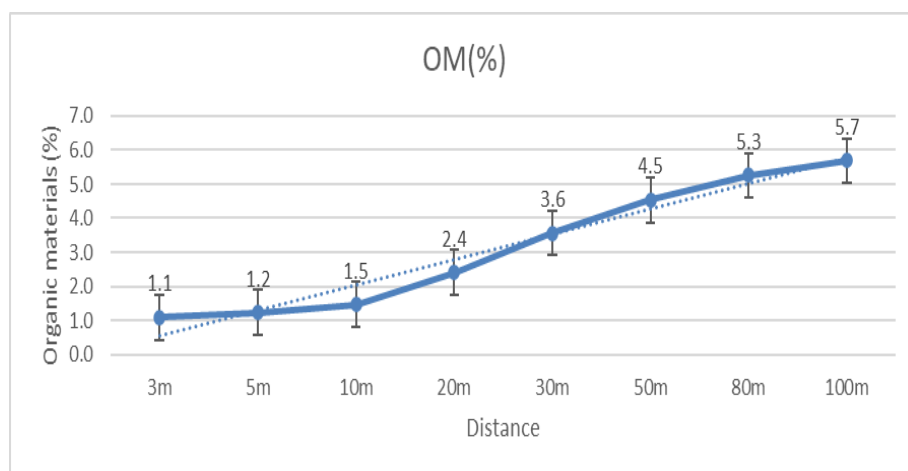
Figure 7. Evolution of organic substances in the soil regarding the distance function

Figure 7 illustrates the evolution of organic substances in the soil in the function of distance. It reveals that from 30m, the standard error bar differs from the value recorded at 3m. The trend line is increasing.

a. Total organic carbon in soil

Figure 8. Evolution of total soil organic carbon in function to distance

Figure 8 indicates the evolution of Total Organic Carbon in the soil in the function of distance. It reveals that from 20m, the standard error bar differs from the value recorded at 3m. The trend line is increasing.

a. Soil pH (0-10cm)
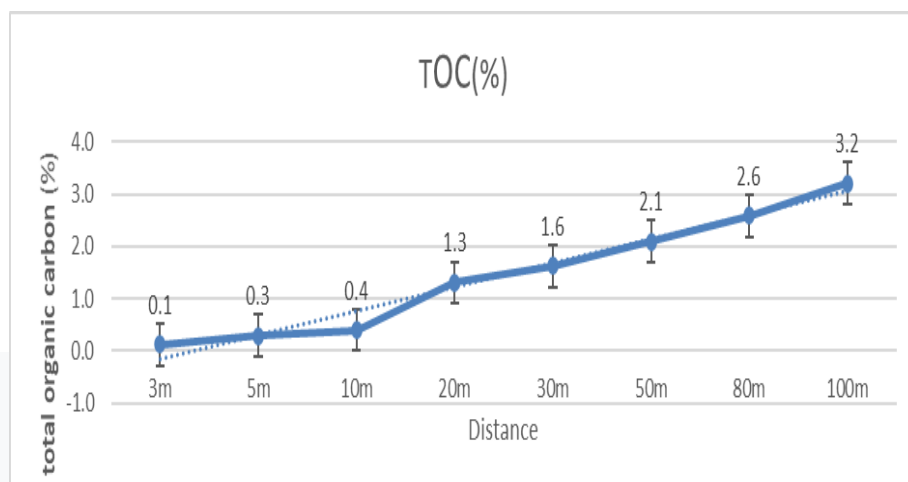
pH in the water-soil suspension

Figure 9. Evolution of soil pH in the water-soil suspension

Figure 9 shows the pH (H_2O) values in the soil in the function of distance. It reveals that from 50m, the standard error bar differs from the value recorded at 3m. The trend line is increasing.
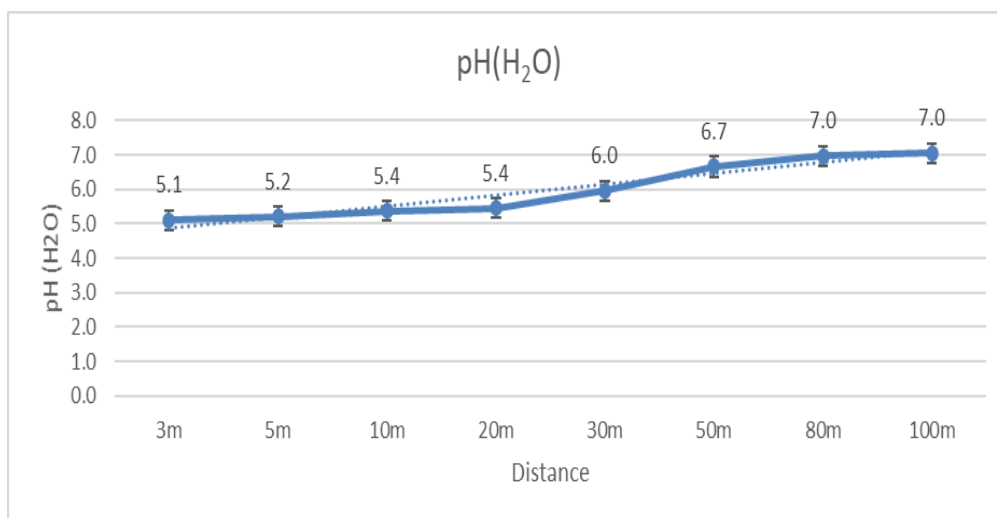
pH in the water-KCl suspension
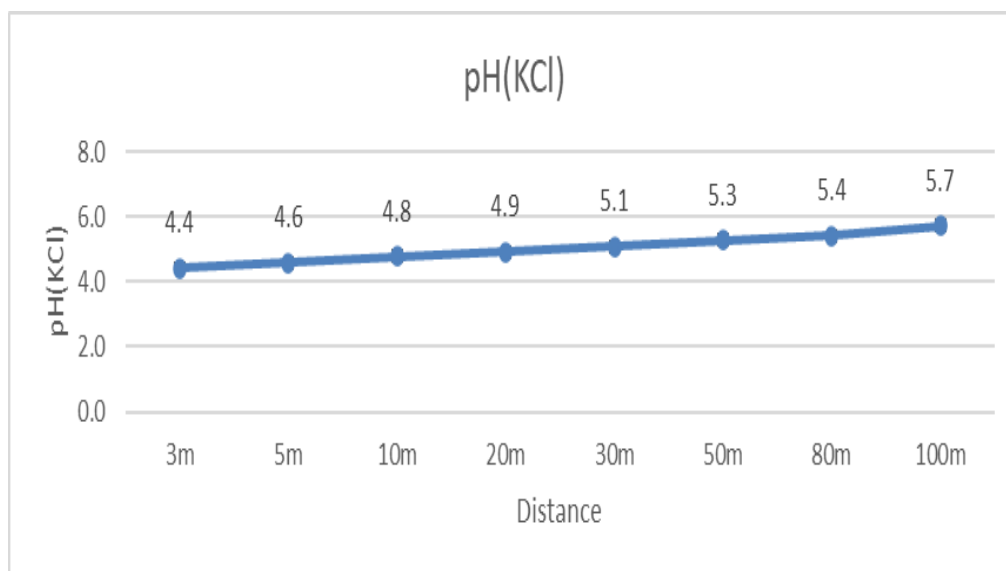
Figure 10. Evolution of the pH in the water-KCl suspension

Figure 10 shows the pH (KCl) values in the soil in the function of distance. It reveals that from 20m, the standard error bar differs from the value recorded at 3m. The trend line is increasing.

Lead in soil
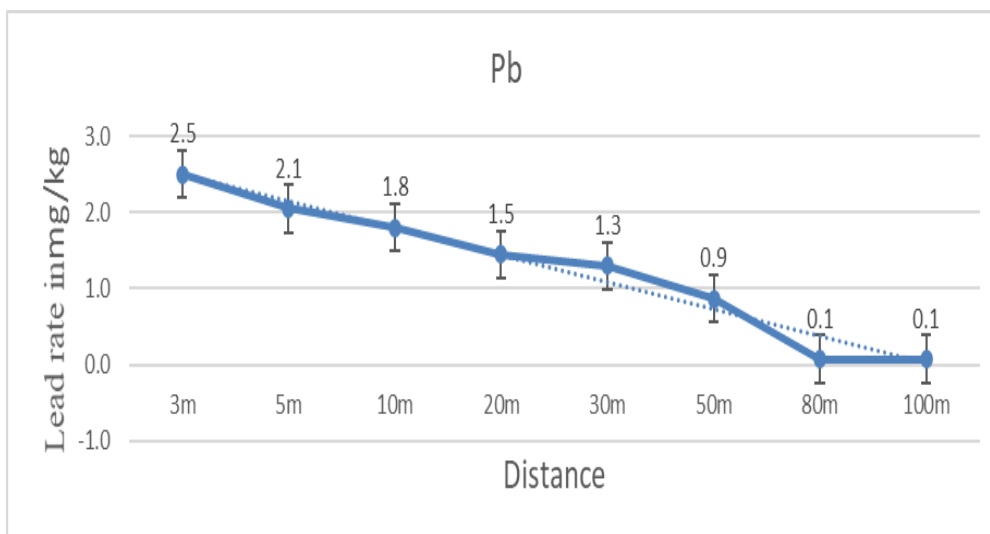
Figure 11. Evolution of lead into the soil in the function of distance

Figure 11 shows the evolution of Pb into the soil in the function of distance. It reveals that from 20m, the standard error bar differs from the value recorded at 3m. The trend line is decreasing.

Cadmium in soil

Figure 12. Evolution of Cadmium in the soil

Figure 12 shows the evolution of Cd into the soil in the function of distance. It reveals that from 5m, the standard error bar differs from the value recorded at 3m. The trend line is decreasing.

Arsenic in soil

Figure 13. Evolution of Arsenic in the soil

Figure 13 shows the evolution of Arsenic in the soil regarding the function of distance. It reveals that from 10m, the standard error bar differs from the value recorded at 3m. The trend line decreasing.

Vegetable

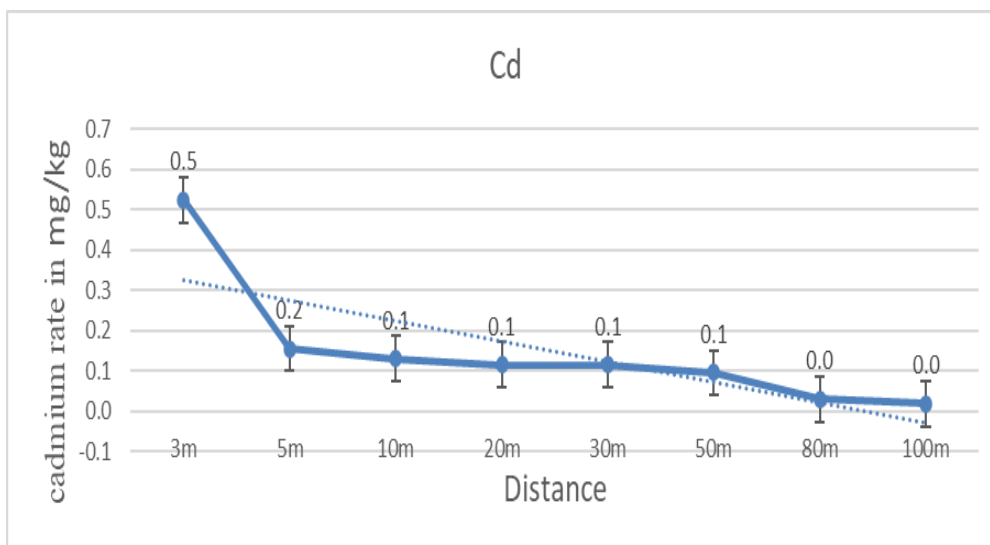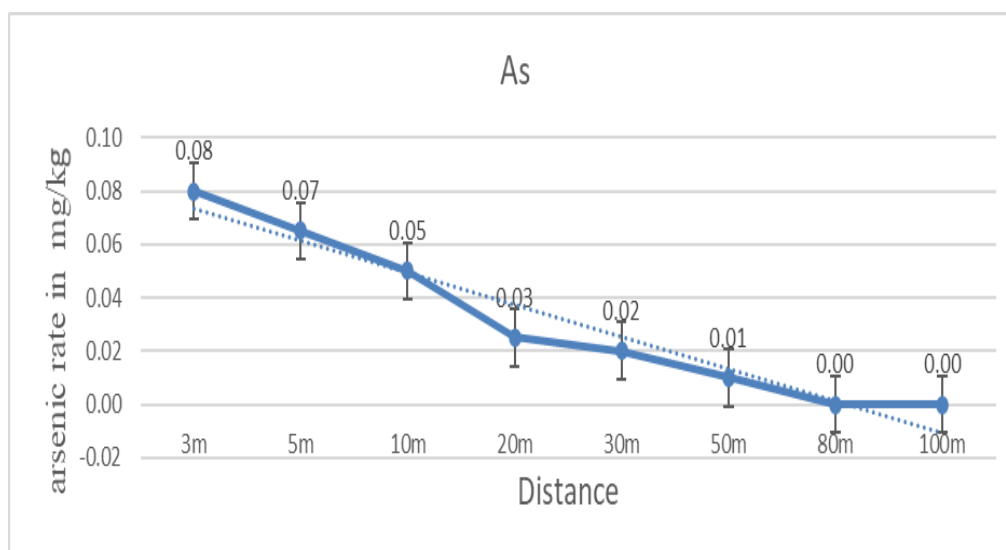**Average Pb, As and Cd in *Amaranthus hybridus***
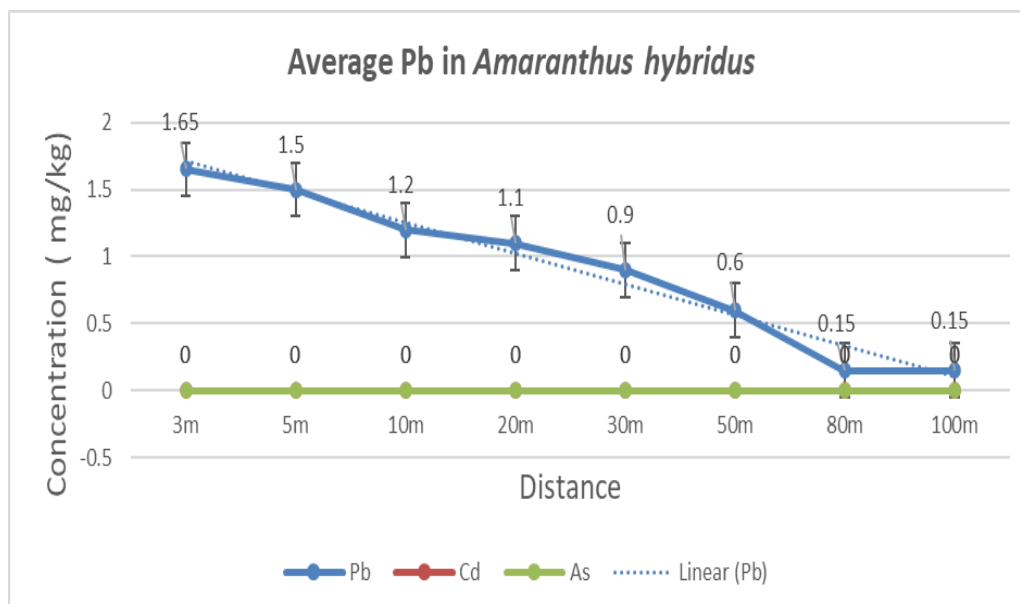
Figure 14. Evolution of ETM in Amaranth

Figure 14 shows the level of contaminating trace metals in Amaranth. It reveals that from 10m, the standard error bar differs from the value recorded at 3m. The trend line is decreasing.

Table 1 below indicates that the lead transfer factor from soil to vegetables varies from 0.6 to 5.7 range from 3 to 50 m from the

The absence of Cadmium and Arsenic levels from 3m from the road is justified by the fact that the exhaust fumes only emit lead from the fuel.

roadway. No transfer factors for Cadmium and Arsenic were observed.

Table 1: Transfer factor (F)

Distance (m)	Kasavubu and Saio Crossways		
	Cd	As	Pb
3	n.d	n.d	0,6
5	n.d	n.d	0,7
10	!n.d	n.d	0,7
20	n.d	n.d	1,0
30	n.d	n.d	1,2
50	n.d	n.d	5,7
80	n.d	n.d	5,0
100			5,0

Disappearance of contaminants compared to distance
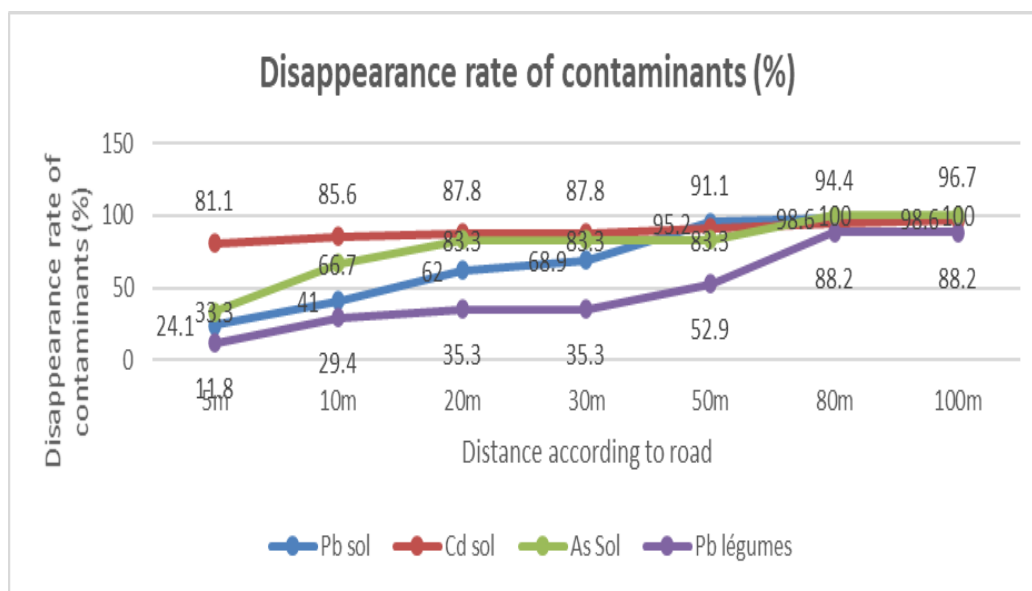
Figure 15. Disappearance rate of contaminants compared to the distance

At a distance of 5m, the disappearance rate is respectively estimated at 81.1% (Cd), 33.3% (As), 24.1% (Pb of the soil), and 11.8% (Pb of vegetables). The rate of disappearance is proportional to the distance. At 100m, the disappearance rate is 100% for As (soil), 96.7% for Cd (soil), 98.6% for Pb in soil, and 88.2% of Pb in vegetables.

Statistical analysis findings

a. **Kasavubu / Saio Pearson correlation coefficient**

These results are presented in Table 2 below:

Table 2. Pearson's correlation coefficient for Kasavubu / Saio

|	pH (KCl)	M.O.	C.O.	Cd/sol	As/sol	Pb/sol	Pb/lég
pH (H$_2$O)	0,86887	0,95795	0,91669	-0,53556	-0,7906	-0,9118	-0,90243
pH (KCl)		0,9026	0,94944	-0,76078	-0,92459	-0,9438	-0,91623
M.O.			0,97608	-0,57616	-0,85742	-0,94115	-0,96991
C.O.				-0,64825	-0,9249	-0,95793	-0,95632
Cd/soil					0,83958	0,77057	0,6536
As/soil						0,96173	0,87519
Pb/soil							0,92393

Table 2 indicates that there is a negative correlation between the physicochemical parameters and the trace metals under study. In contrast, lead from soil and lead from vegetables show a strong correlation (0.92393).

a. **Pearson correlation coefficient of water**

These results are presented in Table 3 below:

Table 3. Pearson correlation coefficient of water

	Water Cd	Water As	Water Pb
Water Cd	1	-0,40203	0,15445
Water As		1	0,06212
Water Pb			1

Table 3 indicates that there is a weak correlation between trace metals in water wells, linked to the same geochemical origin. So, they don't have the same origin.

DISCUSSIONS

The pH of water wells varies between 5.57 and 6.74, values less than 6.8; therefore, slightly acidic but favorable to aquatic life (5-9.0) and consistent with the pH of groundwater.

The dissolved oxygen values of these wells vary between 2.51 and 5.58mg O$_2$ / L. They are lower than those of domestic Maghrebian waters (2.42 mg / L) and lower than the guideline values for physical, chemical, and thorough treatment (> 30 mg / L) (Drouart et al., 1999). This indicates the

presence of microorganisms in these wells. They are also lower than those of the surface water of the Lukaya River (6.7-6.94 mg / L), almost equivalent to that of groundwater where only fish and insects can live (Ngadi et al., 2014).

The soil pH in the soil-H_2O suspension varies increasingly from 5.12 to 7.3 during the two seasons with average values varying between 5. 1 to7. 0. This pH, whose standard error bar stands out at 50 m from the initial value at 3 m, shows that the soil is weakly acidic (6.8). The soil is, therefore, suitable for vegetable crops because the plants assimilate the nutrients soluble in water at this pH. It appears that after 50 m from the road, the pH meets the standards required for topsoil. But, at a distance of fewer than 50 m from the roadways, the soil is acidic. This is due to exhaust gases like CO_2, NO_X, SO_X, etc. These gases dissolve in water, forming corresponding acids with an impact on crops, as the acidic pH increases the Phyto-availability of metals.

The pH (KCl) is a weak acid (<5.6) from 3 to 100 m, due to the abundant captions released by the complex composing of the soil with a tendency to form acid salts, such as aluminum or silicon and others which combine with the soil and thus form absorbent complexes. The pH thus found with KCl as a solvent is called the actual potential pH of the soil. Average pH – KCl values range from 4.4 to 5.7. Although its value at 20m differs from its initial value at 3m, it is not useful for characterizing market gardening soil.

Concentrations of organic substances increase with increasing distance from the road. These values vary from 1.0 to 6.9 % during the two seasons with average values oscillating between 1.1 to 5.7 %. At 30 m, its average value differs from that of 3 m and becomes acceptable for market gardening. Exhaust fumes have almost a negative impact on organic matter, indicative of the organic carbon needed by the plant. These results

are consistent with those of cultivated agricultural soil from Saarbrucken in Germany (1 to 3 %) (Schwartz, 2013).

Varying increasingly with the distance from the road, the total organic carbon ranges from 0.15 to 4% during the two seasons, with average values ranging from 0.1 to 3.2% with a value of 1.3 % differing from the initial value. The presence of proteins, polysaccharides, humic compounds from untreated waste is used to amend the soil and is indicative of organic pollution (presence of carbon), as well as sunburnt substances from gasoline combustion, including benzene, toluene, and others. They also influence the bioavailability of metals such as cadmium and arsenic. The more organic the soil is, the less the metals will tend to go into solution. The results obtained are lower than those of market gardeners from Loraine in France, whose values exceed 4% (Schwartz, *Op. cit*.).

The average values of lead in the soil vary decreasingly, whether it is from Kasavubu or Saio, during the rainy or dry season. Its average values vary between 2.5 to 0.1 mg / kg. These values are lower than those for Tshamalenga garden soil (530 mg/kg) (Banza, 2002) and even the guide values (100 mg/kg) for market gardening soil (Kabata-Pendias et al. 2001; Boukhars et al., 2000 and Tremel-Schaub et al., 2005), and those Polish market garden soil near road traffic, between 3.41 and 1520 mg/kg (Ademe, 2017). These values are close to those of market garden soils of Abidjan (3 mg/kg) and lower than soils of Ebrié, 0.12 mg/kg (Vandjiguila et al., 2012) and higher than soils of Ezazou village in Cote d'Ivoire (4.9 mg/kg), (Nguelieu, 2017). Lead in the soil forms compounds which are insoluble in water at pH> 5 and also, its leaching and deep contamination is less at this pH.

In vegetables, the level of lead decreases with increasing distance. Its average values vary respectively between 1.65 to 0.0 mg/ kg. The change in the lead is inversely

proportional to the distance from the road. Airborne contamination is the main source of lead contamination of vegetables from exhaust fumes. The lead values in the leaves of *Amaranthus hybrithus* obtained are lower than those obtained by the influence of phytosanitary products 4 mg/kg. This shows that vegetables grown under conditions of strong anthropogenic contamination contain high amounts of trace elements including lead (Schwartz et al., 2000).

The values obtained are lower than those of Lubumbashi near the mining areas (3.1 mg/kg) in Tshamalenga and Shinkolobwe (5.352 mg/Kg) (Banza, 2002). These values are beyond the thresholds required for human consumption in accordance with European standards, 2011 (0.1 mg/kg) cited by OPALA (2017) and those described by Banza (Op.cit). Similar work carried out in the market gardening perimeters located along the heavily trafficked roads in Kinshasa by Musibono (2003) reported that the vegetables grown on these sites are polluted by the lead contained in the smoke released by the vehicles itself coming from gasoline containing tetraethyl lead. He further noted that the lead content in both soil and vegetables decreases with increasing distance from the main pathways.

Lead values in vegetables are lower than those in soils and water. All lead values in well water vary between 0.4-2.4 mg/L. These concentrations are higher compared to the limit values (0.2 mg/L) for discharges into aqueous tributaries and the guide values (0.01 mg/L), WHO, 2004. And these concentrations are lower compared to the values defined for irrigation water (5.0 mg/L), (Fatta, Op. cit).

The lead transfer factor from soil to vegetables varies from 0.6 to 5.7, falling within the range set values (0.01 and 10) (Tangou, 2016). Only the value from 50m from the roadways reveals the transfer of soil to the plant because the transfer factor F (5.7) is greater than 5.6. Unlike those of Arsenic and Cadmium, where no transfer is possible because factor F is almost zero. Therefore, at this pH the availability of Cd and as for plants is not possible. According to Bourg and Lock (1995), Cd forms chelate complexes and its absorption becomes independent of pH (Babich et al., 1977).

The cadmium concentration decreases significantly from 5m from the road and stabilizes thereafter. The average cadmium level varies between 0.5 to 0.0 mg / kg. At 5m, it stands out from the value at 3m from the road. These values are greater than 3 m (0.9 mg/kg rainy season and 1.0 mg/kg dry season) of the road than those of arable soil (0.7 mg/kg) (Rousseau 1986 cited by Kabata-Péndias et al., 2001) and to the reference values applicable in Wallonia according to the Flemish regional regulations on the matter (0.2 mg/kg), AFNOR, 2005 cited by Nguelieu (2017), lower than the latter from 5m (0.17 at 0.03 mg/kg), and the French standard for agricultural soil (2 mg/kg). These values are lower than that of Tshamalenga garden soil (1.45mg/kg) (Banza, 2002) and even the guide values (2 mg/kg) for market gardening soil (Kabata-Pendias et al., 2001, Boukhars *et al.,* 2000 and Tremel-Schaub et al., 2005). This situation is due to tire wear at the edges of the main roads but does not affect the entire garden. The Cadmium transfer factor from the soil to the vegetables is zero.

Only wells P6 to P8 (0.7-0.9mg/L) have Cadmium values beyond WHO standards for human consumption (0.03 mg/L) (WHO, 2004). Values higher than those predicted for irrigation water (0.01mg/L), Fatta, (2014) and the limit values for discharges into aqueous tributaries (0.05 mg/L) (Lepot et al., 2013). But these values did not influence the Cd of vegetables analyzed.

Arsenic concentrations decrease less with distance from the road; its average values vary from 0.08 to 0.00 mg/kg. An almost low value in the soil compared to the soil of Tshamalenga (10 mg/kg) Banza, 2002.

The arsenic values of well water are higher than those predicted for surface water (Vandjiguila et al., 2012), for irrigation water (0.1 mg /L) (Fatta, 2014), and the limits of the value (1 mg/L) for discharges into aqueous tributaries (Lepot et al., 2013).

The Student's T of the parameters analyzed showed that whether it is in Kasavubu or Saio, rainy or dry season, the difference is not significant. The values found are averages of these parameters.

The Student's T of the parameters analyzed showed that whether it is in Kasavubu or Saio, rainy or dry season, the difference is not significant. The values found are averages of these parameters.

Pearson's coefficient was applied between physicochemical parameters and trace metals. From this correlation came the following result:

There is an inverse correlation between the trace metals and the physicochemical parameters (pH, Organic matter, and Total organic carbon), i.e. the more the trace metals decrease, the more the physicochemical parameters increase as indicated in Figure 15 below. These parameters influence the trace metals in soils.

Lead, Cadmium, and Arsenic in soil have a very weak correlation, so they do not have the same source of contamination. This weak correlation can be linked to the same geochemical source. Lead in soil has a strong correlation with that in leafy vegetables, so they have the same source of contamination, which comes from anthropogenic sources including exhaust smoke from motor vehicles. Leaching is the main cause of the difference in concentration between lead in soil and that in vegetables; this corroborates the results of Neibor et al., 1980, who found a correlation between the lead content in soil and that in plants.

The trace metals (Pb, Cd, and As) in the water from different wells used for irrigation are not correlated, and therefore do not have the same origin.

CONCLUSION

The main objective of the study was to assess the level of contamination of *Amaranthus hybridus* with toxic metallic trace elements including Pb, Cd and As in order to deduce the safe culture distance or the useful area. Results obtained show that the average level of lead in the soil decreases with distance from the road in all seasons. It ranges from 2.5 to 0.1 mg / kg. In vegetables, the average level of lead decreases with increasing distance. It ranges from 1.65 to 0.00 mg / kg. In addition, lead is more concentrated in green vegetables than in the sauce of cooked vegetables. The lead transfer factor from soil to vegetables varies from 0.6 (3 m) to 5.7 (50m).

The average level of Cadmium in the soil between 3 and 10 m decreases with distance from the road in all seasons. It ranges from 0.5 to 0.00 mg / kg. The Cadmium transfer factor from the soil to the vegetables is zero. The cadmium level is higher in wells 6 (P6) and 12 (P12) and low in wells 3 (P3). Its value is zero in wells 9 (P9)

The average level of Arsenic in the soil decreases a bit with the distance from the Kasavubu and Saio roads. It ranges from 0.1 to 0.00 mg / kg. The arsenic transfer factor from soil to vegetables is zero

Point 0 of these toxic elements is located around 50m from the road. The decrease in these elements is observed relative to the molecular weight of each. The heaviest finish their race at an intermediate distance and the lightest reaches 40-50m. This disappearance also depends on the initial concentration. The disappearance of lead was observed from 40-45m.

The useful area for healthy market gardening is estimated at 50m from the roadway. At this distance, more than 80% of the metallic trace elements (TME) disappeared during the

process. The transfer factor of the lead concentration from the soil to the vegetables is estimated at 5.7 because the pH is 7.09 favoring mobility.

We recommend to the municipal authority a strict ban on vegetable cultivation within 50m of high-frequency motorized roads to protect the population against carcinogenic contaminants.

REFERENCES

Abderrazzak, A. B. Etude de contamination et d'accumulation de quelques métaux lours dans les céréales, légumes et sols agricoles irrigués par les eaux usées de la ville de Hammam Boughrana, Ph.D. dissertation, Abou BekrBelkaid-Tlemen University, Algeria, 2012.

Ademe. Phytodisponibilité des ETM sur les plantes potagères et extrapolation dans la quantification d'exposition des consommateurs, University of Lorraine, France, 2017. (www.ademe.fr/médiathèque).

Ancelle, A. ; *Statistique épidémiologie*, Fundamental Sciences Collection, 2nd Ed., Maloine, 2008.

Atidegla, S. C.; Agbossou, E. K. ; Huat, J.; Kakai R. G. Contamination métallique des légumes des périmètres maraîchers urbains et péri urbains: Case of the municipality of Grand – Popo in Benin. *Int. J. Biol. Chem. Sci.* 2011, 5(6), 2351-2361.

Aubry, C.; Dabat, M. H.; Mawois, M. Fonction Alimentaire de l'agriculture urbaine au Nord et au Sud: Permanence et renouvellement des questions de recherche. ISDA 2010, Jun 2010, Montpellier, France. 13 p. 2010, Hal-00521221.

Babich, H.; Stotzky, G. Sensitivity of Various Bacteria, including Actinomyceles and Fundi to Cadmium and Influence of pH on Sensitivity appl. *Environ. Microbiol*. 1977, 681-685.

Banza, C. Investigation report on chemical pollution in the Tshamalenga and Kabecha districts of the city of Lubumbashi, ESP, *Toxicological Unit*, University of Lubumbashi, Fac. Medicine, 2002, 56 p.

Baize, D. *Teneurs totales en éléments traces métalliques dans les sols*, France: INRA edition, 1997, 408 p.

Barriuso, E.; Calvet, R.; Schiavon, M.; Soulas G. Les pesticides et les polluants organiques des sols. Transformation et dissipation. Forum « Sol, un patrimoine menacé ? *Etude et Gestion des Sols,*1996, 3 (4), 279-295. Paris Special issue.

Boukhars, L. ; Rada A. Exposition au cadmium de végétaux cultivés sur des sols calcaires salés marocains amendés avec des boues et des eaux usées, *Environ. Technol*. 2000, 21, 641-652.

Bricas, N. ; Seck, P. A. L'alimentation des villes du Sud : les raisons de craindre et d'espérer, *Cahiers Agriculture*, n° 13, 10-14 pp.

Clinard, F. ; Delefortrie, A. ; Bellec, S.; Jacquot, G. ; Bonnelles, A. ; Tillier, C. ; Richert, J. Enquête de pratiques agricoles et de consommation alimentaire dans les jardins ouvriers de l'agglomération de Belfort (Franche-Comté). *Environment risks & health*, 2015, 14 (1), 56-71.

Deletraz, G. Géographie des risques environnementaux liés aux transports routiers en montagne. Incidences des émissions d'oxydes d'azote en vallées d'Aspe et de Biriatou (Pyrénées). "Ph.D. Dissertation in Geography-Planning". University of Pau and the Adour countries. Institute for Research on Societies and Planning. 2002, 564 p.

Dubbeling, M. L'intégration de l'agriculture urbaine dans la planification urbaine, Exposé à la Table Ronde sur l'agriculture Urbaine, Institute of Trades of the City and Urban Municipality of Antananarivo, 2009, 4-9 / 9/09.

Dumat, C. ; Xiong, T. Shahid, M. *Agriculture urbaine durable : opportunité pour la*

transition écologique. European University Press, Saarbrücken, 2016, DE. ISBN 978-3-639-69662-2.

Drouart, E. and Vouillamoz, J.M.; *Alimentation en eau potable des populations menacées*, Paris: ACT, Hermat Editions, 1999.

Fatta D.; *Department of civil and environnement engineering*, University of Cyprus, 2014.

FAO, *L'agriculture biologique peut contribuer à la lutte contre la faim*, FAO, Relation media, Rome. 3 p, www.fao.org/newsroom/fr/news/2007.

Flouriot, J.; *Croissance de l'habitat*, in Flouriot, J., De Maximi, R., Pain, M. (Dir.), Atlas de Kinshasa, Kinshasa: National Geographic Institute, 1975.

Hanane, B., Benchaben, H., Nadira A. Abbassia A.; Quantification de l'émission de plomb dans le milieu urbain de Sidi Bel' Abbes (Algérie occidentale) *Europ. Scient. J.* February 2015 edition vol.11, No.6: 82-94 ISSN: 1857 - 7881 (Print) e - ISSN 1857-7431.

Kabata-Pendias, A., *Trace Elements in Soils and Plants*, (3rd Ed.). USA: CRC Press, Boca Raton, 2001.413p.

Kalavrouziotis, I.K., Carter, J., Varnavas, S.P., Mehra, A., Drakatos P.A.; Towards an understanding of the effect of road pollution on adjacent food crops: Zea mays as an example. *Int. J. of Environ. and Pol.*, 2007, 30:576-592.

Lelo, N. F. *Kinshasa, ville et environnement*, Paris: L'Harmattan, 2008.

Lepot, B. and Poulleau J.; *Méthodes de mesurage des polluants rejetés dans l'atmosphère et dans l'eau*, *Final report*, INERIS, 2013, 549p.

Leveque, T., Capowiez, Y., Schreck, E., Mombo, S., Mazzia C., Foucault, Y. & Dumat, C.; Effects of historic metal(loid) pollution on earthworm communities. *Science of the Total Environment*, 2015, *511, 738-746.*

Menkes, D.B. et Fawcett JP. ; Too Easily Lead? Health effects of gasoline additives. *Environ Heulth Perspective*, 1997, 105: 270-273.

Mougeot, L.J.A.; Agropolis: *The Social, Political and Environmental Dimensions of Urban Agriculture*. IDRC, Earthscan, London, 2005, 286 p.

Musibono, D. ; Pollution au plomb des légumes cultivés le long des artères publiques à Kinshasa, INRB. Scientific Department, Conference report published by mail to the readers, 2003, 4p. www.lettres@digitalcongo.net, (accessed June 15, 2018).

Musibono, D. E.; Biey, E., Kisangala, M., Nsimanda, C., Munzundu, B., Kekolemba, V. & Paulus, J.; Urban agriculture as a response to unemployment in Kinshasa, Democratic Republic of Congo. [Vertigo] *The electronic journal of environmental sciences*, 2011,11 (1). [Online], Volume 11 Number 1 | May 2011, posted May 20, 2011, URL: http://vertigo.revues.org/10818; DOI: 10.4000 / vertigo.10818, (accessed June 15, 2018).

Ngadi, R., Idrissa A. and Pongi J.; Impact de rejet fiente de la ferme Minocongo sur la variation saisonnière des paramètres physicochimiques des eaux brutes de la rivière Lukaya. CRIDUPN review, October – December 2014, n ° 61C.

Nguelieu, C.R.; Evaluation des risques de contamination en éléments traces (Pb, Cd, Zn) des sites maraichers urbains de Yaoundé, University of Liège, Master in Agro-Biotechnology, 2017, 59p. (http://lib.ulg.ac.be), (accessed September 12, 2018).

Nieboer, E. et Richardson, D.; The Replacement of the descript term "Heavy Metals" with biologically and chemically significant classification of metal ions, *J. Environ Pollution*, 1980, 3-26.

WHO; *Directives de qualité pour l'eau de boisson*; (3rd.Ed.), (2004).

Opala, C. Impact du trafic routier sur les activités maraichères à Kinshasa, Master Dissertation, UNIKIN, 2017.

Pagotto, C.; *Etude sur l'émission et le transfert dans les eaux et les sols des éléments traces métallique et des hydrocarbures en domaine routier*. Ph.D. Dissertation: water chemistry and microbiology, science and technology. University of Poitiers, 1999, 252 p.

Rhue, R. D.; Mansell, R. S.; Oult Cox, R.; Tang S. R.; etOuyang, Y. The fate and behavior of lead alkyls in the environment: a review. *Crit Rev Environ Control*. 1992, 22, 169-193.

Shahid, M.; Dumat, C.; Khalid, S.; Niazi, N.; Antunes, P. M. C. *Cadmium Bioavailability, Uptake, Toxicity and Detoxification in Soil-Plant System*. 2016, Springer, New York.

Schreck, E.; Dappe, V.; Sarret, G.; Sobanska, S.; Nowak, D.; Nowak, J.; Stefaniak, E. A.; Magnin, V.; Ranieri, V.; Dumat, C. Foliar or root exposures to smelter particles: consequences on lead compartmentalization and speciation in plant leaves. *Science of The Total Environment*, 2014, (476–477), 667–676.

Schwartz, C. Les sols de jardins supports d'une agriculture urbaine intensive, Vertigo, Special issue 15, Atmospheric pollution, transport and agriculture, 2013.

Tangou, T. *Chimie Environnement, pollutions et nuisances*, Ed. P.U.K., University of Kinshasa, 2016, 139 pp.

Tremel-Schaub, A.; Feix, I. *Contamination des sols – Transferts des sols vers les plantes*, EDP Sciences, ADEME, 2005, 416 pp.

Uzu, G.; Schreck, E.; Xiong, T.; Macouin, M.; Lévêque, T.; Fayomi, B.; Dumat, C. Urban market gardening in Africa: metal (oid) foliar uptake and their bioaccessibility in vegetables, implications in terms of health risks. *Water, Air & Soil Pollution*, 2014, 225, 2185.

Vandjiguila, D. ; Darby, V. Problématique du Cd en Côte-d'Ivoire : Pollution environnementale et risque sanitaire, Article, Institut Pasteur de Cote d´Ivoire,

Félix Houphouët Boigny University, Cote d´Ivoire, 2012.

Wekolo, E. Contamination métalliques des légumes des périmètres maraichers de Kinshasa, cas des sites Camp Kokolo et Saio, a Graduate Research paper, Fac. Sciences, UNIKIN. 2018.

Wagemakers, I. ; Makangu, O. D. De Herdt, T. Lutte foncière dans la ville : gouvernance de la terre agricole urbaine à Kinshasa l'Afrique des Grands Lacs. 176 yearbooks 2009-2010, 175-200.

Wieczorek, J.; Wieczorek, Z.; Bieniaszewski T. Cadmium and lead content in cereal grains and soil from cropland adjacent to roadways. *Polish J. of Environ. Stud.* 2005. 14, 535-540.

Xiong, T.; Austruy, A.; Pierart, .A.; Shahid M.; Schreck, E.; Mombo, S.; Dumat, C. Kinetic study of phytotoxicity induced by foliar lead uptake for vegetables exposed to fine particles and implications for sustainable urban agriculture. *Journal of Environmental Sciences*. 2016.

Livelihood Diversification in Relation to The Use of Forests Products by Local Communities of The Nuba Mountains of South Kordofan State, Sudan

Ismail Mirghani Ismail[1]; Mohamed El Mukhtar Ballal[2]

[1] Forestry and Gum Arabic Research Centre, Agricultural Research Corporation, Khartoum, Sudan

[2] Freelancer (Forestry and gum Arabic expert)

ARTICLE INFORMATION

ABSTRACT

The Nuba Mountains in the South Kordofan State of Sudan are endowed with a tremendous legacy of traditional knowledge and rich diversity of tree species and related products that are used for domestic purposes, as income sources, and for export. The objective of the present study was to assess the importance of traditional knowledge in the management of forests and their products for improved livelihoods of the local communities in the state. The study was conducted at the Kalogi locality in the Eastern Nuba Mountains. The area is covered by several isolated hills surrounded by clay and sandy Kalogi-clay plains characterized by a number of natural seasonal watercourses and good natural drainage. A participatory rural appraisal survey was carried out whereby focused group discussions and interviews were conducted in a number of villages. Data and information on indigenous trees, their relative importance, and values in relation to the livelihoods of the local peoples were collected. The results showed high diversity in forest types and species and a wide variety of NWFPs belonging to 24 different families. The frequency indices for a number of species range between 64-70 percent. The study has determined the number and percentage of woody species in each use category. In this respect, the study showed that the species with the highest use-value were mainly the gum-producing species, namely *Acacia senegal, Acacia seyal,* and *Acacia polyacantha,* in addition to some food and medicinal plants. Important Value Indices (IVI) as high as 0.95 for edible fruits, medicinal materials, and gum products were reached. The importance of the different tree species as measured by fidelity level for a particular usage by the local people was also determined.

INTRODUCTION

South Kordofan State lies between latitudes 10º 25′ and 11º 15′ N; longitudes 29º 25′ to 32º E. The state covers an area of about 135,000 km² encompassing 16 localities, namely: Algoz, Gadeer (Kalogi), Heban, Talodi, Alleri, AbuGibeiha, Kadogli, Habela, Dalami, Alboram, Altadamon, Rashad, Alabassia, AlDalang, Eastern countryside, Um Dorein). It has a total population of about 1.4 million. The annual rainfall varies between 500-800 mm, with peak heavy rains in August. The average relative humidity is about 16% in the summer season in March and reaches up to 80% during the peak rainy season in August. The mean maximum temperature in the hot months of March, April, and May is about 39˚C, with a peak in May. The mean minimum temperature varies from 17˚C in January to more than 20˚C at the onset of the rains (SKDP, 2000).

The soil in the state is sandy in its northern parts and clayey, characterized by heavy cracks, in the southern plains of the Nuba Mountains. The sandy soils cover an area of about 50% of the cultivable land, while the clay soils cover only 40%. The sandy are deep, containing coarse to fine sand with low organic matter. The clay soils are dark vertisols, low in nitrogen and phosphorus. Interspaced silt depressions with sandy clays are prevalent in the area and cover about 10% of the total cultivable land (IFAD, 2007). Traditional knowledge has been and is still used by rural communities, especially farmers and pastoralists in Sudan, in the management and rational use of natural resources as food, source of income, and for medicinal purposes. In this respect, some coping strategies were outlined by El Siddig (2001); Abdel Magid and Badi (2002), and Ballal et al. (2014). Examples of local community management of *Acacia senegal* for sustainable production of gum arabic and agricultural crops were given by Ballal et al.,

(2008). However, the existence of a huge heritage of traditional knowledge that has not been explored, especially in the Western Nuba mountains of South Kordofan state, makes the need for exploring that knowledge for revival and improvement by researchers for the benefit of the disadvantaged small farmers and collectors of forests products, of paramount importance.

Therefore, the objectives of the present study were to assess the role of traditional knowledge in improving the livelihoods of the local communities. To achieve this, frequency index (F), the use-value index (UV), and fidelity levels (FL%) for the species and products were determined.

MATERIAL AND METHODS

Study area

This study was carried out at the Kalogi district in the western Nuba Mountains of South Kordofan State (Fig.1). The study area is covered by several isolated hills surrounded by clay and Gardud plains. It is also dissected by a number of seasonal watercourses and is characterized by good natural drainage. According to Harrison and Jackson (1958), the vegetation of the area is characteristic of the so-called special areas of the low rainfall woodland savanna zone. The overstory is endowed with multi-purpose broad-leaved savannah woodlands. The dominant vegetation is typical of the Acacia Seyal-Balanitessavannah zone. The rest of the vegetation is characteristic of the hill catena where *Anogeissus leiocarpus*, *Combretum* spp., *Acacia senegal* and *Acacia polyacantha* cover the high lands. *Borassus aethiopum*, *Cordia africana* and *Terminalia laxiflora* typifies the vegetation of the fertile low land areas, while *Oxytenanthera abyssinica* and *Diospyros mespiliformis* are the most important species along seasonal watercourses (Ballal et.al., 2014).
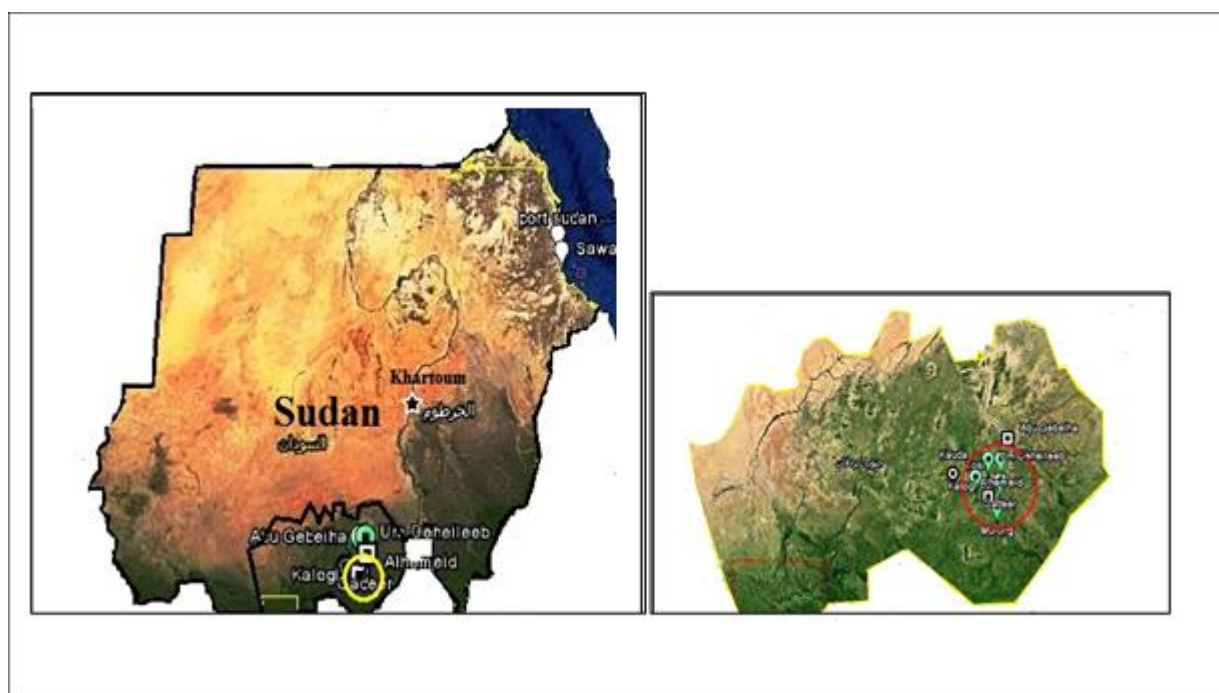
Figure 1. Map of the study area.
Source: Google Earth 2010.

Information regarding the traditional uses of forests products was collected through a social survey. A Rapid Rural Appraisal (RRA) survey was conducted with emphasis on focused group discussions and interviews. Semi-structured interviews were conducted with 65 informants from four villages, namely: Gadeer, Morong, Tosi, Umdiheileeb, including Kadogli, which is the locality capital. Before commencement of the survey, the households' respondents were enlightened about the objectives of the survey and the purpose of the mission through the leaders of the target villages in order to guarantee their involvement and agreement. The interview was designed to provide data on local names of plants and their uses and mode of utilization; the plant parts used; products collection methods; threatening factors to sustainable production; conservation efforts; and endangered species. The social information that is collected includes the names, sex, age, occupation, marital status, and education level of the interviewed persons. Samples of plants' specimens were collected for taxonomic identification and further authentication using standard keys of written floras such as Andrews (1950); (1952) and (1956); and Elamin (1990). Voucher specimens were deposited at the Herbarium of the Forestry and Gum Arabic Research Centre. The botanical names were updated according to the standards of the plant lists and plant families and arranged according to Angiosperm Phylogeny group version four (APG 4).

Data analysis

Frequency index: The frequency index is a mathematical expression of the percentage of frequency of mentioning a single botanical species by informants. The following formula was used to calculate the frequency index:
FI = FC/N × 100
where FC is the number of informants who mentioned the use of the species, and N is the total number of informants (Madikizela et al., 2012).
Use-Value index (VU): Use Value (UV), developed by Phillips and Gentry (1993), is computed to provide a quantitative measure for the relative importance of species. The

UV is calculated as the number of different uses of each species: UV = ΣUi/N. It is calculated by the total number of uses of a plant mentioned by a participant (U) divided by the total number of participants in the study.

Fidelity level (FL%): The importance of a certain plant species for a particular usage was quantified using the fidelity level (FL). FL

was calculated as FL (%) = (Np/N) × 100, where Np is the number of informants that claim the use of a plant species for a particular use, and N is the number of informants that use the plants for any given use category (Tugume et al., 2016).

The statistical analysis of the data was carried out using IPM SPSS statistical package21. Ink package and Microsoft Excel 2007.

RESULTS AND DISCUSSION

Socio-demographic information

Rural communities in target villages use tremendous diversified woody flora in various aspects of their lives. This is much dependent on their rich heritage of traditional knowledge on the use of woody plants. The demographic information revealed that most (92.3%) of the informants are male. The age distribution showed that 20% of the interviewees were young, with an average age of between 20-30 years. However, 27.7% of respondents were

between 30 and 40 years of age, while 26.2 % were above 50 years of age. With respect to education, 18.5% of the informants had a preschool education and about a similar number attended primary schooling. However, the majority attended secondary school education and a significant number (29.2%) were university graduates (Figure 2). This high level of education in rural areas is a reflection of the recent boom in the establishment of a number of new universities and colleges in all of the States of Sudan.

(a)

(b)
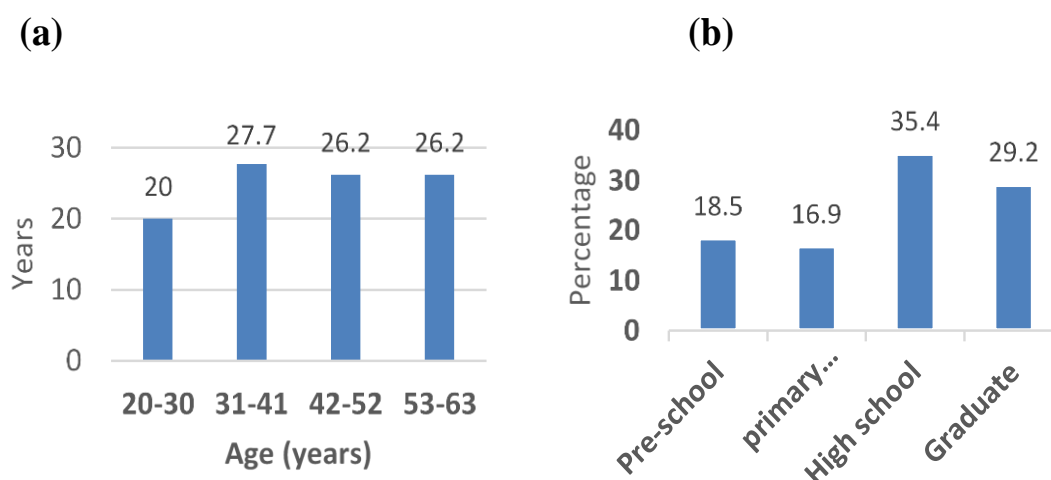
Figure 2. Age distribution(a) and Education level (b) of respondents in South Kordofan.

Taxonomic diversity and use value

A total of 60 plant species belonging to 24 different families were recorded in the current study. The family Fabaceae was the most represented family with 18 different species, followed by Malvaceae,

Combretaceae, and Capparaceae where each of them was represented by four species. However, Meliaceae and Anacardiaceae were represented by three species each. On the other hand, the rest of the families were represented by less than three species (Fig. 3). Moreover, the frequency index

calculation showed that the species with the highest frequency indices (FI) included *Balanites aegyptiaca* (78.6*%), Adansonia digitata* (70%), *Acacia senegal* (68.6%), *Acacia seyal* Del. var. seyal (67.1%), and *Ziziphus spina-christi* (64.3%) as the most frequently cited or acknowledged by the local communities (Table1). Generally, the most cited species by the local people belong to the family Fabaceae. This result is in line with the findings of Arévalo-Marín et al. (2015) with respect to high citations from this family amounting to 12 recorded species constituting 30.7% of the total number of cited species.

With respect to the use of the different species as depicted from the Use-Value index (UV), the results revealed that the species with the highest UV were: *Acacia seyal* (0.12), *Acacia senegal* (0.11), and *Acacia polyacantha* (0.11) representing the highest number of plants uses of all species documented. However, *Annona senegalensis*, *Crativa adansonii*, *Ficus thonngii*, *Oxytenanthera abyssinica*, *Salvadora persica, Detarium microcarpum* and *Croton zambesicus* recorded the least value (0.02) of UV and lowest number of uses and hence they were not included in the previous table that shows only the species of high FI and UV. In this respect, Ballal et al. (2014) confirmed that the high diversity in forest types and species has resulted in a wide variety of NWFPs in South Kordofan State as reflected in the wide variety of edible fruits, gums, oil seeds, medicinal materials, honey and a number of secondary forest products. These authors found a high Important Value Index (IVI) as high as 0.95 for edible fruits, medicinal materials, and gum products.

Fidelity level (FL%)

Fidelity level (FL%) is used to quantify the importance of a certain plant species for a particular usage by the local people. Accordingly, a number of woody plants with high fidelity levels were reported for diverse uses. In this respect, *Acacia senegal* (L.) Willd., Adansonia *digitata* Linn., *Grewia tenax* (Forsk.) Fiori., *Sterculia setigera* Del., *Tamarindus indica* L., and *Ziziphus spina-christi* (L.) Desf., were all reported as contributing to family food with FL% greater than 35%. The main reported medicinal plants were: *Acacia nilotica* subsp. *Adstringens, Acacia senegal* (L.) Willd., *Adansonia digitata* Linn., *Boswellia papyrifera* (Del.), Hochst, and *Tamarindus indica* L.The FL% of the medicinal plants ranges between 33.7-44.2%. However, the main species used as crafts were represented by *Bauhinia reticulata* DC., *Dalbergia melanoxylon* Guill. & Perr., *Hyphaene thebaica* (Linn.) Mart., *Sclerocarya birrea* (A. Rich.) Hochst., *Terminalia laxiflora* Engl. & Diels Monogr. However, the FL% of these wood-based crafts ranges from 20-25%. Other important and diverse tree species that are widely utilized by local communities for domestic consumption as food and for other purposes and for sale were previously highlighted by Ballal (2011).

On the other hand, various domestic uses of wood products such as timber, fuel, fodder, fence, smoke, and tannin were satisfactorily obtained from species such as *Acacia nilotica* subsp. *Adstringens* (FL%=50.0), *Acacia polyacantha* Willd. (*FL%=* 52.5) *Acacia seyal* Del. var. seyal (*FL%=* 69.8), *Balanites aegyptiaca* (L.) Delile (FL%= 45.1*), Boswellia papyrifera* (Del.) Hochst. (FL%= 50.0), *Dalbergia melanoxylon* Guill. & Perr. (FL%=79.2), *Dichrostachys cinerea* (L.) (FL%=63.4), *Sclerocarya birrea* (A. Rich.) Hochst. (FL%= 40.5), and *Terminalia laxiflora* Engl. & Diels Monogr. with FL%= 48.2.

Annona senegalensis is used as fuel, *Crativa adansonii* for crafts**, *Ficus thonningii* as food, *Oxytenantera abyssinica* as a building material, *Salvadora persica* for crafts, *Detarium microcarpum* and *Croton zambesicus both* for medicinal purposes each species cited with FL% = 100% for its

particular use respectively (Table 1). On the other hand, low FL% values were obtained for species with several uses such as *Adansonia digitata* (0.87) for building material, *Acacia senegal* (2.97) for hand crafts, *Anogeissus leiocarpa (4.84%)* as fodder, *Grewia tenax* (6.1) for crafts and *Acacia seyal* (5.92) for crafts and as a smoke wood for women's skin beauty. It is obvious that the FL% values decrease with the increase in plant use. These results were in line with the fact that high values of FLs (100%) are usually recorded for plants for which almost all use-mentions refer to the same purpose, that is, the plants (and their use for a particular purpose) are most preferred, whereas low FLs are generally obtained for plants that are used for many different purposes (Ong and Kim, 2014).
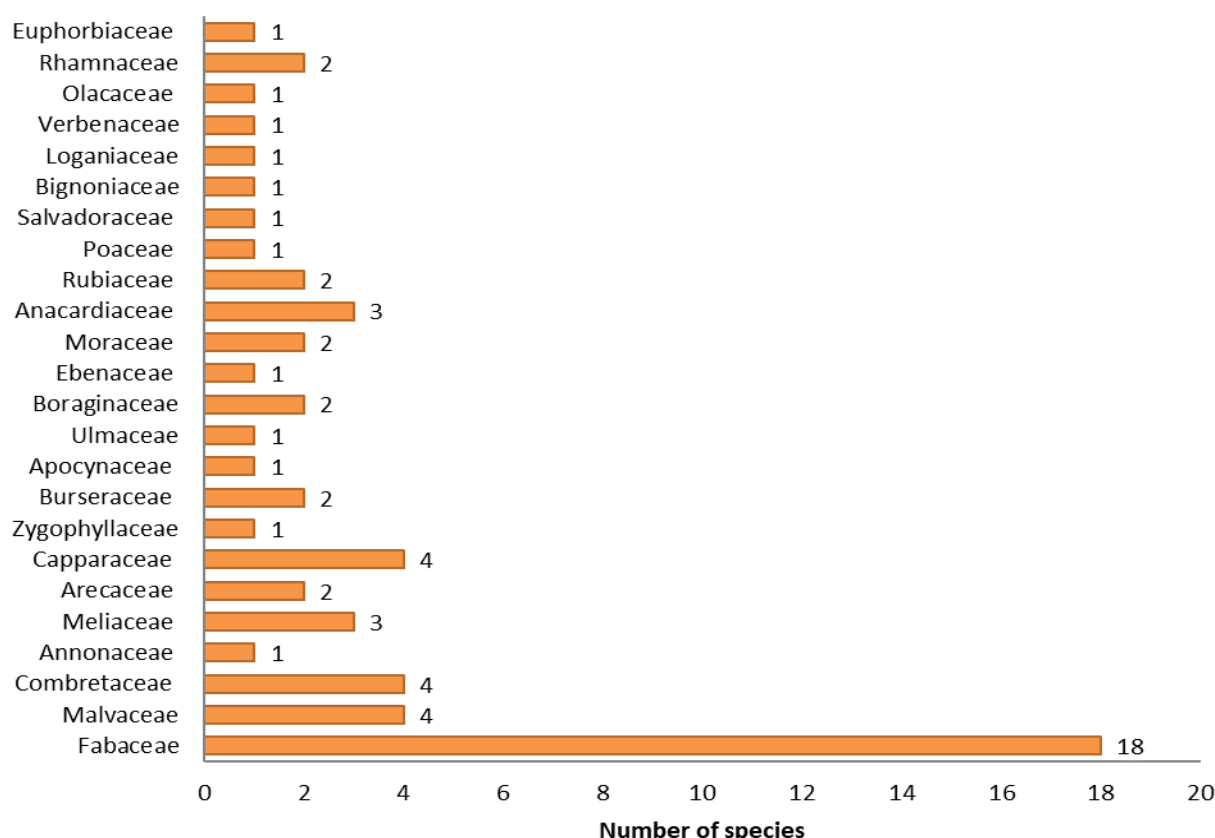
Figure 3. The relative number of species per family.

It is important to note that the majority of identified species were used for construction or building (75%), medicine (71.7), Fuel (70%) utensils and handicrafts (68.3%), food (51.7%), and Fodder (31.7%). However, small percentages were used as smoke wood (8.3%), fencing material (5%), and tannin (1.7%). Generally, most of the species (about 40 plants) produce building material for various construction purposes. About a similar number of plants were locally used as medicine, fuelwood, and in manufacturing different handicrafts. A considerable number of species, about 31, produce edible fruits for food and/or beverages. Moreover, 19 species were used as fodder while the rest (1-8.3%) were used for producing tannin, fencing material, and smoke wood for the local sauna (Fig. 4).

Table 1. Frequency index (FI), Use value (UV), Fidelity levels (FL), and Used parts of plant species used for various uses by key informants

Species	Frequency index (FI)	Use-value (Index UVs)	Fidelity index (%0				Part(s) used
			Food	Medicine	Handcrafts	Domestic use of wood products	
Acacia nilotica subsp. *Adstringens.*	22.9	0.08		42.1	7.89	50.0	Wood, Leaves, Fruit, Flowers
Acacia polyacantha Willd.	18.6	0.11	27.5	12.5	7.5	52.5	wood, Gum, Leaves, Fruits
Acacia senegal (L.) Willd.	68.6	0.11	38.6	33.7	2.97	24.7	Gum, Wood, Leaves, Branches
Acacia seyal Del. var. seyal	67.1	0.12	13.8	10.5	5.92	69.8	Gum, Wood, Leaves, Branches.
Adansonia digitata Linn.	70	0.06	42.6	39.1	17.4	0.9	Fruits, Leaves, Bark
Bauhinia reticulata DC.	40	0.09	34.7	21.3	20	24.0	Fruit, Wood, Leaves
Balanites aegyptiaca (L.) Delile	78.6	0.09	22.3	22.8	9.82	45.1	Fruits, Wood, Leaves
Boswellia papyrifera (Del.) Hochst.	37.1	0.06		44.2	5.77	50.0	Wood, Leaves, Bark, Gum
Dalbergia melanoxylon Guill. & Perr.	18.6	0.05			20.8	79.2	Wood, Leaves
Dichrostachys cinerea (L.)	21.4	0.08		31.7	4.88	63.4	Wood, Fruits, Leaves, Bark
Grewia tenax (Forsk.) Fiori.	54.3	0.08	43.9	30.5	6.1	19.5	Fruits, Wood
Hyphaene thebaica (Linn.) Mart.	51.4	0.09	23.8	21	24.5	5.1	Fruits, Leaves, Wood
Sclerocarya birrea (A. Rich.) Hochst.	42.9	0.09	23.8	14.3	21.4	40.5	Wood, Fruits, Leaves
Sterculia setigera Del.	7.14	0.06	50	25	12.5	12.5	Gum, Wood
Terminalia laxiflora Engl. & Diels Monogr.	15.7	0.08		29.6	22.2	48.2	Wood
Tamarindus indica L.	57.1	0.08	51.9	35.1	3.9	9.1	Fruits, Leaves, Wood
Ziziphus spina-christi (L.) Desf.	64.3	0.09	28.5	22.5	15.9	33.1	Wood, Fruits, Leaves,
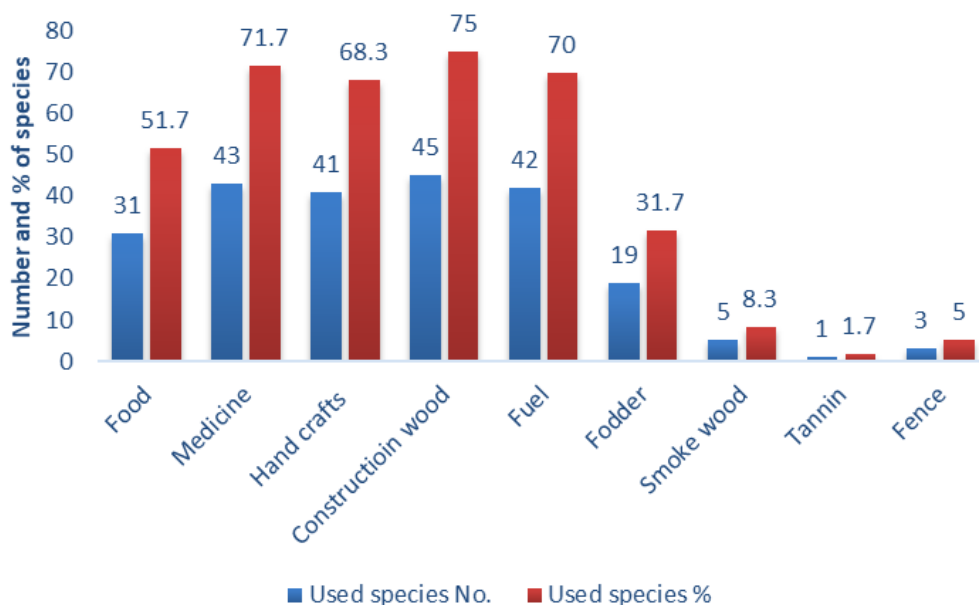
Figure 4. Number and percentage of woody species in each use category.

With respect to collection methods of usable plant parts, as stated by respondents, the results showed that the products of 37% of the woody species were obtained by full or partial cutting of plant parts for the different uses, namely: building material, domestic utensils, and crafts, and for energy, etc. The woody species referred to were: *Acacia seyal*, *Acacia seiberiana*, *Dalbergia melanoxylon*, *Faidherbia albida*, *Khaya senegalensis*, *Oxytenanthera abyssinica*, *Prosopis africana*, *Cordia africana*, *Pseudocedrela kotschyi,* etc.,

which are listed as endangered species (Fig. 5). The products of a considerable number (28) of these species were obtained by picking especially the trees that produce edible fruits such as *Adansonia digitata, Borassus aethiopum, Balanites aegyptiaca, Bauhenia reticulatum, Grewia tenax*, *Cordia afri*such as *Adansonia digitata* for making ropes*,* and other medicinal plants. Several woody species produced more than one used part; hence these species may be subjected to a number of collection methods at the same time.
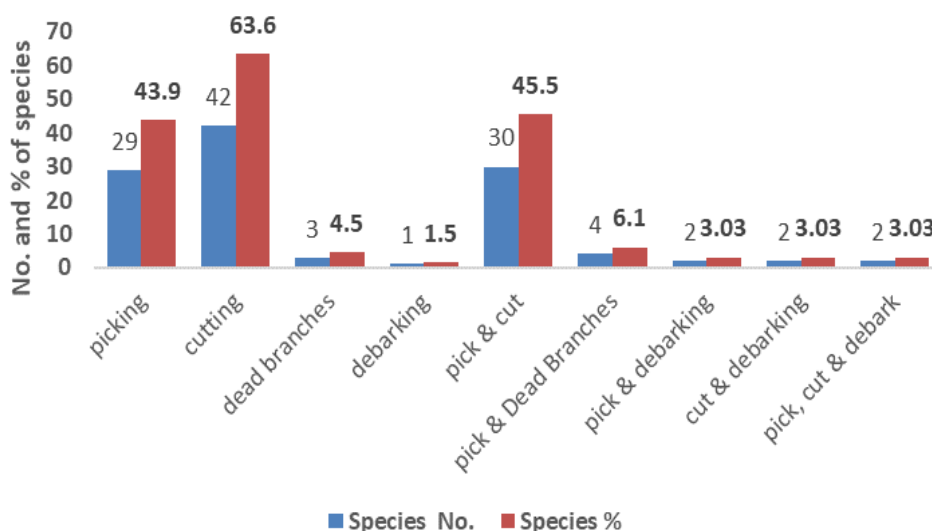
Figure 5. Collection methods for different woody species.

CONCLUSION

The main findings of this study revealed that the species with the highest use-value were mainly the gum-producing tree species, namely *Acacia senegal, Acacia seyal,* and *Acacia polyacantha,* in addition to some food and medicinal plants. Important Value Indices (IVI) as high as 0.95 for edible fruits, medicinal materials, and gum products were reached. The importance of the different tree species as measured by fidelity level for a particular usage by the local people was also determined.

Declaration of Competing Interest

We, as the authors, declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Abdel Magid, T.; Badi, K. Forest related traditional knowledge (report *in Arabic*). Forests National Corporation (FNC), Khartoum, 2002, 1-79.

Arévalo-Marín, E. A.; Lima, J.; Palm, A.; Reinaldo Farias Paiva de Lucena, R, F, P.. Traditional Knowledge in a Rural Community in the Semi-Arid Region of Brazil: Age and gender patterns and their implications for plant conservation. Ethnobotany Research and Applications. · December 2015, 331-344.

Ballal, M. E. Formulating a strategy for production, value addition and marketing of products from arid and semi-arid lands in Sudan. Ed. Edited by Muchina Munyua, S. J. and Mbiru S. Sudan report for: Intergovernmental Authority on Development (IGAD), 2011, 1-76.

Ballal, M. E.; Talaat, A.; Hamid, A. A. Forest-related traditional knowledge with emphasis on Acacia Senegal bush-fallow systems in the Sudan. Special issue on the occasion of: The Joint Meeting of the African Forestry and Wildlife Commission (AFWC) and the Near East Forestry Commission (NEFC). *Sudan Silva*. 2008, X1 (1), 67 –77.

Ballal, M. E.; Salih, N. K.; Abdel Magid, T. D. Ethno-botany of natural forests of Nuba mountains, South Kordofan, Sudan. *Journal of Forest Products and Industries*. 2014, 3(1), 13-19.

El Amin, H. M. Trees and shrubs of the Sudan. Ithaca Press, 1990, 1-484.

El Siddig, A. A. Community based natural resources management in Sudan. Report submitted to the regional IGAD workshop on CBNRM, Kenya, 2001, 142-170.

Harrison, M. N.; Jackson, J. K. Ecological classification of the vegetation of the Sudan. Forests Bulletin No. 2 (new series). Agricultural Publications Committee, Khartoum, 1958, 1-44.

IFAD. Greater Kordofan Diagnostic Survey Report, Conducted for Western Sudan Natural Resources Management Programme by a multi-disciplinary team from El Obeid and Kadugli Research Stations. 2007, 1-156.

Kankara, S. S.; Ibrahim, M. H.; Mustafa, M.; Go, R. Ethnobotanical survey of medicinal plants used for traditional maternal healthcare in Katsina state, Nigeria. *S Afr J Bot*. 2015, 97, 165–75.

Madikizela, B.; Ndhlala, A. R.; Finnie, J. F.; Van Staden, J. Ethnopharmacological study of plants from Pondoland used against diarrhea. *Journal of Ethnopharmacology*. 2012, 141, 61–71

Ong. H. G.; Kim, Y. D. Quantitative ethnobotanical study of the medicinal plants used by the Ati Negrito indigenous group in Guimaras island, Philippines. *Journal of Ethnopharmacology*. 2014, 157 (2), 28–242.

Philips, O.; Gentry, A. H. The useful plants of Tambopata, Peru: I. statistical hypotheses tests with a new quantitative technique. *Economic Botany*. 1993, 47, 15–32.

SKDP., Southern Kordofan development program, volume (1), main report. January 2000. IBID, I- XIII.

Tugume, P.; Kakudidi, E. K.; Buyinza, M.; Namaalwa, J.; Kamatenesi, M.; Mucunguzi, P.; Kalema, J. Ethnobotanical survey of medicinal plant species used by communities around Mabira central Forest reserve, Uganda. *J Ethnobiol Ethnomed*. 2016, 12(5), 1-28.

Journal of Agriculture & Forestry Research
Volume no. 1, Issue no. 2, Year 2021
www.sarpo.net

Research Article

Open access

Marketing and Utilization of *Dacryodes edulis* (G. Don) H.J. Lam) in Makurdi Local Government Area of Benue State, Nigeria

Leoskali Nguuma Sambe[1*], Nguemo Anita Aondoana[2], Lucia Nkiru Nsiogu[3]

[1,3] Department of Social and Environmental Forestry, Joseph Sarwuan Tarka University, Makurdi, Benue State

[2] Ministry of Environment and Water Resources, Department of Forestry, Benue State

ABSTRACT

The study was conducted to determine the marketing and utilization of *Dacryodes edulis* in Makurdi metropolis, Benue State, Nigeria. Purposive sampling and simple random sampling techniques were used to elicit data from respondents. A semi-structured questionnaire was used to collect relevant information from marketers of *Dacryodes edulis* fruit. Descriptive statistics, Gross margin, and Gini coefficient were used to analyze the result. The study established that the basic uses of *Dacryodes edulis* fruit in Makurdi metropolis are as a source of food, medicine, and income. The majority of the marketers (61.5%) do not belong to any association while 38.5% indicated they belong to one association or another. The marketing of *Dacryodes edulis* is a profitable business venture that is mostly dominated by a female. Weekly profits made from the marketing of *Dacryodes edulis* in the three markets sample (Wurukum Market, Modern Market, and Wadata Market) are ₦ 29,842, ₦ 29,727, and ₦ 27,830 respectively. Marketing of *Dacryodes edulis* is faced with the challenges of perishability, poor transportation facilities, and lack of capital. To address the problem of capital, marketers of *Dacryodes edulis* should form co-operatives as this would increase their opportunities in accessing loans from financial organizations.

INTRODUCTION

The African pear tree (*Dacryodes edulis* (G.Don) H.J.Lam; Burseraceae) is a tropical oleiferous fruit tree that possesses enormous potential in Africa (Kengué, 1990). It is a non-timber forest product (NTFP) that has in many areas made a transition from the forest to the farm and it is commonly cultivated in agroforestry systems as a shade provider and secondary crop in cocoa and coffee farms

(Okafor *et al.,* 2002). The fruits are edible, and the bark; leaves, stems, and roots are employed for a variety of purposes (Waruhiu et al. 2004). The fruit pulp may be cooked (softened) or eaten raw. The cooked flesh of the fruit has a texture similar to butter (Enujiugha, and Ayodele, 2005). *Dacryodes edulis* is a delicacy among the people of Nigeria where it is consumed as an accompaniment with fresh maize (Onuegbu, 2000; Agbogidi and Eshenbeyi, 2006), while the fruits are sold in local markets and, to some level, have attracted international trade (Ajibesin, 2011). The scientific researches on *Dacryodes edulis* on the nutritive value of its pulp and its oil (Ajayi et al., 2006), and the oil extraction processes (Kapseu, 2009) have revealed excellent nutritional qualities of fruit pulp and interesting food processing properties of the oils extracted from the pulp and kernel of *Dacryodes edulis* (Poligui et al., 2013). The pulp, the only edible part of the fruit is particularly rich in lipids, indicating that *D. edulis* could be an important source of oil (Ondo-Azi et al., 2013). Besides lipids, the pulp contains substantial amounts of many other nutrients including proteins, carbohydrates, minerals, vitamins, and fibers (Poligui et al., 2013).

The wood of *Dacryodes edulis* has general use for carpentry, tool handles, and occasionally for construction, the stem exudates serve as glue and cosmetic components while the plant improves soil quality and contributes greatly to traditional medicines (Ajibesin, 2011). The gathering of the fruits of *Dacryodes edulis* serves as a veritable source of employment and income for the rural populace (Agbogidi and Eshegbeyi, 2006). *Dacryodes edulis* fruits like most fruits are highly perishable due to the ease of spoilage by microorganisms resulting in a short shelf-life of about 3-5 days (Onuorah et al., 2001). This has led to huge losses and market glut during harvest as noticed by large heaps of unsold rotten fruits in the refuge dumps or sites of villages and urban markets when the supply of a good or service far exceeds its demand, usually resulting in a substantial fall in its price in the market (Nwanekezi, 2007). This problem of perishability has an effect on the marketing efficiency of the fruit because marketers are often compelled to sell their fruits at a very low price to avoid huge wastage or total loss (Awono et al., 2002).

The Marketing of Non-Timber Forest Products (NTFPs) is reported to be characterized by an inefficient marketing system. The problems of poor marketing facilities, transportation cost, seasonality of products, crude storage and processing, supply and demand constraints, consumer preferences, and inefficient pricing systems have characterized the trade (Awono *et al.*, (2002); Busari Ahmed et al., (2015); Fon Dorothy and Mbondji Ntombe (2018); Meinhold and Darr (2019). An efficient marketing system is vital to sustain profitability and promote the provision of jobs and income and thus drastically reduce poverty. According to Pandey *et al.*, (2016) and Nzeh et al., (2015), the market of NTFP is extremely imperfect, unstructured with complex value chains and multiple stages and actors involved in the process of getting a product from forest to consumer. They are also dynamic and change over time and as such information about the quantity and quality of the product, price and market are very important.

With increasing population pressure, the upsurge of demand and commercial value for this multipurpose forest fruit tree species, as well as the seasonality of fruit production and the inability of the fruits to store well for a long period of time (Onuegbu, 2000, Shackleton and Pandey, 2014), it is important to study the socioeconomic benefits derivable from the tree species. According to Ingram and Bongers (2009) the contribution of NTFPs to the subsistence economy and to food security, to the national economy as a source of employment and for trade and exports, is missing in forestry and economic statistics. The paucity of information on NTFPs is reflected in the lack of policy attention, conflicting regulatory and policy frameworks, and a lack of support for trade in

these products (Tahir et al., 2004; Belcher, 2005; Ingram and Bongers, 2009).

Therefore, adequate knowledge and information regarding the capacity of *Dacryodes edulis* to contribute significantly to the improvement of the economic status local population and providing a safety net can important for food security. This study specifically identified the various uses and marketing channels of *Dacryodes edulis*, determined the market structure and performance and income accrued in the marketing of *Dacryodes edulis,* and identified the challenges of its marketing system Makurdi Local Government Area.

MATERIALS AND METHODS

Study area

The study was carried out in Makurdi Local Government Area, one of the twenty-three Local Government Areas in the Benue State of Nigeria. Makurdi Local Government Area is the headquarters of Benue State, Nigeria. It lies between longitude 8^0 and 9^0 East and between latitude 7^0 and 8^0 North in the middle belt region of Nigeria. The climate of Makurdi town is the tropical wet and dry type, Koppen's Aw classification, with double maxima (Ayoade, 1983). The rainy season lasts from April to October, with 5 months of the dry season (November to March). Annual rainfall in Makurdi town is consistently high, with an average annual total of approximately 1173 mm (Abah, 2012). The temperature in Makurdi is, however, generally high throughout the year, with February and March as the hottest months. The temperature in Makurdi varies from a daily of 40 °C and a maximum of 22.5 °C (Ologunorisa and Tor, 2006). The vegetation of Makurdi town is the guinea savannah type. This vegetation type has been adversely affected by human activities leading to the clear-cutting of tree cover in many parts of the town. Due to this, artificial vegetation has replaced natural secondary vegetation. Makurdi town is inhabited by many tribes

with a population of 297,398 to 157,295 males and 140,103 females (FGN, 2007). These tribes include the Tivs, Idomas, Etilos, Jukuns, Egede, Hausas, Yorubas, and Ibos. The Tivs are the dominant tribe. Makurdi town is made up largely of people who engage in civil service duties, commercial activities, and agrarian peasantry. Makurdi town is a built-up area with the highest concentration of people in high level and Wadata. A dense population also exists in some low-lying parts of the town such as Wurukum.

Population and sampling procedure

The population is comprised of marketers of *Dacryodes edulis* within Makurdi Metropolis. The study was carried out in three markets purposively selected based on the availability of *Dacryodes edulis* in such markets. The purposively selected markets were; Wurukum Market, Wadata Market, and Modern Market respectively. Thus, 57 marketers from Wurukum Market, 53 marketers from Wadata Market, and 33 marketers from Modern Market were sampled making a total of 143 marketers using the Taro-Yamane formula. The formula is shown below:

$$n = \frac{N}{1+N(e)2}$$

Where:
n=corrected sampled size,
N= population size,
e = marginal of error (10%)

Data collection

Data for this research project were collected through oral interviews and the administration of a semi-structured questionnaire. An oral interview was conducted with selected marketers of *Dacryodes edulis* in each of the three markets selected. A structured questionnaire was administered to one hundred and forty-three (143) marketers of *Dacryodes edulis* in the three selected markets. It was administered

to fifty-seven respondents in the Wurukum market, fifty-three respondents in the Wadata market, and thirty-three respondents in Modern market areas of Makurdi Local Government Area of Benue State.

Data analysis

The data collected was analyzed using descriptive statistics such as frequency, percentages and mean, and tables. SPSS Statistics Version 20 was used to analyze the data. The Gross Margin analysis was applied to determine the profitability of *Dacryodes edulis* marketing. Gini – coefficient was used to determine the total quantity of *Dacryodes edulis* sold in the markets.

Determination of gross margin

Gross margin is determined mathematically using the formula:

GM = GI – TVC

Where:

GM = Gross Margin

GI = Gross Income

TVC = Total Variable Cost

Determination of market concentration

Gini – Coefficient is determined by the formula:

G = 1 - ∑XY …………………………………………. 1

Where:

G = Gini-coefficient

X = Cumulative percentage of sellers

Y = Cumulative percentage of sales

NOTE: G has a value ranging from 0-1 expressing the extent to which the market is concentrated. When G = 0, there is perfect equality in the size of the distribution of sellers, but when G = 1, there is inequality in the size of sellers.

RESULTS

Socio-economic characteristics of respondents in the study area

The result revealed that the majority of the marketers (80.4%) were female and only 19.6% were male. Most respondents in the study area were between 41-50 years (50%), only 7% were less than 20 years, 16% were between 21-30 years, 27% were between 31-40 years and 14% were less than 50 years (Table 1). In terms of marital status as a greater proportion (68.5%) of the result were married while 31.3% were single. In terms of educational level, the majority of the respondents (37.8%) of the respondents had informal education, this is by followed primary education (32.9%), secondary education (26.6%) while only 2.8% had tertiary education. Based on years of experience of the respondents, a greater proportion of the respondents (32.9%) had between 5-10 years of experience in *Dacryodes edulis* marketing, 31.5% had 10-15 years of experience, 16.1% had less than 5, 12.6% had 15-20 years, while 7.0% had marketing experience greater than 20 years.

Various uses of Dacryodes edulis

From Table 2 it is revealed that a higher proportion (72.7%) uses it for food, 23.78% use it for medicine while only 3.5% indicated that they use it for oil extraction.

Table 1. Socio-economic characteristics of respondents.

Socio-economic characteristics	Frequency	Percentage (%)
Gender		
Male	28	19.6
Female	115	80.4
Total	**143**	**100.0**
Age		

>20	10	7.0
21-30	24	16.8
31-40	39	27.3
41-50	50	35.0
<50	20	14.0
Total	**143**	**100.0**
Marital Status		
Single	45	31.5
Married	98	68.5
Total	**143**	**100.0**
Edu. Status		
Primary	47	32.9
Secondary	38	26.6
Tertiary	4	2.8
Informal	54	37.8
Total	**143**	**100.0**

Table 2. Various uses of *Dacryodes edulis*

Variables	Frequency	Percentage (%)
Food (fruit)	104	72.7
Medicine (leaves and bark)	34	23.78
Oil extraction (seed)	5	3.5
Total	**143**	**100**

Membership of the market association

The result from Table 3 indicated that the majority (61.5%) of the traders do not belong to the association while only 38.5% are members of the association.

Table 3. Respondents' membership in the association

Membership in Association	Frequency	Percentage (%)
Yes	55	38.5
No	88	61.5
Total	**143**	**100.0**

Nature of business

Table 4 shows that 51.0% of the marketers of *Dacryodes edulis* are involved in a retail business, 30.8% are involved in Wholesale while only 18.2% are into both wholesale and retail business.

Table 4. Nature of business of *Dacryodes edulis* marketers in Makurdi LG

Nature of Business	Frequency	Percentage
Retail	73	51.0
Wholesale	44	30.8
Wholesale and Retail	20	18.2

Sales and supply period

The highest period (62.2%) of *Dacryodes edulis* supply is obtained between January and March followed by April to June (26.6%) while the least supply period (11.2%) is from July to September (Table 5).

Table 5. Sales and supply period of *Dacryodes edulis*

Variables	Frequency	Percentage (%)
Period supplied most		
Jan – March	80	55.9
April – June	59	41.3
July – Sept	4	2.8
Total	**143**	**100.0**
Period sold most		
Jan – March	89	62.2
April – June	38	26.6
July – Sept	16	11.2
Total	**143**	**100.0**

Market concentration in Dacryodes edulis marketing in Makurdi LGA

Table 6 shows the result of the market concentration of *Dacryodes edulis* in the study area. The result indicates that the highest proportion of sellers 30.1% accounted for 30.1% of sales, this was followed by 25.9% sellers of accounting for 27.4% of sales, 23% of sellers accounted for 21.4% sales while the least proportion of sellers (5.6%) possessed 7.3% of sales at the market weekly.

Table 6. Gini-coefficient analysis of *Dacryodes edulis* sales in Makurdi LGA

Sales	Frequency	Percentage of Sellers X	Cumulative % of Sellers	Total Sales	Percentage of Sales	Cumulative % of Sales Y	XY
200001.00-400000.00	37	25.9	25.9	999000	27.4	27.4	0.0709
400001.00-600000.00	43	30.1	55.9	1100000	30.1	57.5	0.1715
600001.00-800000.00	22	15.4	71.3	503500	13.8	71.3	0.1090
800001.00-1000000.00	33	23.1	94.4	783000	21.4	92.7	0.2141
1000001.00 +	8	5.6	100.0	265000	7.3	100.0	0.0560
Total	**100.0**	**100.0**		**3650500**	**100.0**		**0.6223**

GC = 1 - ∑XY = 1 − 0.6223 = 0.3777

Marketing channels of Dacryodes edulis in Makurdi LGA

As shown in Table 7, the majority of the respondents (38.5%) indicated that the channel used in the acquisition of the fruit is through farms gate middlemen, 30.1% 0f the

respondents indicated that they get the product through wholesales, 21.7% indicated that they obtain *Dacryodes edulis* directly from the farmers while only 9.8% of the respondents indicated that they get their product from neighboring states.

Table 7. Marketing channels of *Dacryodes edulis* marketing in Makurdi LGA

Variables	Frequency	Percentage (%)
Farmers	31	21.7
Farmgate middlemen	55	38.5
Wholesalers	43	30.1
Neighboring state	14	9.8
Total	**143**	**100.0**

Source: Field Survey, (2019)

Profitability of Dacryodes edulis marketing

At the end of each week, traders in Wurukum Market go home with ₦29, 842.11; similarly, the traders in Modern Market go home with ₦ 29,727.27 while those of Wadata Market go home with ₦ 27,830.19 (Table 8).

Table 8. Weekly profitability of *Dacryodes edulis* marketing in Makurdi LGA

Markets	No. of Traders	C.P (100kg)	S.P (100kg)	WQS	WVC	Total C.P	Total S.P	TVC	GM	GM/Trader
A	B	C (₦)	D (₦)	E	F (₦)	G (C x E) (₦)	H (D x E) (₦)	I (F + G) (₦)	J (H − I) (₦)	K(J/B) (₦)
Wurukum	57	23,500	26,500	570	9000	13,395,000	15,105,000	13,404,000	1,701,000	29,842.11
Modern	33	24,000	27,000	330	9000	7,920,000	8,910,000	7,929,000	981,000	29,727.27
Wadata	53	24,000	26,800	530	9000	12,720,000	14,204,000	12,729,000	1,475,000	27,830.19

NOTE: C.P = Cost Price, S.P = Selling Price, WQS = Weekly Quantity Sold, WVC = Weekly Variable Cost (Government Collection 5000 + Transportation 4000 = 9000), TVC = Total Variable Cost, GM = Gross Margin

T-Test analysis of gross margin of Dacryodes edulis marketing

Tables 9 and 10 show the T-Test analysis of *Dacryodes edulis* marketing in Makurdi Metropolis. The analysis indicated that the overall gross margin was significant but with no significant differences in the profit generated across the 3 markets.

Table 9. T-Test Analysis of Gross margin *Dacryodes edulis* marketing in Makurdi LGA

	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
GM	23.656	142	0.000*	38758.74126	35519.8782	41997.6043

*Significant at 5% level of probability

Table 10. T-Test for the three markets of *Dacryodes edulis* marketing sampled in Makurdi LGA

Market		T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference
						Lower
Wurukum Market	GM	14.416	56	0.000*	40163.15789	34582.2712
Modern Market	GM	10.451	32	0.000*	40284.84848	32433.0559
Wadata Market	GM	16.379	52	0.000*	36298.11321	31851.1963

Challenges in the marketing of Dacryodes edulis

Table 11 the lack of storage facilities (23.1%) has the major constraint facing the marketing of *Dacryodes edulis.* This was followed by Transportation (21.7%), lack of capital (21.0%), seasonal fluctuations (9.1%), high cost of tax (7%), sources of supply (14.0%) while the least challenge indicated was government policies (4.2).

Table 11. Challenges in *Dacryodes edulis* marketing

Variables	Frequency	Percentage (%)
Lack of storage facilities	33	23.1
Transportation	31	21.7
Lack of capital	30	21.0
Supply sources	20	14.0
Market price instability	13	9.1
Tax	10	7.0
Government policies	6	4.2
Total	**143**	**100.0**

Source: Field Survey, (2019)

DISCUSSION

The predominance of the female gender in the marketing of *Dadryodes edulis* could be because retailing requires a certain level of patience and it takes one or more days to finish the stock and also that most urban retailers are mostly women with stalls in the market or roadside sellers Nzeh et al. (2018).

Awono et al. (2002). According to Velde (2006), the dominance of women reason is that it requires few capital inputs for trading and also it tends to have low returns per unit and such reasonable incomes can usually only be achieved based on high volumes traded, for which capital to buy, store and transport products is needed.

The majority of the respondents being above 21 years of age implies that those most engaged in the marketing of *Dacryodes edulis* were adults and their involvement in the trade sustains their livelihood. This finding is in line with the submission of Okumadewa *et al.* (2000) that traders in this age group are productive and energetic with greater potential for better performance and to explore opportunities in their existing trade business. The greater number of respondents being married implies that *Dacryodes edulis* marketing serves as a source of income to marketers as marriage confers responsibility and thus helps them cater for their family needs (Akinbile, 2007).

The fact that the majority of the respondents have formal education defines their effectiveness towards their livelihood activities. Based on the years of experience of the respondents, a greater proportion of the respondents have long years of experience in the trade of *Dacryodes edulis* which means that most traders are involved in the marketing of *Dacryodes edulis* have been in the business for long and are quite experienced in the trade.

The use *Dacryodes edulis* mostly for food according to Onuegbu and Ihebiohanma (2008) is due to the important role it plays in the nutrition of the people. Dimelu and Odo (2013); Omonihinmin (2014); and Kadji et al. (2016) also reported that *Dacryodes edulis* is used for many purposes such as medicine, food, fed to livestock, vegetable oil, and fruit pulp.

The fact that the majority of the marketers are members of market associations implies that access to the market must be granted by the officials. The individual intending to become a trader follows a procedure by meeting with the officials to seek recognition as a member of the market.

The dominance of retailers in the trade can be explained by the fact that women are involved more in retailing generally because the work is usually within their area of residence while men are more concentrated in the wholesale trade (Awono et al., 2002, Fon Dorothy and Mbondji Ntombe 2018). Wholesalers buy products directly from producers in rural areas to resell in the wholesale markets in urban areas either directly to retailers or to sedentary wholesalers who are sometimes between wholesalers and retailers. The same people could play the role of wholesalers and retailers.

The reason most of the traders indicated that that supply is mostly between January to March implies that the supply and the selling period are within the same period and this is because *Dacryodes edulis* is a seasonal fruit and cannot be stored for a long time to sell it at a convenient time. The is in line with the finding of Agbonkolo *et al.* (2016).

The Gini-correlation of *Dacryodes edulis* marketing obtained in the study area was 0.3777. According to Tedro (1981) for relatively equitable distribution, the Gini-coefficient value should be between 0.20 and 0.35. UNDP reported that Gini-coefficient with high inequality typically lies between 0.5 and 0.7. This implies that Dacryodes *edulis* marketers were not able to control large proportions of supply or sales in the study area. As such, none could influence supplies by increasing or decreasing the quantity supplied. There is no formal setting to guide the determination of the price of *Dacryodes edulis* which means individual marketers can sell their products at the price they feel is fit provided the buyers agree to buy at that rate. Therefore, the marketing of *Dacryodes edulis* is determined and controlled by the forces of demand and supply. The high perishability of the fruit also makes it difficult to place a fixed price on the product. Each of the participant outputs was an insignificant part of the volume of trade in the market such that it could not affect market price. The overall structure of *D. edulis* market indicates that there are many small-scale traders such that

none could control the market. The individual dealers have little influence on the market price. Sambe (2015) and Enete (2008) made a similar observation with Timber Trade Analysis in Benue State, Nigeria, and Charcoal in Abia State, Nigeria.

There are mainly four marketing channels of *Dacryides edulis* in the study area. A farmer may sell his produce through farm gate meddle men for further distribution to wholesalers or sale directly to wholesalers. *Dacrydes edulis* can also be gotten from neighboring states like Enugu but this happens in rare cases. Mostly, *Dacryodes edulis is* obtained from Vandeikya and Kwande Local Government Areas of Benue State which presently stands as the dominant producers of the fruit in the State. The distribution channel from forest collector to urban wholesaler consists of middlemen that sell it to local traders which in turn sell it to the urban center and finally reach consumers.

The amount generated per trader in each of the markets suggests that the business is profitable since it is higher than the minimum wage presently in Nigeria. Agbokolor *et al*. (2016) reported a positive marketing efficiency greater than one in Imo State Nigeria while Ibeagwa et al. (2020) reported a profitability index of 0.43 (43%) and a Benefit-Cost Ratio (BCR) of 2.31 of NTFPs which all indicate moderate profitability and viability in Edo State respectively. He posited that this could be due to fluctuations in supply due to the seasonality of the products as well their high perishability and also because the demand for agricultural produce including NTFPs in many developing countries is inelastic and this affects the price and ultimately profitability.

This implies that lack of storage facilities, poor and high transportation network and cost and lack of capital are the major problems in the marketing of the products. This finding is in line with that of Ndubueze et al. (2018) that poor transportation network and perishability are the basic challenges in seasonal fruits marketing.

REFERENCES

Ajibesin, K. K. Dacryodes edulis (G. Don) H. J. Lam: A review on its medicinal, phytochemical and economic properties. *Research Journal of Medicinal Plant*. 2011, 5(1), 32- 41.

Atangana, A. R.; Asaah, E.; Tchoundjeu, Z.; Schreckenberg, K.; Leakey, R. R. B. Biophysical characterisation of *Dacryodes edulis* fruits in three markets in Cameroon. 2002, 106–118 pp.

Awono, A. O.; Ndoye, K.; Schreckenberg, H.; Tabuna, F. I.; Temple, L. Production and marketing of Safou (*Dacryodes edulis*) in Cameroon and internationally. *Market development issues. Forest, Trees and Livelihoods*, 2002, (12), 125-147.

Ayoola, P. B.; Adeyeye, A.; Onawumi, O. O.; Faboya, O, O. P. Phytochemical and Nutrient Evaluation of *Tetracarpidium conophorum* (African Walnut) Root. *International Journal of Research and Reviews in applied sciences*, 2011, 7(2),197- 202.

Ayuk, E. T.; Duguma, B.; Franzel, S.; Kengue, J.; Mollet, M.; Tiki-Manga, T.; Zekeng, P. Uses, management and economic potentials of *Dacryodes edulis* (Burseraceae) in the humid lowlands of Cameroon. *Economic Botany*. 1999, 53(3), 292-301.

Bakari, U. M.; Usman, J. Marketing of some selected vegetables in Yola-north and south local government areas of Adamawa State, Nigeria. *International Journal of Engineering and Science* 2013, 2(11), 2319-1805.

Belcher, B. M. Forest product markets, forests and poverty reduction. *International Forestry Review.* 2005, 7(2), 82-89.

Busari, Ahmed; idris-Adeniyi, K. M.; Lawal A. O. Food Security and Post-Harvest Losses in Fruit Marketing in Lagos Metropolis,

Nigeria. *Discourse Journal of Agriculture and Food Sciences.* 2015, 3(3), 52-58.

Dabonne, S. Physico-chemical properties of Safou (*Dacryodes edulis*) fruits grown in Côte d'Ivoire. *Journal of Applied Biosciences*. 2016, 105, 10103 –10110.

Dimelu, M. U.; Odo, R. N. Production preference and importance of fruit species in home garden among rural households in Igbo-Eze North Agricultural Zone of Enugu State, Nigeria. *Afr. J. Agric. Res.* 2013, 8(46), 5733-5740.

Enete, A. A. Resource use, marketing and diversification decision in Cassava producing households of Sub-Saharan Africa. Ph.D. Thesis Dissertation, K.U. Leuven. 2003.

Enujiugha, V. N.; Ayodele, O. Evaluation of Nutrients and anti- nutrients in lesser known under- utilized oil seeds. *International Journal of Food Science and Technology*, 2005, 38 (1), 525-528.

Eze, S. O.; Onwubuya E. A.; Ezeh, A. N. Women marker's perceived constraints on selected Agricultural Produce marketing in Enugu South Area: Challenges of Extension Training for Women Groups in Enugu State, Nigeria. *Agro-science Journal of Tropical, Agricultural, Food, Environment and Extension*. 2010, 9(3), 215- 222.

Fon Dorothy, E.; Mbondji Ntombe, P. B.; Analysis of marketing channels of Plum (*Dacryodes edulis*) from the Njombe-Penja production basin. *Journal of Agricultural Science and Food Technology*. 2018, 4 (9),173-181.

Ibeagwa, O. B.; Ehirim, N. C.; Ukoha, I. I.; Osuji, E. E.; Essien, U. A.; Offor, E. I.; Uhuegbulem, I. J.; Nnamerenwa, G. C. Analysis of the profitability and viability of the non-timber forest products marketing in Imo State, Nigeria, *Kobia International Journal of Agriculture and Environmental Studies.* 2020 1(1), 80-86.

Ingram, V.; Bongers, G. 2009. Valuation of non-timber forest product chains in the Congo basin: a methodology for valuation. CIFOR. Yaounde, Cameroon, FAO-CIFOR-SNV-World Agroforestry Center-COMIFAC. 80 p.

Kalenda D. T.; Ella Missang C.; Kinkela T.; Krebs H. C.; Renard, C. M. G. C.; New developments in the chemical characterization of the fruit of *Dacryodes edulis* (G. Don) H. J. Lam. *Forests, Trees and Livelihoods*. 2002, 12(12), 119–123.

Kar, P. S. Non-timber forest product (NTFP) utilization and livelihood development in Bangladesh. Ph. D. Dissertation. School of forest resources. Pennsylvania University, USA. 2010.

Kengue, J.; Kapseu, C.; Kayem G. J. (eds.) 3ème séminaire international sur la valorisation du Safoutier et autres oléagineux non-conventionnels Yaoundé, Cameroun, 3–5 October 2000. Presses Universitaires d'Afrique, Yaounde.

Kengue, J. C. African pear, *Dacryodes edulis* (G. Don) H. J. Lam. *Journal on the Science of Food and Agriculture.* 1990, (38), 67–72.

Kinkéla, T. R.; Kama-Niamayoua, D.; Mampouya, T. Variations in morphological characteristics, lipid content and chemical composition of safou (*Dacryodes edulis* (G. Don) J. Lam. according to fruit distribution: A case study. *African Journal of Biotechnology*. 2006, 5(12),1233- 1238.

Leakey, R. R. B.; Atangana, A. R.; Kengni E.; Waruhiu, A. N.; Usuro, C.; Anegbeh, P. O. Tchoundjeu Z. Domestication of *Dacryodes edulis* in West and Central Africa: Characterization of genetic variation. *Forests, Trees and Livelihoods.* 2002, 12(1/2), 57–71.

Marlene Ngansop T.; Denis, J. Sonwac, Evariste Fongnzossie F.bd, Biyé Elvire H. b, Forbi Preasious F. ab, Takanori Oishie, and Nkogmeneck Bernard-Aloys. Identification of main Non-Timber Forest Products and related stakeholders in its value chain in the Gribe village of southeastern Cameroon. Conference paper march 2019.

Mbofung, C. M. F.; Silou, T.; Mouragadia, I. Chemical characterization of safou (*Dacryodes edulis*) and evaluation of its potential as ingredient in nutritious biscuits. *Forests Trees and Livelihoods.* 2002, 12, 105 – 107.

Meinhold, K.; Darr, D. The processing of non-timber forest products through small and medium enterprises - a review of enabling and constraining factors. *Forests* 2019, 10, 1026.

Nwaru, J. C.; Iwuji, O. Marketing margins and their determinants in plantain marketing in Owerri agricultural zone of Imo State, Nigeria; Agricultural Rebirth for Improved Production in Nigeria. *In*: Orherliata, A. M; Nwokoro, S. O.; Ajayi, M. T.; Adekunle, A. T.; Asumugha, G. N. (eds); Proceedings of the 39th Annual Conference of the Agricultural Society of Nigeria. University of Benin, Benin City. Oct 9, 2005, 13, 385-387.

Nzeh, E. C.; Eboh Chukwu, B.; Nzeh, L. Microeconomic analysis of marketing Non-Timber Products (NTFPs) in Agwu Agricultural Zone of Enugu State, Nigeria. *Asian Journal of Agriculture Extension, Economics and Sociology*. 2018, 26(3), 1-9.

Nzeh, E. C.; Eboh, E.; Nweze, N. J. Status and trends of deforestation: An insight and lessons from Enugu State, Nigeria. *Net Journal of Agricultural Science*. 2015, 3(1), 23-31. Available: http://www.netjournals.org/pdf/NJAS/2015/1/15-011.pdf ISSN: 2315-9766.

Oghogho, I. A.; Nwiwe, C. N.; Okere, R. A.; Oyaide, W. J. Marketing of perishable agricultural products in Benin City. a case study of Tomatoes, Bananas and Pineapples. *International Journal of Agricultural Economics and Rural Development*. 2014, 6(1),102-109.

Omogbai, B. A.; Ojeaburu, S. I. Nutritional composition and microbial spoilage of *Dacryodes edulis* fruits vended in Southern Nigeria. *Science World Journal* 5(4), 5-10.

Omonhinmin, C. A. Ethnobotany of *Dacryodes edulis (G.Don) H.J. Lam* in Southern Nigeria 2. Practices and Application Among Igbo-speaking People. *Journal Plants People and applied Sciences, Ethnobotany Research & Applications*. 2014, 12, 71-80.

Pandey, A. K.; Tripathi, Y. C.; Kumar, A. Non timber forest Products (NTFPs) for sustained livelihood. Challenges and strategies. *Res. J. For*. 2010, 10,1-7.

Sambe, L. N. Analysis of timber trade in Benue State Msc unpublished thesis in the Department of Social and Environmental Forestry, Federal University of Agriculture, Makurdi. 2015.

Sofowora, L. A. Medicinal plants and tradition- al medicine in Africa. 2nd Edition. Spectrum Book Ltd., Ibadan, Nigeria. 2008.

Tahir, B. A. E.; Gebauer, J. Non-timber forest products: opportunities and constraints for poverty reduction in the Nuba Mountains, South Kordofan, Sudan. Deutscher Tropentag Conference on International Agricultural Research for Development. Berlin, Deutschland. 2004.

Tchotsoua, M.; Mapongmetsem, P. M. Le safoutier (*Dacryodes edulis*): Zones ecologiques et commercialisation des fruits au Cameroon. 1998, Pp 261–272 in Kapseu C. and Kayem G.J. (eds.) 1998. *Proceedings of the 2nd International workshop on African pear improvement and other new sources of vegetable oils.* ENSAI, Presses Universitaires de Yaoundé.

Te Velde, D. W. T.; Rushton, J.; Schreckenberg, K.; Marshall, E.; Edouard, F.; Newton, A.; Arancibia, E. Entrepreneurship in value chains of non-timber forest products. *Forest Policy and Economics*. 2006, 8, 725- 741.

Waruhiu, A. N.; Kengue, J.; Tanana, A. R.; Tchound-jeu, Z.; Leakey, R. R. B. Domestication of *Dacryodes edulis*: 2. Phenotypic variation of fruit traits in 200 trees from four populations in the humid lowlands of Cameroon. *Journal of Food, Agriculture and Environment.* 2004, 2(1), 340- 346.

Journal of Agriculture & Forestry Research
Volume no. 1, Issue no. 2, Year 2021
www.sarpo.net

Research Article   **Open access**

Morphometric Characterization and Length-length Relationship of *Jagora* spp. Collected from Tilapia Pond

Reyes, A. T.; De Dios, J. P.; Macasaquit, A. L.; dela Cruz, J. A. D.

College of Fisheries, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines

ABSTRACT

Fifty (50) pieces of *Jagora* spp. collected from tilapia pond in General Tinio, Nueva Ecija, Philippines were subjected to shell morphometrics in order to evaluate its length-length relationship. The shell morphometrics were presented as average: Shell length (SL) = 38.40±4.06 mm, Aperture length (AL) = 12.34±1.41 mm, Whorl height 1 (WH1) = 7.96±1.26 mm, Whorl height 2 (WH2) = 5.84±0.83 mm, Whorl height 3 (WH3) = 4.58±0.57 mm, Aperture width (AW) = 6.40±0.89 mm, Whorl width 1 (WW1) = 7.96±1.48 mm, Whorl width 2 (WW2) = 10.60±1.56 mm, Body whorl width (BWW) = 13.12±1.86 and Interior aperture length (AILL) = 8.52±1.00 mm. The correlations of SL to all of the considered morphometrics were strong or the *r-value* is from 0.6 to 0.8. The first three highest *r* values were recorded between SL-AL, SL-WH1, and SL-AW, thus, the value of AL, WH1, and AW could be best predicted given that SL is known.

INTRODUCTION

Our country is considered a major 'hot spot' of species richness with a very high degree of endemism (Department of Environment and Natural Resources, 1997; Myers et al. 2000; Mittermeier et al., 2000). For example, a total of 519 vertebrate species are endemic to the Philippines, 64% of them are mammals (Heaney, 1998). However, the documentation of the Philippine biodiversity is still continuing, in particular of invertebrate taxa. There is a scarcity of ecological,

biogeographical, or evolutionary information for most representatives of the Philippine fauna and flora. At the same time, this rich biota is under severe threat due to the accelerating destruction of natural habitats (Dudgeon, 2000).

One of these limnetic groups is Cerithioidea, a basal caenogastropod superfamily with about 17 predominantly marine, but also some brackish and freshwater families. In approximation, this superfamily has 200 genera and several thousand species. This superfamily is of great ecological importance

as grazers and detritus feeders in most tropical to subtropical aquatic ecosystems (Glaubrecht, 1996; Kohler and Glaubrecht, 2001).

One of the freshwater species under the superfamily Cerithioidea is *Jagora* spp. that is recorded in the northern part of the Philippines. It can grow up to 50 mm in length and 18 mm in width. Its shell is highly towered, usually dark brown in color. The body is gray to black with filiform antennae. *Jagora* spp. is characterized by a unique reproductive system, including a long sperm gutter, a very short spermatophore bursa, and a prominent lateral ridge working as a seminal receptacle. Females carry eggs and juvenile stages within their mantle cavity. This snail feeds primarily on detritus and algae (Kohler and Glaubrecht, 2003; Kohler and Dames, 2009).

Morphological and morphometric studies in snails are important for species identification even in the advent of molecular tools (Prioli et al. 2002). Morphological measurements such as shell length, shell width, body whorl length, penultimate whorl width, aperture length, and aperture width are commonly used in the process of snail identification (Hamli et al. 2020). The length-length relationship studies are practically used in the study of population dynamics, ecology, taxonomic differences, life history events, and stock management (Le Cren, 1951; Lagler et al. 1962; Abdoli et al. 2008; Ferreira et al. 2008; Vaslet et al. 2008; Epler et al. 2009).

This study aimed to morphologically characterize the shell of *Jagora* spp. that was collected from a tilapia pond in General Tinio, Nueva Ecija, Philippines and to eventually use these measurements to assess the length-length relationship.

MATERIALS AND METHODS

Collection and preparation of samples

Fifty (50) pieces *Jagora* spp. were collected from a tilapia pond with 5 m in width and 10 m in length in General Tinio, Nueva Ecija. Snail samples were brought home for cleaning and visceral mass removal. The gastropod shell was photographed using a digital camera.

Measurement of shell

A total of 10 shell morphometrics were measured using a Vernier caliper based on the works of Sherely (1996) (Figure 1). The detailed shell morphometrics and characteristics are shown in Table 1.
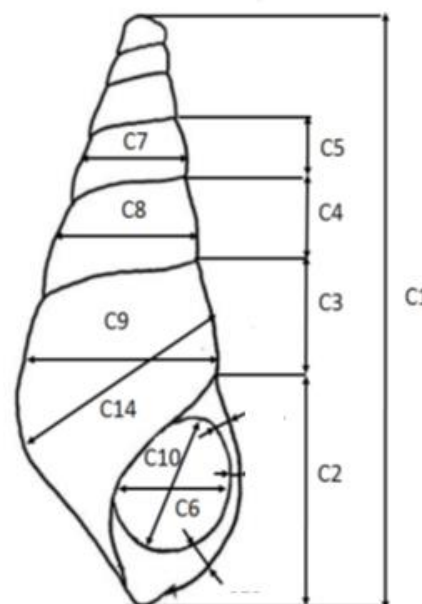
Figure 1. Shell characteristics that are used in this study (Sherely, 1996)

Determinination of the degree of association between morphometrics

The degree of associations between the shell length (SL) and aperture length (AL), whorl heights (WHS), aperture width (AW), whorl widths (WWs), body whorl width (BWW), and interior aperture length (AINL) was based on the computed correlation coefficient (*r*) using trendline analysis in Microsoft (MS) Excel.

Estimation of length-length relationship

The length-length relationship of the snail samples was estimated using the formula: $X = e^a (SL^b)$.

Where:
SL = shell length in mm

W = the other length in mm (AL, WH, AW, WW, BWW, and AINL)
a = intercept
b = slope

Table 1. Abbreviations and descriptions of Pachychilidae shell morphometrics (Sherly, 2006)

Measurement number	Abbreviation	Description
C1	SL	Shell length: maximum length of the shell
C2	AL	Aperture length: the maximum outside dimension of the aperture measured along an offset line to the right of the long axis of the shell
C3	WH1	Whorl height: measured from the intersection of the outside margin of the apertural lip and the edge of the periostracum on the first whorl that meets the apertural lip to the suture between adjacent whorls
C4	WH2	Whorl height: between the top and bottom sutures of adjacent whorls
C5	WH3	Whorl height: between the top and bottom sutures of adjacent whorls
C6	AW	Aperture width: maximum width of the aperture measured from the line demarcating the edge of the periostracum on the columella to the outer edge of the apertural lip
C7	WW1	Whorl width: dimensions were taken along lines parallel to the sutures from the midpoints of arcs formed by the outer edges of successive whorls
C8	WW2	Whorl width: dimensions were taken along lines parallel to the sutures from the midpoints of arcs formed by the outer edges of successive whorls
C9	BWW	Body whorl width: dimensions were taken along lines parallel to the sutures from the midpoints of arcs formed by the outer edges of successive whorls
C10	AINL	Interior aperture length: maximum interior length of the aperture measured from the interior edges of the apertural lip

RESULTS AND DISCUSSION

Shell morphometrics

In Table 2, the shell measurements of 50 pieces of *Jagora* spp that were collected in a tilapia pond in General Tinio, Nueva Ecija, Philippines are presented. Ten (10) shell measurements were considered in this study, namely shell length (SL), aperture length (AL), whorl height 1 (WH1), whorl height 2 (WH2), whorl height 3 (WH3), aperture width (AW), whorl width 1 (WW1), whorl width 2 (WW2),

body whorl width (BWW) and interior aperture length (AILL).

Table 2. Average shell measurements of *Jagora* spp. that were collected in tilapia a pond in Gneral Tinio, Nueva Ecija, Philippines

Shell morphometrics	Average measurement (mm)
Shell Length (SL)	38.40±4.06
Aperture Length (AL)	12.34±1.41
Whorl Height 1 (WH1)	7.96±1.26
Whorl Height 2 (WH2)	5.84±0.83
Whorl Height 3 (WH3)	4.58±0.57
Aperture Width (AW)	6.40±0.89
Whorl Width 1 (WW1)	7.96±1.48
Whorl Width 2 (WW2)	10.60±1.56
Body Whorl Width (BWW)	13.12±1.86
Interior Aperture Length (AILL)	8.52±1.00

The snail SL ranged from 30 to 48 mm (38.40±4.06 mm) with 35 and 40 mm as the most common. AL was from 10 to 18 mm (12.34±1.41 mm) with 12 mm as the most frequent. WH1 was from 6 to 10 mm (7.96±1.26 mm) with 9 mm as the dominant. WH2 fluctuated from 4 to 8 mm (5.84±0.83 mm) with 6 mm as the foremost. WH3 ranged from 4 to 6 mm (4.58±0.57 mm) with 4 mm as the most frequent. AW was recorded from 5 to 8 mm (6.40±0.89 mm) with 6 mm as the dominant width. WW1 ranged from 4 to 12 mm (7.96±1.48 mm) with 7 mm as the leading width. WW2 ranged from 5 to 14 mm (10.60±1.56 mm) with a width of 10 mm as the most common. BWW was from 7 to 19 mm (13.12±1.86 mm) with 12 mm width as the most frequent. AILL varied from 7 to 11 mm (8.52±1.00 mm) with 9 mm as the most dominant (Table 2).

According to several studies, the shell measurements are influenced by ecological factors such as latitude, depth of distribution, tidal excursion or shore level, water movements such as waves, turbulence and currents, type of sediment, and trophic conditions (Fiori and Defeo, 2006; Claxton et al. 1998; Franz, 1993; Akester and Martel, 2000; Nagarajana et al. 2006). In *Jagora* spp., there are no available morphometrics studies on the various factors that might influence shell morphometrics. This present study only provides basic information on the shell morphometry of *Jagora* spp. that was only collected from a tilapia pond.

Degree of association between shell length and the rest of shell morphometrics

A correlation coefficient measures the statistical relationship between two variables: the correlation between SL and the rest of the shell morphometrics. The correlations of SL to all of the morphometrics were strong or *r* value is from 0.6 to 0.8 (SL-AL = 0.785, SL-WH1 = 0.782, SL-WH2 = 0.628, SL-WH3 = 0.605, SL-AW = 0.769, SL-WW1 = 0.756, SL-WW2 = 0.699, SL-BWW = 0.653 and SL-AILL = 0.741). All paired variables showed direct relationship as indicated by positive *b* values (SL-AL = 0.803, SL-WH1 = 0.211, SL-WH2 = 0.855, SL-WH3 = 0.698, SL-AW = 1.017, SL-WW1 = 1.370, SL-WW2 = 1.069, SL-BWW = 0.895 and SL-AILL = 0.815), thus, an increase of 1 unit in the X variable will result

to a certain unit of increase in the Y variable (Table 3). The first three highest *r* values were recorded between SL-AL, SL-WH1, and SL-AW, thus, the value of AL, WH1, and AW could be best predicted given that SL is known. The computed values of *r* and *b* in this present study are impossible to compare because of the unavailability of literature about *Jagora* spp.

Table 3. Intercept (*a*), slope (*b*), coefficient of determination (*r²*), and correlation coefficient (*r*) of the paired shell morphometrics.

Paired variables	a	b	r^2	r
SL-AL	-0.182	0.803	0.617	0.785
SL-WH1	-0.030	0.211	0.612	0.782
SL-WH2	-0.590	0.855	0.394	0.628
SL-WH3	-0.447	0.698	0.366	0.605
SL-AW	-0.807	1.017	0.592	0.769
SL-WW1	-1.274	1.370	0.571	0.756
SL-WW2	-0.671	1.069	0.489	0.699
SL-BWW	-0.302	0.895	0.427	0.653
SL-AILL	-0.361	0.815	0.549	0.741

Length-length relationship equation

In Table 4, the summary of length-length equations is provided. These equations could be used to predict the value of AL ($0.834\ SL^{0.803}$), WH1 ($0.970\ SL^{0.211}$), WH2 ($0.554\ SL^{0.855}$), WH3 ($0.640\ SL^{0.698}$), AW ($0.446\ SL^{1.017}$), WW1 ($0.280\ SL^{1.370}$), WW2 ($0.511\ SL^{1.069}$), BWW ($0.739\ SL^{0.895}$) and AILL ($0.697\ SL^{0.815}$) if SL is given. The first three highest *r* value was recorded in pairs SL-AL, SL-WH1, and SL-AW. The value of AL, WH1, and AW could be best predicted given that SL is known.

The length-length relationship studies are practically used in the study of population dynamics, ecology, taxonomic differences, life history events, and stock management (Le Cren, 1951; Lagler et al. 1962; Abdoli et al. 2008; Ferreira et al. 2008; Vaslet et al. 2008; Epler et al. 2009).

Table 4. Length-length relationship (LLR) equation of the paired shell morphometrics.

Paired variables	LLR equation
SL-AL	$AL = 0.834\ SL^{0.803}$
SL-WH1	$WH1 = 0.970\ SL^{0.211}$
SL-WH2	$WH2 = 0.554\ SL^{0.855}$
SL-WH3	$WH3 = 0.640\ SL^{0.698}$
SL-AW	$AW = 0.446\ SL^{1.017}$
SL-WW1	$WW1 = 0.280\ SL^{1.370}$
SL-WW2	$WW2 = 0.511\ SL^{1.069}$
SL-BWW	$BWW = 0.739\ SL^{0.895}$
SL-AILL	$AILL = 0.697\ SL^{0.815}$

CONCLUSION

The correlations of SL to all the morphometrics were strong or the *r* value is from 0.6 to 0.8. The first three highest *r* values were recorded between SL-AL, SL-WH1, and SL-AW, thus, the value of AL, WH1, and AW could be best predicted provided that SL is known. The following were recommended for the improvement of future studies: (1) compare the shell morphometrics and LLR equation of *Jagora* spp. collected from ponds, streams and rivers, and irrigation canals; (2) consider the influence of sex in the shell morphometrics and LLR equation of *Jagora* spp.; and (3) increase the frequency of sampling.

REFERENCES

Abdoli, A.; Rasooli, P.; Mostafavi, H. Length-weight relationships of *Capoeta capoeta capoeta* (Guldenstaedt, 1772) in the Gorganrud River, South Caspian Basin. Journal of Applied Ichthyology. 2009, 24, 96-98.

Akester, R.; Martel, A. Shell shape, dysodont tooth morphology, and hinge-ligament thickness in the bay mussel *Mytilus trossulus* correlate with wave exposure. Canadian Journal of Zoology. 2020, 78(2), 240-253.

Department of Environment and Natural Resources. Philippine biodiversity: An assessment and action plan. United Nations Environment Programme. Makati City: Bookmark, Inc., 1997, 1-40 pp.

Dudgeon, D. Ecological strategies of Hong Kong Thiaridae (Gastropoda: Prosobranchia). Malacological Review. 2020, 22, 39-53.

Epler, P.; Nowak, M.; Popek, W. Growth rate of the chub (*Squalius cephalus*) and the nase (*Chondrostoma nasus*) from Raba, Dunajec and Poprad river. AACL Bioflux. 2009, 2, 1-8.

Franz, D. R. Allometry of shell and body weight in relation to shore level in the intertidal bivalves *Geukensia demissa* (Bivalvia: Mytilidae). *Journal of Experimental Marine Biological and Ecological*. 1993, 174(2), 193-207.

Ferreira, S.; Sousa, R.; Delgado, J.; Carvalho D.; Chada, T. Weight-length relationships for demersal fish species caught off the Madeira archipelago (eastern-central Atlantic). *Journal of Applied Ichthyology*. 2008, 24, 93-95.

Fiori, S.; Defeo, O. Biogeographic patterns in life-history traits of the yellow clam, *Mesodesma mactroides*, in Sandy Beaches of South America. Journal of Coastal Research. 2006, 224, 872-880.

Glaubrecht, M. Evolutionsökologie und Systematik am Beispiel von Süß- und Brackwasserschnecken (Mollusca: Caenogastropoda: Cerithioidea): Ontogenese-Strategien, paläontologische Befunde und historische Zoogeographie. Leiden: Backhuys, 1996, 1-230 pp.

Hamli, H.; Hamed, N. A.; Azmai, S. H. S.; Idris, M. H. Conchology variations in species identification of *Pachychilidae* (Mollusca, Gastropoda, Cerithiodea) through multivariate analysis. Tropical Life Sciences Research. 2020, 31(2), 145-158.

Heaney, L. R. A. Synopsis of the mammalian fauna of the Philippine Islands. Fieldiana: Zoology. New Series. 1998, 28, 1-61.

Köhler, F.; Dames, C. Phylogeny and systematics of the Pachychilidae of mainland Southeast Asia – Novel insights from morphology and mitochondrial DNA (Mollusca, Caenogastropoda, Cerithioidea). *Zoological Journal of the Linnean Society*. 2009, 157, 679-699.

Köhler, F.; Glaubrecht, M. Morphology, reproductive biology and molecular genetics of ovoviviparous freshwater gastropods (Cerithioidea: Pachychilidae) from the Philippines, with description of the new genus *Jagora*. *Zoologica Scripta*. 2003, 32(1), 35-59.

Köhler, F.; Glaubrecht, M. Toward a systematic revision of the Southeast Asian

freshwater gastropod *Brotia* H. Adams, 1866 (Cerithioidea:Pachychilidae): An account of species from around the South China Sea. *Journal of Molluscan Studies*. 2001, 67, 281-318.

Lagler, K. F.; Bardach, J. E.; Miller, R. R. Ichthyology. John Wiley and Sons, Inc., New York, 1962, 1-546 pp.

Le Cren, E. D. The length-weight relationships and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*. 1951, 20, 201-219.

Mittermeier, R. A.; Myers, N.; Mittermeier, C. G. Hotspots: Earth's biologically richest and most endangered terrestrial ecoregions. Chicago: University of Chicago Press, 2000, 1-345 pp.

Myers, N.; Mittermeier, R. A.; Mittermeier, C. G.; da Fonseca, G. A. B.; Kent, J. Chicago: Biodiversity hotspots for conservation priorities. Nature. 2000, 403, 853-858.

Nagarajana, R.; Lea, S.; Goss-Custard, J. Seasonal variations in mussel, *Mytilus edulis* L. shell thickness and strength and their ecological implications. *Journal of Experiental Marine Biology and Ecology*. 2006, 339(2), 241-250.

Prioli, S. M.; Prioli, A. J.; Julio, H. F.; Pavanelli, C. S.; Oliveira, A. V.; Carrer, H.; Prioli, L. M. Identification of *Astyanax altiparanae* (Teleostei, Characidae) in the Iguaçu. *Genetic and Molecular Biology*. 2002, 25(4), 421-430.

Sherely, G. Morphological variation in the shells of *Placostylus* species (Gastropoda: Bulimulidae) in New Zealand and implications for their conservation. New Zealand. *Journal of Zoology*. 1996, 23(1), 73-82.

Vaslet, A.; Bouchon-Navaro, Y.; Louis, M.; Bouchon, C. Weight-length relationships for 20 species collected in the mangroves of Guadeloupe (*Lesser Antilles). Journal of Applied Ichthyology*. 2008, 24, 99-100.

Journal of Agriculture & Forestry Research

Research Article   **Open access**

Winter Rye Spike Parameters in the Westsik's Crop Rotation Long-term Field Experiment

Ágnes Hadhazy[1]; Waleed A.E.; Abido[2], István Henzsel[1]

[1]Research Institute of Nyiregyhaza, Institutes for Agricultural Research and Educational Farm, University of Debrecen, Hungary
[2]Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt
[2]Post-Doctoral at Institutes for Agricultural Research and Educational Farm, University of Debrecen, Hungary

ARTICLE INFORMATION	ABSTRACT

Research work was carried out in Westsik's crop rotation long-term field experiment during the 2018 and 2019 seasons. The Westsik's crop rotation long-term field experiment includes fifteen crop rotations (CR), but this study focused on only seven crop rotations (CRs) i.e. (I, VI, VII, X, XI, XIV, and XV). The main purpose of this study was to analyze the effects of long-term crop rotations on rye spike components. Results showed that the effect of the applied straw manure and lupine green manure without chemical fertilizer resulted in the lowest results at every analyzed spike parameter in both years. The fallow was able to result in better spike parameters than the straw manure or lupine green manure without chemical fertilizer. The farmyard manure without chemical fertilizer was more effective than straw manure or lupine green manure without chemical fertilizer at all analyzed spike parameters. The results of correlation analysis indicated a close, positive correlation between the seed weight/spike and spike length, spike weight, and the 1000 seed weight. While the correlation was medium, positive between the seed weight/spike and spike weight in the 2018 season. Moreover, the correlation was close, positive between the seed weight/spike and all other analyzed spike parameters in the 2019 season.

INTRODUCTION

Winter rye (*Secale cereale* L.) is an important cereal crop well adaptive for growing in newly reclaimed sandy soil, its seed is used for both human consumption and animal feeding (Bushuk, 2001). According to (FAO, 2020) the total production area of rye in Hungary reached about 25767 hectares with a total production of 84.116 tonnes.

The fallow system was not a modern soil cultivation method when our research field experiment was established in 1929 but it has many benefits for the soil. Vilmos Westsik wanted to compare its effect with different organic and chemical fertilization effects. In this connection, applying the land fallow is a natural soil fertility regeneration method (Barrios et al., 2005). The farmers let the land fallow for restoration of soil fertility in the tropical area (Sánchez, 1995). Fallow is used for sustainable soil fertility improvement (Tian et al., 2005). In general, using different manuring methods in a long-term field experiment is well known worldwide having a lot of advantages. Many researchers noticed that long-term organic manure application improves the soil's physical and chemical properties, increases the carbon concentration in the soil, and consequently increases the soil fertility (Kätterer et al., 2011). Applying organic manure significantly increased the organic carbon content of the soil and soil fertility which is realized in yield parameters as compared to chemical fertilizer (Dersch and Bohm, 2001). In addition, using organic manures in combination with inorganic fertilizers increase the nitrogen (N) and phosphorus (P) contents of soil, maintains and renews the organic matter of soil, and improves the physical and chemical properties of soil (Alam et al., 1997). Organic manure has several benefits, like balancing the nutrient supply including the micronutrients, increasing the soil nutrient availability, increasing the soil microbial activity, improving the soil structure, and increasing soil water availability (Han et al., 2016).

Many researchers found that rye seed components *i.e.* spike parameters are strongly influenced by not only the soil fertility but the manuring system, too. Also, spike length, spike weight, seed weight/spike determine the yield of rye and they have a positive connection with rye yield (Kilic and Yağbasanlar, 2010). Moreover, seed weight/spike is considered the most important component of grain yield (Yağbasanlar and Ozkan, 1995; Parado and Joshi, 1970).

Thus, the purpose of this study was to analyze the effect of organic manuring methods of Westsik's crop rotation long-term field experiment on spike parameters of winter rye plants.

MATERIAL AND METHODS

Study site and objectives

Research work was carried out during 2018 and 2019 at the Westsik's crop rotation long-term field experiment, Research Institute of Nyíregyháza, IAREF, University of Debrecen, Hungary. The winter rye was sown on September 2017 and October 2018 in both seasons, respectively. The soil of this experiment is acidic sandy soil (pH_{KCL} 3.80-5.17) with low humus content (0.43-0.86%) in the 0-20 cm soil layer.

The Westsik's crop rotation long-term field experiment includes fifteen crop rotations (CR), but this study focused on only seven crop rotations (CRs) *i.e* (I, VI, VII, X, XI, XIV, XV) as presented in Table 1. In gernal, the fallow was applied before the rye plant (CR I); straw manure is applied directly before the rye plant in CRs VI and VII; farmyard manure is the applied of the rye plant in CRs X and XI and the lupine green manure (as a second crop) was grown as a previous crop before sowing rye plant in CRs XIV and XV.

Sampling and measured parameters

Rye plant samples were collected at the end of ripening, at the 2nd and 11th of July in both seasons, respectively. The plant samples were harvested by using a square wooden frame 100 × 100 cm ($1m^{-2}$), three repetitions/plot. The spike parameters *i.e.,* spike length (cm), spike weight (g), seed weight/spike (g) were determined from 10 spikes per m^{-2}. To determine the 1000 grain weight (g), 1000 grains from each sample were measured. The ratio of seed

weight/spike to the weight of spike was calculated.

Table 1. The number of crop rotations, the applied fertilization methods and fertilization doses of the rye before its sowing in the Westsik's crop rotation experiment. Numbers indicate the applied fertilizers/manures of the studied rotation phase

Number of crop rotation	N (kg ha⁻¹ active ingredient)	P_2O_5 (kg ha⁻¹ active ingredient)	K_2O (kg ha⁻¹ active ingredient)	Farmyard manure (t ha⁻¹)	Straw manure (t ha⁻¹)	Lupine green manure as a second crop
I						-
VI	65	47	56		26.1	-
VII					26.1	-
X				26.1		-
XI		31	28	26.1		-
XIV	43	31	28			+
XV						+

Statistical analysis

The obtained data were statistically analyzed using the IBM SPSS Statistical Software Package 21.0 version by one-way ANOVA as described by (Snedecor and Cochran, 1980) then Tukey's test, $P < 0.05$ as mentioned by (Tukey, 1977) was used to compare the means. In addition, Pearson's correlation analysis was done to find relations between the fertilization methods and rye yield components.

RESULTS

Spike length

Data presented in Table 2 clearly show that the average rye spike length in the crop rotations was between 4.3 and 8.1 cm in 2018 and between 6.4 and 9.4 cm in 2019. The CR I resulted in a 7.6 cm spike length in 2018, and 6.7 cm in 2019. The straw manured with chemical fertilizer resulted in longer spikes (8.1 and 8.6 cm) than CR VII without chemical fertilizer (4.3 and 6.4 cm) in both years, respectively. Moreover, using the farmyard manure with chemical fertilizers resulted in the highest averages of spike length (7.6 cm) in 2018, while a longer spike (9.4 cm) resulted in CR X of farmyard manure without chemical fertilizer in 2019. Also, at lupine green manured CRs XIV and XV, where lupine was grown as a second crop, CR XIV resulted in longer spikes with chemical fertilizer (6.6 and 9.0 cm) than CR XV without fertilizer (5.9 and 7.1 cm) in both years, respectively. Straw manure and lupine green manure with NPK fertilizer resulted in longer spikes compared to the similar CRs without NPK fertilizer. On the other hand, results of statistical analysis in the 2018 and 2019 seasons, showed that CR VII without chemical fertilizers produced the shortest spikes (4.3 and 6.4 cm), respectively. The straw manure with chemical fertilizer was more effective than farmyard manure or lupine green manure (as a second crop). The farmyard manure was more effective in the 2018 season as compared with the 2019 season.

Table 2. Spike length (cm) as influenced by Westsik's crop rotation experiment (mean ± standard deviation, n=3).

Crop rotations system	2018	2019
I	7.6 ± 0.93 [c]	6.7 ± 0.34 [a]
VI	8.1 ± 0.61 [c]	8.8 ± 0.41 [b]
VII	4.3 ± 0.10 [a]	6.4 ± 0.85 [a]
X	6.8 ± 0.20 [bc]	9.4 ± 0.78 [b]

XI	7.6 ± 0.26 [c]	8.9 ± 0.35 [b]
XIV	6.6 ± 0.51 [bc]	9.0 ± 0.40 [b]
XV	5.9 ± 0.96 [b]	7.1 ± 0.58 [a]
Main average	6.7 ± 1.33	8.0 ± 1.29

Different letters indicate significant differences of means according to Tukey's test (p<0.05).

Spike weight

Data presented in Table 3 clearly show that the different fertilization methods resulted in different spike weights. The main averages of spike weight were 1.000 and 1.171 g in 2018 and 2019, respectively. The CR I produced 1.267 and 0.907 g of spike weight in 2018 and 2019, resp. In addition, applying straw manure besides using chemical fertilizers in CR VI resulted in the highest values of spike weight (1.500g and 1.263g) as compared with without chemical fertilizer in CR VII (0.433 and 0.673g) in both seasons, respectively. Also, applying farmyard manured in CR X and XI resulted in spike weight 1.067 and 1.267g and 1.570 and 1.446 g in both seasons, respectively. The rye plants received farmyard manure with or without chemical fertilizers resulted in the highest values of spike weight in 2019. Moreover, the lupine green manure with chemical fertilizer in CR XIV resulted in a higher spike weight (0.900 and 1.421g) as compared with without chemical fertilizers in CRXV (0.700 and 0.919g). On the other side, straw manured CR VII resulted in the lowest averages of

spike weight (0.433 and 0.673g) in both years, respectively. The farmyard manure besides chemical fertilizers and fallow system resulted in the same effect to the increase of spike weight this year moreover, the results of statistical analysis showed a significant difference between the manuring systems in both years as shown in Table 3.

Seed weight/spike

Data presented in Table 4 clearly show that the crop rotation system significantly affected seed weight/spike in both years. Results show that the highest values of seed weight/spike were resulted from CRs VI, XI, and I and without significant differences between them. The corresponding data were 1.233, 1.067, and 1.033gin the first year, respectively. On the other side, straw manured without chemical fertilizer CR VII recorded the lowest values of seed weight/spike (0.333) in the first year. Lupine green manure with chemical fertilizer CR XIV produced a higher seed weight/spike (0.700g) than without chemical fertilizer CR XV (0.500g).

Table 3. Spike weight (g) as influenced by Westsik's crop rotation experiment (mean± standard deviation, n=3)

Crop rotations system	2018	2019
I	1.267 ± 0.57 [de]	0.907 ± 0.12 [ab]
VI	1.500 ± 0.20 [e]	1.263 ± 0.19 [bc]
VII	0.433 ± 0.57 [a]	0.673 ± 0.16 [a]
X	1.067 ± 0.57 [cd]	1.570 ± 0.07 [c]
XI	1.267 ± 0.57 [de]	1.446 ± 0.09 [c]
XIV	0.900 ± 0.10 [bc]	1.421 ± 0.13 [c]
XV	0.700 ± 0.17 [b]	0.919 ± 0.21 [ab]
Main average	1.000 ± 0.36	1.171 ± 0.31

Different letters indicate significant differences of means according to Tukey's test (p<0.05).

As shown in Table 4 there are no significant differences between the CRs X, XI, XIV and VI on seed weight/spike during the second year

2019, these CR achieved the highest values of these characters (1.317, 1.199, 1.165 and 1.029g, respectively). Moreover, straw

manure plus chemical fertilizer produced a higher seed weight/spike in CR VI (1.029g) than without chemical fertilizers in CR VII (0.501g). Also, the farmyard manure without significant. Regarding the lupine green manure gave a higher seed weight/spike with chemical fertilizer gave a higher seed weight/spike in CR X (1.317g) than with chemical fertilizer in CR XI (1.199g) but the difference between these data was not chemical fertilizer in CR XIV (1.165g) than without chemical fertilizer in CR XV (0.733g).

Table 4. Seed weight/spike (g) as influenced by Westsik's crop rotations experiment (mean± standard deviation, n=3)

Crop rotations system	2018	2019
I	1.033 ± 0.57 [de]	0.737 ± 0.12 [ab]
VI	1.233 ± 0.15 [e]	1.029 ± 0.19 [bc]
VII	0.333 ± 0.05 [a]	0.501 ± 0.16 [a]
X	0.867 ± 0.05 [cd]	1.317 ± 0.07 [c]
XI	1.067 ± 0.05 [de]	1.199 ± 0.09 [c]
XIV	0.700 ± 0.10 [bc]	1.165 ± 0.13 [c]
XV	0.500 ± 0.10 [ab]	0.733 ± 0.21 [ab]
Main average	0.800 ± 0.31	0.954 ± 0.31

Different letters indicate significant differences of means according to Tukey's test (p<0.05).

According to the results of statistical analysis presented in Table 4, the seed weight/spike in CRs VII and XV were significantly different from the CRs I, VI, X., and XI data in the 2018 season. Moreover, seed weight/spike in CRs I, VII, and XV were significantly different from CRs X, XI and XIV data in the 2019 season. Also, the CRs I, VII, and XV produced the lowest values of seed weight/spike. In these CRs only straw manure (VII), lupine green manure as a second crop (XV), and fallow (I) were applied without chemical fertilizers.

1000 seed weight

1000 seed weight (g) was significantly affected by the crop rotations system in both years. Results in Table 5 showed that the main averages of 1000 seed weight were 24.400 and 26.881g in both years. Farmyard manure plus phosphorous and potassium chemical fertilizers in CR XI resulted in the highest values of 1000 seed weight (27.700g) in the first year. The CRs VI, I and XIV recorded the second rank and without significant differences between them. The corresponding data were 25.933, 24.967, and 24.733g in 2018, respectively. On the other hand, CRs VII and XV recorded the lowest averages of 1000 seed weight (21.500 and 21.667g) in 2018.

Table 5. 1000seed weight (g) as influenced by Westsik's crop rotations experiment (mean± standard deviation, n=3)

Crop rotations system	2018	2019
I	24.967 ± 0.86 [bc]	27.000 ± 1.80 [bc]
VI	25.933 ± 0.73 [c]	26.500 ± 0.87 [bc]
VII	21.500 ± 0.26 [a]	22.500 ± 0.50 [a]
X	24.233 ± 0.28 [b]	29.667 ± 1.61 [c]
XI	27.700 ± 0.70 [d]	28.333 ± 2.57 [bc]
XIV	24.733 ± 0.80 [bc]	29.000 ± 0.87 [bc]
XV	21.667 ± 0.23 [a]	25.167 ± 1.15 [ab]
Main average	24.400 ± 2.16	26.881 ± 2.69

Different letters indicate significant differences of means according to Tukey's test (p<0.05).

Regarding the obtained results in Table 5, 1000 seed weight was higher in CRs X, XIV, I, and VI, and there were no significant differences between them in 2019, the weight of 28.333g in 2019. It could notice that using farmyard manure in a long-term period, plus or without NPK fertilizer led to increasing the soil cation exchange capacity and the organic carbon content of the soil. Lupine green manure without chemical fertilizer in CR XV resulted in 25.167g for 1000 seed weight in the 2019 year.

Data statistical analysis showed that CRs VII and XV were significantly different from all of the other data recorded from other crop rotation systems. As shown in Table 5, these crop rotations recorded the lowest values of 1000 seed weight (21.500 and 21.667g) in 2018seasons. Also, CR VII recorded 22.500g and was significantly different from CRI, VI, X, XI, and XIV in 2019. The CR VII received straw manure only. According to (Prasad 1996) neither inorganic fertilizer nor organic manure can alone maintain plant productivity. In addition, organic fertilizer (straw manure and lupine green manure) with chemical fertilizer, resulted in a higher 1000 seed weight than without chemical fertilizer in both years.

corresponding data were 29.667, 29.000, 27.000, and 26.500g, respectively. Also, applying the farmyard manure with chemical fertilizer in CR XI resulted in a 1000 seed

The ratio of seed weight/spike to spike weight

Data presented in Table 6 clearly showed that the ratio of seed weight/spike to spike weight was significantly affected by the crop rotation system in both years. Data revealed that the main averages of this character were 79.44 and 81.06% in both 2018 and 2019years. The straw manure and green lupine manure crop rotations with chemical fertilizer in CRs VI and XIV resulted in a higher ratio of seed weight/spike to spike weight (82.32%, 81.31%, and 77.59%, 79.48%) than without chemical fertilizer (76.67%, 74.37% and72.50%, 79.48%) in both years. In addition, the analyzed data of farmyard manure CRs X and XI was higher with chemical fertilizer (84.19%), than without chemical fertilizer (81.21%) in 2018. While in 2019 the farmyard manure produced a higher ratio between seed weight/spike and spike weight without chemical fertilizer in CR X (83.90%), than with chemical fertilizer in CR XI (82.88%) and the difference between them was not significant.

Table 6. The ratio of seed weight/spike to spike weight (%) is influenced by Westsik's crop rotation experiment (mean ± standard deviation, n=3)

Crop rotations system	2018	2019
I	81.62 [ab]± 4.12	81.06 [b]± 1.83
VI	82.32 [ab]± 2.31	81.31 [b]± 1.90
VII	76.67 [ab]± 2.89	74.37 [a]± 2.17
X	81.21 [ab]± 1.05	83.90 [b]± 0.34
XI	84.19 [b]± 0.74	82.88 [b]± 1.36
XIV	77.59 [ab]± 2.51	81.85 [b]± 2.10
XV	72.50 [a]± 9.01	79.48 [b]± 2.42
Main average	79.44 ± 5.17	80.69 ± 3.34

Different letters indicate significant differences of means according to Tukey's test (p<0.05).

Correlation analysis

Correlation coefficients indicated a positive significant correlation between the seed weight/spike and other measured rye yield parameters (Table 7) in both analysed years.

Data indicated that there was a pronounced positive and close correlation between the seed weight/spike and spike length (0.913**), spike weight (0.992**) and 1000 seed weight (0.832**). This means, in that

crop rotations, which resulted in higher spike long, spike weight, and 1000 seed weight the seed weight was higher. Moreover, there was a positive and medium correlation between the seed weight and the ratio between seed weight/spike to spike weight in the 2018 season. Several investigations indicated that the grain yield is closely correlated with the number of grains per spike and the number of spikelets (Perryand D'Antuono, 1989; Sayre et al., 1997).

The correlation analysis resulted in a close and positive correlation between all of the analyzed data in 2019 i.e. between the seed weight/spike and spike length (0.938**), spike weight (0.998**), 1000 seed weight (0.778**) and the ratio of seed weight/spike to spike weight (0.852**). Moreover, the analyzed data detected between the seed yield and spike weight, seed weight/spike, number of spikes per area were in positive correlation, as was found by (Nouraein 2019).

Table7. The correlation coefficient of the linear relationship (r-values) among the seed weight/spike and other rye spike parameters (n=3)

Person's correlation	Spike length (cm)	Spike weight (g)	1000 seed weight (g)	The ratio between seed weight/spike to spike weight (%)
Spike weight (g)in 2018 season	0.913**	0.992**	0.832**	0.632**
Spike weight (g) in 2019 season	0.938**	0.998**	0.778**	0.852**

Pearson's correlation ** Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

DISCUSSION

According to our results, all spike parameters (spike length, spike weight, seed weight/spike, 1000 grain weight, and the ratio of seed weight/spike to the weight of spike significantly different from all other crop rotations. Straw manure and lupine green manure with NPK fertilizer resulted in a longer spike compared to the similar CRs without NPK fertilizer. Applying farmyard manure or green manure improved the organic carbon content of the soil which contributes to reaching the higher yield components (Nambiar, 1994; Swarup, 1999; Kundu et al., 2002; Zhichen et al., 2008), increasing the soil cation exchange capacity and the organic carbon content of soil and increases the soil microbial activity (Tejada et al., 2008). In addition, applying farmyard manure increased the available nutrient and micronutrient content of soil compared to chemical fertilizers (Hemalatha and

Chellamuthu, 2013), increase the available nitrogen content and microorganism activity in the soil, which has a good effect on the next plant production (Bhardwaj et al., 1998). In addition, applying organic manure with or without fertilizer to the soil have good benefits for improving the physical and chemical properties of the soil, increasing the spike weight of rye plants (Rabindra et al., 1990; Liu et al., 2010). Using farmyard manure in a long-term period, plus or without NPK fertilizer led to an increase in the soil cation exchange capacity and the organic carbon content of the soil. In addition, applying farmyard manure increased the available nutrient and micronutrient content of soil compared to chemical fertilizers (Hemalatha and Chellamuthu, 2013). Applying N fertilizer alone over years, decreased the number of

microbial organisms, enzyme activity, and soil

pH, which had a negative effect on the plant yield attributes (Prasad, 1996; Bandyopadhyay et al., 2010; Liu et al., 2010). In general, using in combined organic manure and inorganic fertilizer together increase available NPK content and organic matter content of soil (Gill and Meelu, 1982) and increases the fertilizer use efficiency and the yield components (Kumar and Mishra, 1992). These results are similar to those obtained by (Bokhtiar and Sakurai 2006). Also, at lupine green manured CRs XIV and XV, where lupine was grown as a second crop, CR XIV resulted in longer spikes with chemical fertilizer than CR XV without fertilizer in both years. In this connection, (Bokhtiar et al., 2003; Goto and Nagata, 2000) showed that applied green manure plays an important role in increasing the total carbon content and bulk density of the soil, which resulted in the higher yield components. Straw manure and lupine green manure with NPK fertilizer resulted in longer spikes compared to the similar CRs without NPK fertilizer. Applying organic and inorganic fertilizer together is very effective in plant productivity (Naik and Ballal, 1968; Yadav and Sharma, 1981; Bangar et al., 1994). We also found that the fallow method helps to restore the soil organic matter content into the upper layers of the soil, which increase the biological activity in the surface of the soil and to rehabilitate the activity of soil microorganisms, which is reduced during the cultivation phase (Styger et al., 2006). In addition, applying straw manure besides using chemical fertilizers in CR VI resulted in the highest values of spike weight. Results also showed that using straw manure and lupine green manure recorded higher seed weight/spike besides chemical fertilizers, than without chemical fertilizer in both of analyzed years, many researchers indicated that seed weight per spike is influenced by nutrients applications. In this connection, (Castagna et al., 1996; Thorup-Kristensen and Bertelsen, 1996; Granstedt and Kjellenberg, 1997; Takunov and Yagovenko, 2000; Bradley et al., 2008; Gong et al., 2009; Marino et al., 2009; Boumand et al., 2010) noticed that nitrogen doses significantly influence the number of grains per spike, consequently increased the seed weight/spike. Several investigations indicated the positive effect of organic manure and chemical fertilizer using together, through increasing the soil organic carbon and NPK content therefore the crop productivity of soil and decreasing the damage that can be induced by chemical fertilizer using alone (Kaur et al., 2005; Chand et al., 2006; Murmu et al., 2013). In addition, organic matter affects not only the yield by supplying the nutrients but indirectly affects soil physical and chemical properties, too (Darvish *et al.,* 1995).

CONCLUSION

It can be concluded that spike parameters were influenced by the crop rotations system. Application of organic fertilization methods with NPK fertilizer has a good effect on the length of the spike. Application of organic manure with chemical fertilizer had a significantly better effect on the seed weight/spike than without chemical fertilizer in both analyzed years. Application of straw manure and green lupine manure with chemical fertilizer resulted in a higher 1000 seed weight than without chemical fertilizer. However, the farmyard manure could be able to produce the same result without chemical fertilizer, too. In addition, using organic fertilizer with chemical fertilizer was increased the ratio between seed weight/spike to spike weight. On the other hand, using straw manure without chemical fertilizer resulted in the lowest values of spike parameters in both analyzed years. Moreover, applying a fallow system resulted

in better rye spike parameters than using straw manure and lupine green manure weight/spike and spike length, spike weight, 1000 seed weight, and the ratio between seed weight/spike to spike weight. Finally, seed weight/spike is strongly influenced by the other spike parameters i.e. spike length, spike weight, and 1000 seed weight.

Compliance with ethical standards

without chemical fertilizer. Also, there was a close positive correlation between the seed The corresponding author declares that there is no conflict of interest regarding the publication of this manuscript.

Funding

REFERENCES

Alam, F.; Majid, M. A.; Islam, M. J. Improvement of soil and substitution of nitrogen with green-manure crops on follow-up sugarcane (*Saccharum officinarum*). *Indian J. of Agric. Sci.* 1997. 67(10), 455-458.

Bandyopadhyay, K. K.; Misra, A. K.; Ghosh; P. K.; Hati, K. M. Effect of integrated use of farmyard manure and chemical fertilizers on soil physical properties and productivity of soybean. *Soil and Tillage Res.* 2010, 110,115–125.

Bangar, K. S.; Maini, A.; Sharma, S. R. Effect of fertilizer nitrogen and press mud cake on growth, yield and quality of sugarcane. *Crop Res.* 1994, 8, 23–27.

Barrios, E.; Cobo, J. G.; Idupulapati; M. R.; Thomas, R. J.; Amézquita; E.; Jiménez, J. J.; Rondón, M. A. Fallow management for soil fertility recovery in tropical Andean agroecosystems in Colombia. *Agric. Ecosyst. Environ.* 2005, 110(1-2), 29-42.

Bhardwaj, H. L.; Hamama, A. A.; Merrick, L. C. Genotypic and environmental effects on lupin seed composition. *Plant Foods Hum. Nutr.* 1998, 53:1–13.

Bokhtiar, S. M.; Sakurai, K. Effects of organic manure and chemical fertilizer on soil fertility and productivity of plant and ratoon crops of sugarcane. *Arch. Agron. Soil Sci.* 2005, 51(3), 325-334.

Bokhtiar, S. M.; Gafur, M. A.; Rahman, A. B. M. M. Effects of Crotalaria and Sesbania aculeata green manures and N fertilizer on soil fertility and the productivity of sugarcane. *J. of Agric. Sci. Cambridge Univ.* 140, 305–309.

Bradley, E. F.; Kurt, D.Th.; Doo, H. M. Use of manure, compost, and cover crops to supplant crop residue carbon in corn stover removed cropping systems. *Agron. J.* 2008, 100(6),1703-17010.

Broumand, P.; Rezaei, A.; Soleymani, A.; Shahrajabian, M. H.; Noory, A. Influence of forage clipping and top dressing of nitrogen fertilizer on grain yield of cereal crops in dual purpose cultivation system. *Res. on Crops*, 2010, 11(3), 603-613.

Bushuk, W. Rye production and uses worldwide. *Cereal Chem.* 2001, 46(2), 70–73.

Castagna, R.; Minoia, C.; Porfiri, O.; Roccheti, G. Nitrogen level and seeding rate effects on the performance of hulled wheats (*Triticum monococcum* L., *T. dicoccum Schubler* and *T. spelta* L.) evaluated in contrasting agronomic environments. *Journal of Agron and Crop Sci*. 1996, 176, 173-181.

Chand, S.; Anwar, M.; Patra, D. D. Influence of long-term application of organic and inorganic fertilizer to build up soil fertility and nutrient uptake in mint-mustard cropping sequence. *Commun Soil Sci Plant Anal.* 2006, 37(1-2), 63-76.

Darvish, O. H.; Persaud, N.; Martens, D. C. Effect of long-term application of animal manure on physical properties of three soils. *Plant Soil*, 1995, 176:289–295.

Dersch, G. and Bohm K. Effects of agronomic practices on the soil carbon storage potential in arable farming in Austria. *Nutr. Cycling Agroecosyst.* 2001, 60, 49–55.

FAO. Food and Agriculture Organization of the United Nations, FAOSTAT, FAO Statistics Division. 2020, November.

Gill, H. S.; Meelu, O. P. Studies on the substitution of inorganic fertilizers with

soil organic matter fractions and microbes under a wheat–maize cropping system in northern China. *Geoderma*, 2009, 149(3-4), 318-324.

Goto, S.; Nagata, S. Effect of Clotararia, sorgum and pampas grass incorporated as green manure on the yield of succeeding crops and soil physical and chemical properties. *Soil Sci. Plant Nutr*. 2000, 71(3), 337-344.

Granstedt, A.; Kjellenberg, L. Long-term field experiment in Sweden: Effects of organic and inorganic fertilizers on soil fertility and crop quality. In Proceedings of an International Conference in Boston, Tufts University, Agricultural Production and Nutrition, Massachusetts, 1997, March 19-21:1-14.

Han, S. H.; An, J. Y.; Hwang, J., Kim, S. B., Park, B. B. The effects of organic manure and chemical fertilizer on the growth and nutrient concentrations of yellow poplar (*Liriodendron tulipifera* Lin.) in a nursery system. *Forest Sci Technol.* 2016, 13(3), 137-143.

Hemalatha, S.; Chellamuthu, S. Impacts of long-term fertilization on soil nutritional quality under finger millet maize cropping sequences. *J. Environ. Res. Develop.* 7(4a), 1571-1576.

Kätterer, T.; Bolinder, M. A.; Andrén, O.; Kirchmann, H.; Menichetti, L. Roots contribute more to refractory soil organic matter than above-ground crop residues, as revealed by a long-term field experiment. *Agric. Ecosyst. Environ.* 2011, 141(1-2), 184-192.

Kaur, K.; Kapoor, K. K.; Gupta, A. P. Impact of organic manure with and without mineral fertilizers on soil chemical biological properties under tropical conditions. *Journal of Soil Sci. Plant Nutr.* 2005, 168(1), 117–122.

organic manure and their effect on soil fertility in rice-wheat rotation. *Fertilizer Res.* 1982, 3,303-314.

Gong, W.; Yan, X.; Wang, J.; Hu, T.; Gong, Y. Long-term manure and fertilizer effects on

Kilic, H.; Yağbasanlar, T. The effect of drought stress on grain yield, yield components and some quality traits of durum wheat (*Triticum turgidum ssp. durum*) cultivars. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 2010, 38 (1),164-170.

Kumar, V.; Mishra, D. Manurial value of press mud cake (Ganna-khoi) Indian Farmers Digest, 1992, 25,33 – 34.

Kundu, S.; Ved, P.; Ghosh, B. N., Singh, R. D.; Shrivastava, A. K. Quantitative relationship between annual carbon inputs and soil organic carbon build-up in Soybean (*Glycine max*)-wheat (*Triticum aestivum*) cropping sequence. *In*: Proceedings of the 2nd International Agronomy, Congress, New Delhi, India, 2002, November 26-30, 108-110 pp.

Liu, E.; Yan, C.; Mei, X.; He, W.; Bing, S. H.; Ding, L.; Liu, Q.; Liu, S.; Fan, T. Long-term effect of chemical fertilizer, straw, and manure on soil chemical and biological properties in northwest China. *Geoderma*. 2010, 158(3-4), 173-180.

Marino, S.; Tognetti, R.; Alvino, A. Crop yield and grain quality of emmer populations grown in central Italy, as affected by nitrogen fertilization. *Eur. J. Agron.* 2009, 31(4), 233-240.

Murmu, K.; Swain, D. K.; Ghosh, B. C. Comparative assessment of conventional and organic nutrient management on crop growth and yield and soil fertility in tomato-sweet corn production system. *Aust. J. Crop Sci.* 2013, 7(11), 1617–1626.

Naik, B. N.; Ballal, D. K. Effect of association of organic matter with nitrogen fertilizer on availability and uptake of plant nutrients and the growth of the plant. II. Uptake of the nutrients and growth of the plant. J. Indian Soc. Soil Sci. 1968, 16: 391–397.

Nambiar, K.K.M. Soil fertility and crop productivity under long-term fertilizer use

in India. Indian Council of Agricultural Research, New Delhi, India. 1994.

Nouraein, M. Elucidating seed yield and components in rye (*Secale cereale* L.) using discriminant function for selection in wheat. *Heredity*, 1970, 25, 383-392.

Perry, M. W.; D'Antuono, M. F. Yield improvement and associated characteristics of some Australian spring wheat cultivars introduced between 1860 and 1982. *Aust. J. Agric. Res.* 1989, 40, 457-472.

Prasad, R. Cropping systems and sustainability of agriculture. *Indian Farming*, 1996, 46, 39-45.

Rabindra, B.; Gowda, S. N. S.; Gowda, H. Effect of continuous use of nitrogenous fertilizers on soil physico-chemical properties, yield and juice quality of sugarcane. *Indian Sugar*, 1990, 9, 843-845.

Sánchez, P. Science in agroforestry. *Agrofor. Syst*. 1995, 30, 5-55.

Sayre, K. D.; Rajaram, S.; Fischer, R. A. Yield potential progress in short bread wheats in northwest Mexico. *Crop Sci.* 1997, 37, 3642.

Snedecor, G. W.; Cochran, W. G. Statistical methods. Seventh Edition. Ames Iowa: Statistical Methods. 7Th Ed. Iowa State University Press, Iowa, USA., 1980, 507, pp.

Styger, E.; Erick, C. M. F. Contributions of managed fallows to soil fertility recovery. *Biol. Approaches to Sustainable Soil Systems*, 2006, 29, 426-437.

Swarup, A. Emerging soil fertility management issues for sustainable crop production in irrigated system. In: Swarup, A., Reddy, D.D., Prasad, R.N. (Eds.), Long-term soil fertility management through integrated plant nutrient supply. *Indian Institute of Soil Sci. Bhopal*, 1998, 54-68.

Takunov, I. P.; Yagovenko, L. L. Yellow lupin (*Lupinus luteus* L.) as a green manure crop preceding winter rye (*Secale cereale* L.). *In*: Santen, E. van; Wink, M.; Weissmann, S.;

path and correlation analyses. *Genet. Resour. Crop Evol.* 2019, 66, 1533-1542.

Parado, S. R.; Joshi, B. A. Correlations, path coefficients and the implication of

Römer, P. Book chapter; Conference paper: Lupin, an ancient crop for the new millennium: Proceedings of the 9th International Lupin Conference, Klink/Muritz, Germany, 20-24 June, 1999.

Tejada, M.; Gonzalez, J. L.; Garcia-Martinez, A. M.; Parrado, J. Effects of different green manures on soil biological properties and maize yield. *Bioresour. Technol.* 2008, 99, 1758-1767.

Thorup-Kristensen.; Bertelsen, K. M. Green manure crops in organic vegetable production. *In*: Kristensen, N. H., Hoeg-Jensen H. New Research in Organic Agriculture. Proceedings from the 11th Int. Sci. IFOAM Conf. Copenhagen, 1996, 75-79 pp.

Tian, G.; Kang, B. T.; Kolawole, G. O.; Idinoba, P.; Salako, F. K. Long-term effects of fallow systems and lengths on crop production and soil fertility maintenance in West Africa. *Nutr. Cycl. Agroecosystems*. 2005, 71, 139-150.

Tukey, J. W. Exploratory data analysis. Addison-Wesley, Reading, Statistical Science, 1977, 18(3), 311-318.

Yadav, R. L.; Sharma, R. K. Effect of nitrogen applied to plant cane crop of sugarcane on the yield and quality of subsequent ratoon crop. Indian J. Agric. Sci. 1983, 53: 38–43.

Yağbasanlar, T.; Ozkan, H. Correlation and path coefficient analysis for ear characters in triticale under Mediterranean climatic conditions. J. Agron. Crop Sci. 1995, 174, 297-300.

Zhichen, Y.; Yizhong, L.; Fengrong, Z.; Xiaoping, X.; Mo, L. Comparative analysis of the effects of straw-returning and decomposed manure on paddy soil fertility betterment. *Chinese Society of Agricultural Engineering*. 2008, 24(3), 214-218.

Journal of Agriculture & Forestry Research

Research Article	Open access

Attitude to Agricultural Enterprise Among Students of Tertiary Institution in Ibadan, Oyo State

Olayemi Olabode Oluseye[1]; Ajanaku Adenike Olubunmi [1]; Odeyale Olajumoke Celinah [1]; Marizu Josephine Tayo[1]; Ogunwale Oluwatobi Grace [1]; Adebayo Adekunle Segun[1]; Awonuga Christopher Oluwakorede [1]; Emmanuel Ileri-oluwa Busayo [2]

[1]Federal College of Forestry, Ibadan, Oyo State. P.M.B.5087
[2]Forestry Research Institute of Nigeria, Ibadan, Oyo State.P.M.B.5054

ARTICLE INFORMATION

ABSTRACT

Agriculture is a known profession in Nigeria and the largest employer of labor in the country, so therefore it's worthwhile to investigate attitude to agricultural enterprise among students of tertiary institutions in Ibadan, Oyo State. Multi-stage sampling techniques were used to select 112 respondents for the study. Data was obtained through the use of a structured questionnaire from the respondents and descriptive statistics such as mean, frequency tables, and percentages were used to describe data while inferential statistical tools such as PPMC (Pearson Product Moment Correlation) were used to analyze the hypothesis of the study. The result showed that the majority of the respondents were in the age bracket of 21-25 years, also were males and single with the majority of the respondents having low agricultural enterprise preference and also an unfavorable attitude toward agricultural enterprise in the study area. There is a significant relationship between willingness to an established agricultural enterprise of the respondents and attitude to agricultural enterprise among respondents in the study area. It is, therefore, recommended that government and non-governmental organizations should render special assistance to students studying agriculture upon their graduation inform of granting loans or scholarships to the students who show a positive attitude towards agriculture and establish an agricultural enterprise.

INTRODUCTION

The environment is the complex physical factors that make up our surroundings (Britannica, 2002), and in turn act upon us. The first factor in career choice, environment, may influence the career students to choose. For example, students

who have lived on an island may choose a career dealing with the water, or they may choose to leave the island behind, never to have anything to do with water again.

The job market for agriculture has expanded into a wide range of fields. According to Okorie (2001), career opportunities in agriculture include crop production, crop protection, crop processing, animal production, drug production, farm produce distribution, teaching, researching, extension services, soil management and analysis, banking, and finance, input supplying and a lot of jobs available in agro-allied industries. Some students grow up knowing what they want to do in life. These are the students who will go the extra mile to reach their dream job. However, students often settle on a different path due to many factors they can't control. Students will research their chosen career path and explore everything about it. The salary and benefits of that job do not play a role in this Decision. In a research study the factor "match with interest" is rated over job characteristics, major attributes, and psychological and social benefits in importance when students choose a major course (Beggs et al., 2008). Students will seek out schools that are well known for that major or trade. Most students today are more concerned with the amount of money they can earn.

However, there are a few students who pursue their dreams (Mcglynn, 2007). Many students choose their major based on their academic ability (Beggs et al., 2008). However, some students do not have the ability or the work habits to succeed in some majors that may require more study than other fields of study. These students may find a better fit in a less work-intensive major that requires fewer difficult classes and this may affect the career paths of these students.

Despite the fast-growing opportunities in this sector, it is alarming and quite incredible to see many rural youths opting out of farming in search of non-existed white-collar jobs in the cities, leading to the unprecedented level of rural-urban migration. This is obviously a potent threat to the aspiration of the government to achieve food security by 2010. More depressing is the fact that most farmers train their children into becoming doctors, lawyers, etc. as they do not want them to become farmers like them. It has also become worrisome that children of professional agriculturists, those who teach Agriculture in higher institutions now opted for careers other than agriculture. So, therefore, it is against this background that investigates attitude to agricultural enterprise among students of tertiary institutions in Ibadan, Oyo State.

The specific objectives include the following: describe the socio-economic characteristics of respondents in the study area, identify preferred agricultural enterprises in the study area and determine students' attitude to Agricultural enterprises as a future career in the study area.

MATERIALS AND METHODS

The study was carried out in selected institutions in Ibadan, Oyo State with a latitude of 8'00N and longitude of 4'00E, and a total estimated population of 6,617,720 people. It is bounded in the north by Kwara State, in the east by Osun State, in the south by Ogun State, and in the west partly by Ogun State and partly by the Republic of Benin. It's also home to Africa's leading fountain of knowledge, the iconic University of Ibadan, Oyo State College of Education, The Polytechnic, a State-owned University (The Ladoke Akintola University of Technology LAUTECH Ogbomoso), there are also the Federal College of Agriculture Ibadan, Federal College of Animal Health and Production Technology Ibadan, Federal College of Forestry Ibadan, all in Ibadan.

Sampling procedure and sample size

A multi-stage sampling technique was used for this study. The first stage is a purposive sampling of tertiary institutions offering

agriculture and related studies such as the University of Ibadan, Federal College of Forestry, Ibadan, and Federal College of Agriculture, Ibadan. The second stage is the purposive selection of departments with agricultural courses from each tertiary institution offering agriculture and related studies which are Department of Agricultural Extension and the Rural Sociology University of Ibadan, Department of Agricultural Extension and Management Federal College of Forestry, Ibadan, and Department of Agricultural Technology Federal College of Agriculture, Ibadan. The third stage is the random selection of 20% agricultural students (respondents) in each selected tertiary institution i.e 20% of 300 from the Department of Agricultural Extension and Rural Sociology University of Ibadan, 20% of 60 from the Department of Agricultural Extension, and Management Federal College of Forestry, Ibadan and 20% of 200 from Department of Agricultural Technology Federal College of Agriculture, Ibadan to give a total of 112 respondents used as the sample size in the study area.

Method of data collection and data analysis

Data were obtained from both primary and secondary sources. Primary data was collected through the use of a structured questionnaire designed carefully to capture the objectives of the study from the respondents. Secondary data was obtained from textbooks, journals, research papers, and other relevant literature to complement the primary data.

Data were analyzed with the use of descriptive statistics such as (frequency counts, percentages, and mean) using Statistical Package for Social Science (SPSS Version 20), and inferential statistic such as Pearson Product Moment Correlation (PPMC) was employed to determine the relationship between willingness to establish an agricultural enterprise and student's attitude toward agricultural enterprise in the study area.

RESULTS AND DISCUSSION

Table 1. The socio-economic characteristic of the respondents.

	Frequency	Percentage	Mean
Age			
16-20 years	11	9.8	23.6
21-25years	71	63.4	
26-30years	30	26.8	
Gender			
Male	58	51.8	
Female	54	48.2	
Marital status			
Single	108	96.4	
Married	4	3.6	
Ethnicity			
Yoruba	66	58.9	
Hausa	1	0.9	
Igbo	34	30.4	
Others	11	9.8	
Father's occupation			
Farming	9	8.0	
Civil servant	42	37.5	
Law	11	9.8	

Medical practitioner	25	22.3	
Engineering	16	14.3	
Others	9	8.0	
Mother's Occupation			
Farming	1	0.9	
Civil servant	51	45.5	
Teaching	27	24.1	
Trading	31	27.7	
Others	2	1.8	
Place of residence from birth			
Urban	91	81.3	
Rural	21	18.8	
Farming experience before getting admitted			
No	73	65.2	
Yes	39	34.8	
Present course of study			
Agric extension	54	48.2	
Agronomy	21	18.8	
Agric economics	9	8.0	
Animal science	18	16.1	
Crop protection	8	7.1	
Horticulture	2	1.8	
Level of study			
HND2	52	46.4	
500 level	60	53.6	
Name of institution			
UI	60	53.6	
FCF	12	10.7	
FCA	40	35.7	
Total	112	100.0	

Field survey 2020

The result of analysis from Table 1 showed that the majority of the students were in the age bracket of 21-25 years. This is in line with Akinbile (2007) and Adedeji et al., (2013) who reported that respondents with 20-50 years constitute the active workforce of the population. Thus, the respondents could be categorized as adults, at this age, they should have stopped thinking of themselves as children and started thinking more about the future. Also, parents at this age expect mature behavior from the children. Consequently, it was expected from the students to be able to make decisions about potential careers to pursue.

Also shows that more respondents were males (51.8%) and (48.2%) were females. It could be deduced from the result that there are more males studying agriculture than females, with the majority of them being

single (96.4%) and 3.4% being married. Results also reveal that the respondents cut across the major ethnic groups within the country. 0.9% Hausa, 34% Igbo, and 66% were Yoruba which constitutes the largest percentage. Other respondents who fall outside these major ethnic groups in Nigeria have 11% percent. Andrew (2016) had earlier established that ethnicity has a role to play in determining the entrepreneurial decision of an individual.

Furthermore, the majority of respondents 81.3% reside in the urban area. This might give the students the privilege of understanding professional careers along with their roles and economic opportunities. Also, the result showed that more than half of the respondents (73%) had NO farming experience before admission. With these characteristics, it could be said that most respondents were not from farming families and are not expected to develop in agricultural professions. This is in tandem with the findings of Jeffrey, Marcia, and Susan (2004) cited by Ayanda et al. (2012) who noted that parents and guardians play a significant role in the occupational aspirations of their children. Result revealed that 54% of the respondents are from the department of agricultural extension, 21% respondents are from the department of agronomy, 18% are from the department of animal science, 9% from the department of agricultural economics, 8% offers Crop protection and lastly 2% studies Horticulture.

Table 2a. Respondents' agricultural enterprise preference.

Agricultural enterprises	Most preferred	Preferred	Not interested
fishery and aquaculture production	34 (30.4)	57 (50.9)	21 (18.8)
crop production	42(37.5)	51(45.5)	19 (17.0)
livestock production	60 (53.6)	41 (36.6)	11 (9.8)
plant and animal geneticist	29 (25.9)	71 (63.4)	12 (10.7)
soil scientist/pedologist	42 (37.5)	40 (35.7)	30 (26.8)
horticulture/olericulture	7 (6.3)	41 (36.6)	64 (57.1)
agricultural education (Trainer/Teacher/Lecturer	65 (58.0)	37 (33.0)	10 (8.9)
Veterinarian	29 (25.9)	23 (20.5)	60 (53.6)
Feed Production, Sales and Management	42 (37.5)	21 (18.8)	49 (43.8)
Sales and supply of farm outputs	45 (40.1)	48 (42.9)	19 (17.0)
Farm input supply and sales	32 (28.6)	34 (30.4)	46 (41.1)
Construction and fabrication of farm machineries and structures	29 (25.9)	22 (19.6)	61 (54.5)
Agri-processing	46 (41.1)	43 (38.4)	23 (20.5)
Extension agent	30 (26.8)	53 (47.3)	29 (25.9)
Other jobs not related to agriculture	26 (23.2)	75 (67.0)	11 (9.8)

Field survey, 2020

Table 2b. Categorization of respondents based on their agricultural enterprise preference

	Frequency	Percentage	Min	Max	Mean=15.8
High (Above mean)	51	45.5	1	24	
Low (Below mean)	61	54.5			
Total	112	100			

Field survey, 2020

The result of analysis in Table 2b revealed that (54.5%) of the respondents had a low preference for agriculture enterprise while (45.5%) had a high preference for agriculture enterprise in the study area. The result of analysis in Table 2a revealed that the majority of the respondents (53.6%) most preferred livestock production, (58.0%) most preferred agricultural education (Trainer/Teacher/Lecturer) and also the majority of the respondents (50.9%) preferred fishery and aquaculture production, (63.4%) preferred plant and animal geneticist and (67.0%) preferred other jobs not related to agriculture. While the majority (57.1%) of respondents are not interested in horticulture/olericulture, (53.6%) not interested in veterinarian, and also (54.5%) are not interested in the construction and fabrication of farm machinery and structures in the study area. This finding tally with the report of Mbeine (2012) that marketing-related information and value addition skill is needed by young people involved in agricultural business.

Table 3a. Respondent attitude to establish agricultural enterprises

Parameters of measurement	SA	A	UD	D	SD
Agricultural science is the best course of study	27(24.1%)	58(51.8%)	19(17.0%)	7(6.3%)	1(0.9%)
Studying agriculture has a lot of prospect in Nigeria	53(47.3%)	44(39.3%)	10(8.9%)	4(3.6%)	1(0.9%)
Agriculture is a lucrative business	25(22.3%)	72(64.3%)	14(12.5%)	1(0.9%)	-
Agriculture has high potential for self-employment	68(60.7%)	38(33.9%)	6(5.4)		-
Agriculture is a prestigious field	20(17.9%)	65(58.0%)	17(15.2%)	10(8.9%)	-
Agriculture is my last opportunity to obtaining a tertiary education and certificate	13(11.6%)	57(50.6)	9(8.0%)	23(20.5%)	10(8.9%)
Agriculture has no viable potential	4(3.6%)	42(37.5%)	4(3.6%)	21(18.8%)	41(36.6%)
Many Nigerians have made a lot of fortunes from agriculture	66(58.9%)	35(31.3%)	6(5.4%)	2(1.8%)	3(2.7%)
Agriculture is not so lucrative	3(3.7%)	41(36.6%)	12(10.7%)	13(11.6%)	43(38.4%)

Field survey, 2020

Table 3b. Categorization of respondents based on their attitude towards agriculture

	Frequency	Percentage	Min	Max	Mean=33.5
Favourable (Above mean)	50	44.6	23	41	
Unfavourable (Below mean)	62	55.4			
Total	**112**	**100**			

Field survey, 2020

The result of analysis in Table 3b revealed that (55.4%) of the respondents had an unfavorable attitude towards agriculture while (44.6) had a favorable attitude towards agriculture in the study area.

The result of analysis in Table 3a revealed that the majority of the respondents (60.7%) strongly agree that agriculture has a high potential for self-employment and (58.9%) strongly agree that Many Nigerians have made a lot of fortunes from agriculture while (51.8%) agree that agricultural science is the best course of study, (64.3%) agree that agriculture is a lucrative business, (58.0%) agree that agriculture is a prestigious field and (50.6%) agree that agriculture is my last opportunity to obtaining tertiary education and certificate as an attitude to establish agricultural enterprises in the study area.

Table 4: PPMC analysis showing the relationship between willingness to establish an agricultural enterprise and student's attitude toward the agricultural enterprise

	r-value	p-value	Decision
Willingness and	0.338*	0.000	S
Attitude			

Computed analysis, 2020

PPMC analysis table revealed that there is a significant relationship between willingness to establish an agricultural enterprise and student's attitude toward agricultural enterprise in the study area. This implies that the student's attitude would determine their willingness to establish agricultural enterprise as a future career.

CONCLUSION

The empirical finding of the study showed that the majority of the students fell between the age bracket of 21-25 years. Thus, could be categorized as adults, with more males, and the majority of them were single. Results also revealed that the respondents cut across the major ethnic groups within the country with Yoruba's constituting the largest percentage in the study area. Furthermore, the majority of respondents reside in the urban area which hinders them from farming experience before admission. In addition, the study revealed that the majority of the respondents strongly agree that agriculture has a high potential for self-employment and Many Nigerians have made a lot of fortunes from agriculture while the majority agree that agricultural science is the best course of study, Agriculture is a lucrative business, Agriculture is a prestigious field and agriculture is the last opportunity to obtaining in tertiary education and certificate as an attitude to establish agricultural enterprises in the study area.

Furthermore, results revealed that the majority of the respondents most preferred livestock production, agricultural education (Trainer/Teacher/Lecturer), fishery and aquaculture production, Plant and animal geneticist, and other jobs not related to agriculture in the study area. There is a significant relationship between willingness to establish an agricultural enterprise and

student's attitude toward agricultural enterprise in the study area. It is, therefore, recommended that special assistance should be given to students studying agriculture upon graduation as the students show a positive attitude towards agriculture and establishing an agricultural enterprise as they think self-employment and are willing to establish agricultural enterprises on completion of degree and HND programmed. This can be achieved by giving scholarships for further study, granting loans and providing Agricultural inputs to students.

REFERENCES

Adedeji, T.O., Nosiru, M.O., Akinsulu, A.A., Ewebiyi, I.O., Abiona, B.G. and Jimoh, T.S. 2013. Adoption of New Rice for African (NERICA) technology in Ogun State, Nigeria.*Journal of Development and Agricultural Economic*. 5(9): 365-371. Sept. 2013.

Akinbile, L. 2007. Social impact of limestone exploitation in Yewa North Local Government of OgunState.*Pakistan journal of social science*. 1:107-111

Andrew, H (2016): Does religion influence entrepreneurial behaviour?International Small Business Journal: Researching Entrepreneurship 35(5): 597–617

Ayanda I.F., Olooto F., MotunrayoA.,Abolaji G.T., Yusuf O. J. and Subair S.K. (2012).

'Perception of Kwara state university agricultural students on farming as means of future livelihood. *International Journal of Agri Science* .2(11): 1053-1061.

Beggs, J.M., Bantham, J.H. and Taylor, S. (2008). Distinguishing the factors influencing College students' choice of major. *College student Journal* 42 (2), 381 – 394.

Edozien, N.N. (2002). Empowering the poor through micro finance. A paper presented at 20th Biennial Conference of the Development Finance Department of Central Bank of Nigeria.

Jeffrey Taylor, Marcia B. Harris, and Susan Taylor. (2004). Parents Have their say...About their College-Age Children Career Decision. Winter 2004 Journal. Pp 1- 5. http://www.jobweb.com

Mc Glym, A.P. (2007). Millennials in College: How do we motivate them? The Hispanic Outlook in Higher Education, 17 (25), 34 – 36.

Mbeine, E. (2012), "How can we attract the Ugandan Youth to Agriculture?" FIT Uganda Ltd.

Okorie, J.U. (2001). Vocational Industrial Educatioon, Bauchi League of Researchers in Nigeria.

Research Article

Open access

The Residual Effect of Different Levels of Rice Mill Ash on Maize-Soybean Intercrop

Nweke, I. A. [1]; Ngonadi E. N. [2]; Maduekwe, C. C. [2]; Aniamalu, J. M. I.[2]

[1]Department of Soil Science Chukwuemeka Odumegwu Ojukwu University
[2]Department of Crop Science and Horticulture Chukwuemeka Odumegwu Ojukwu University

ARTICLE INFORMATION

ABSTRACT

A two-year (2013 and 2014) field trial was conducted at the experimental farm of Crop Science and Horticulture Department Chukwuemeka Odumegwu Ojukwu University to study the residual effect of different fertility levels of rice mill ash on maize-soybean intercrop. In order to achieve the objective of the study, the experiment was arranged in a randomized complete block design (RCBD) comprising of nine (9) treatments and three (3) replications. The treatments were sole maize (SMO), sole soybean (SBO), maize/soybean intercrop without application of rice mill ash (IMBO), soybean + 10 t/ha rice mill ash (SB10), sole maize + 10 t/ha rice mill ash (SM10), maize - soybean intercrop + 10 t/ha rice mill ash (IMB10), sole maize + 20 t/ha rice mill ash (SM20); sole soybean + 20 t/ha rice mill ash (SB20) and maize/soybean intercrop + 20 t/ha rice mill ash (IMB20). Data generated were subjected to analysis of variance of which the result of the study showed that for 2 years under study, incorporated rice mill ash (RMA) and intercropping system significantly increased the soil productivity, yield, and yield components of maize and soybean studied. The application of rice will ash at the rate of 20 t/ha competitively among other treatment increased fertility of the studied soil and the yield parameter assessed across the sole and intercrop. This however declined in the 2nd year (2014) result but the residual impact was strong though relatively alike and statistical equal for 10 t/ha and 20 t/ha RMA results. The equivalent and relative yield of both maize and soybeans in the intercrop were found to be greatly influenced relative to their individual sole yield results. Findings from the study equally showed an intercrop advantage with land equivalent ratio (LER) for the 2 years study ranged 1.31 - 1.94 for 2013-year planting and 1.81 -2.74 for the 2014-year planting. With this result farmers within the area are encouraged to adopt this production system for soil productivity improvement and efficient land management.

INTRODUCTION

The use of chemical fertilizer to replenish lost nutrient and sustain agricultural soils is very minimal in Nigeria and most of the African countries at large. The reason being that most farmers cannot afford the cost and the attendant problems such as unavailability at the point of need, soil acidity, nutrient imbalance etc. In this contest therefore, the management of wastes is very critical in keeping the agricultural soils supplied with essential plant nutrients for healthy growth of crops. Wastes are bound in urban cities and in mini and large agricultural processing industries but the problem is the policy articulation and adequate management of the wastes to ensure maximum benefits from them. When wastes are properly managed especially with referred to soil it becomes a source of fertilizer that reduces the cost of production and the use of chemical fertilizer in crop production. It can also be used to reclaim degraded and marginal soils. The good thing about soil is that it is a natural filter, thus important medium for wastes disposal. The essence of life on this planet earth depends largely on the sustainability of the soil. In all cases also, man and animal depend on plant for life sustenance therefore the fertility status of any given soil should be paramount to farmers, as it is a measure of the availability of the nutrients to the plant in their right proportion and balances. The objectives of intercropping is to produce more crop yield on a piece of land by making use of resources otherwise would not have been utilized by a single crop. This wonderful method of cropping if properly planned and implemented in Nigeria soils especially southeastern region soils taken into account the climate, crop type and variety, disease and pest, as Nweke (2018) argued could be a panacea for sustainable food production, environmental harmony and a strong check to land degradation in the area.

This new and improved method of cropping advocated has been avoided by farmers especially the large and commercial farmers on the pretense of complications of planting and harvesting. Nonetheless, intercropping usually give benefit from increased light interception, root contact with more soils and more nutrients, increased microbial activity and can act as a deterrent to pest and weed of the other crop. Available growth resources such as light, water and nutrient are more completely absorbed and converted to crop biomass by the intercropping as a result of differences in competitive ability for growth factor between intercropping components (Nweke, 2018, 2020). However, food production is based on continuous availability of plant nutrients in the soil, and continuous cropping without adequate input and to the depletion of soil nutrients with resultant poor yield of cultivated crops. With this trend soil nutrients that will boost crop growth and yield decline progressively unless the nutrients are replenished through organic wastes or chemical fertilizers. Soils and crops differ in their response to organic wastes amendments and therefore important to investigate more closely the influence of these organic wastes on a range of crops and of soil physical, chemical, and biological properties. Thus, the objective of this study is to determine the residual effect of rice mill ash at different fertility levels on the maize-soybean intercrop.

MATERIALS AND METHODS

The experiment was carried at Teaching and Research form of Crop Science and Horticulture of Chukwuemeka Odumegwu Ojukwu University, Igbariam Campus Anambra State Nigeria, Between May-September 2013 and 2014 planting season. The area is located between the latitude 06 14 `N and longitude 06 45 `E and within the humid tropical rainforest zone characterized

by both wet and dry season with high rainfall and high temperature.

Land Preparation /Treatment Allocation and Experimental Design

The land area measuring 434 m^2 was manually cleared with cutlass and debris removed. The dominant weed species in the area before they were cleared were *Imperata cylindrical* (spear glass), *Talinum triangular* (water leaf), *Eleusine indica* (crow foot grass) and *Aspila africana* (wild marigold). The experiment was laid out in a randomized complete block design (RCBD) with 9 treatments.
The treatments are as follow;
Sole maize (SMo)
Sole soybean (SBo)
Maize-Soybean intercrop (IMBo)
Sole maize treated with a 10 t/ha rice mill ash (SM$_{10}$)
Sole soybean treated with 10 t/ha rice mill ash (SB$_{10}$)
Maize-Soybean intercrop treated with 10 t/ha rice mill ash (IMB$_{10}$)
Sole maize treated with 20 t/ha rice mill ash (SM$_{20}$)
Sole soybean treated with 20 t/ha rice mill ash (SB$_{20}$)
Maize -soybean treated with 20 t/ha rice mill ash (IMB$_{20}$)
The treatments were randomly assigned to each plot measuring 3 m x 4 m (12 m^2) and adjacent plots were spaced at 0.5 m within each block and 1m between blocks. The treatments were replicated 3 times. Two seeds of maize and soybean were sown directly on their respective plots. Supply on non-germinated seeds were done two weeks after planting for maize and 28 days after planting for soybean. Weeding was done manually every other week with either hoes or hand pulling. The maize and soybean were harvested when they are matured and dried for their seed and grain yield. The same procedures were followed in 2014 with exception of application of rice mill ash. Soil samples were collected from 0 – 25 cm depth

randomly from the land area before cultivation and bulk together as composite sample. After harvest soil samples were collected from each plot at the depth of 0 – 25 cm. These soil samples were air dried and sieved with 2 mm mesh sieve and used to analyze selected soil chemical properties and core samples used for the analysis of selected physical properties of the soil. The analysis of both physical and chemical properties follows the method outlined in Black (1965) Agronomic parameter measured include; number of nodules of which destructive sampling was used to determine number of nodules at 10 weeks after planting using ten (10) randomly tagged plants which were uprooted, weight of nodules, weight of pods, maize grain yields, and soybean seed yield (t/ha).

Relative yield of maize

This was used to evaluate the yield of maize expressed as sole crop and intercrop using the equation;

$$RY = \frac{YIMB}{YSM}$$

Where RY = Relative Yield, YIMB = Yield of maize as intercrop in soybean
YSM = Yield of maize as a sole crop.

Relative yield of soybeans

The yield of soybean expressed as sole crop and intercrop using the equation;

$$RY = \frac{YISM}{YSB}$$

Where; RY =Relative yield, YISM = Yield of soybean as intercrop in maize
YSB = Yield of soybean as a sole crop

Equivalent yield of maize and soybean

This was done by calculating the total yield of maize grain as compared to soybean seed in t/ha. The following equations were used;

$$EYs = YSB + \left(\frac{YIM \times PM}{PB}\right)$$

$$EYm = YSM + \left(\frac{YIB \times PB}{PM}\right)$$

Where:

EY$_S$ = Equivalent yield of soybean

EY$_M$ = Equivalent yield of maize

YSB= Yield of sole soybean

YSM= Yield of sole maize

YIM= Yield of maize in intercrop

YIB= Yield of soybean in intercrop

PM= Selling price of maize at the period of study

PB= Selling price of soybean at the period of study

Land equivalent ratio (LER)

This tool was used to evaluate the intercrop efficiency in yield to sole crop

$$LER = \frac{YIM}{YSM} + \frac{YIB}{YSB}$$

Where;

LER = Land equivalent ratio

YIM = Yield of maize in intercrop

YSM = Yield of sole maize

YIB = Yield of soybean in intercrop

YSB = Yield of sole soybean

Data analysis

Data generated from the study was subjected to the analysis of variance test based on randomized complete block design (RCBD) and treatment means were separated using least significant difference at 5% alpha level.

RESULTS

On farm observation

The maize seed germinated within 4 - 5 days after sowing while the soybean germinated 14 days after planting. Pest attack was a major problem, in the soybean plot amended with rice mill ash. It seems the ash attracted the pest as their effects declined in 2014 planting year that ash was not applied. Flea flies and grasshopper were major pest while

in the sole plots these insects were not seen but maggot was noticed to eat the leaf of the plant which often lead to death of the affected plant. Another problem is the bush rat that dug up a hole and eat up the nodules of soybean, mostly observed in plots amended with 10 t/ha of rice mill ash. Soil erosion problem was partly observed but was controlled. On the whole, number of plants survived to maturity was observed to be higher in sole cropping compared to intercropping. However, the above numerated problems were drastically reduced in the second year of the planting season (2014).

Initial soil properties

The chemical characteristics of the studied soil indicated low level in all the parameters tested, except for base saturation (BS) value and available P that is of moderate value (Table 1).

Nutrient content of rice mill ash before the study

The properties of rice mill ash before application in Table 2 showed that the pH of the ash is strongly alkaline (11.40) however the ash contains lower levels of exchangeable bases, P, organic carbon (OC) and total nitrogen (TN).

Effect of different fertility levels of rice mill ash and intercrop system on the chemical properties of the studied soil

The result of the chemical properties of the studied soil presented in Table 3 showed significant difference among the treatments in 2013 planting season except for the results of K, Na, EA, ECEC and BS while the 2014 planting season result showed non-significant ($p < 0.05$) different among the treatments in all the parameters assessed except for pH, OC and BS. Most of the parameters tested in 2013 and 2014 planting season showed increment in value as the RMA levels increased. Also decreased value were recorded in 2014 planting season

relative to 2013 planting season results in all the parameters assessed in the study. The RMA increased the pH of the soil to alkaline in 2013 planting season but slightly acidic in 2014 planting season. The residual effect of RMA on the parameters were strong but relatively alike in value. Most of the values obtained in 2014 planting season from 10 t/ha RMA and 20 t/ha RMA fertility levels were the same and statistical equal. The obtained values in the study were however higher in amended plots relative to the control plots though more pronounced in 2013 planting season than 2014 planting season result.

Table 1. Initial soil properties

Parameter	value
Sand	770 gkg^{-1}
Silt	780 gkg^{-1}
Clay	152 gkg^{-1}
Textural class	Sandy loam
pHH$_2$O	6.46
Available P	26.10 mgkg^{-1}
Total N	0.126%
OC	0.77%
OM	1.32%
Ca	5.60 cmolkg^{-1}
Mg	2.40 cmolkg^{-1}
K	0.118 cmolkg^{-1}
Na	0.096 cmolkg^{-1}
EA	0.40 cmolkg^{-1}
ECEC	8.614 cmolkg^{-1}
BS	95%

Table 2 Chemical properties of rice mill ash before the commencement of the study

Parameter	Value
pHH$_2$O	11.4
OC%	0.16
N%	0.22
P mgkg^{-1}	0.45
Ca comlkg^{-1}	3.84
Mg cmolkg^{-1}	1.28
K cmolkg^{-1}	0.78
Na cmolkg^{-1}	2.25

Effect of different fertility levels and intercrop system on the physical properties of the studied soil

The physical properties of the soil showed that apart from % clay result the treatment differed significantly ($P < 0.05$) in 2013 planting season (Table 4). But in 2014 planting season the particle size result indicated non-significant but showed significant effect on the result of bulk density (BD) and total porosity (TP). The value of BD decreased and TP increased with incremental increase in RMA in 2013 planting season

while there was no particular order in the result in 2014 planting season. However, the highest recorded value for BD and TP were from 10 t/ha RMA and 20 t/ha RMA respectively. There was a little bit decrease in BD value of 2013 planting season relative to 2014 planting season while the 2014 planting showed increased TP value relative to the 2013 planting season result. The particle size data indicated increased constant sand and silt and decreased constant clay in 2014 planting season compared to the obtained value of the parameters in 2013 planting season.

Table 3. Effect of different fertility levels of RMA on the chemical properties of the studied soil

Treatment	2013 planting season											2014 planting season										
	pH H₂O	P mg kg⁻¹	N %	OC %	Ca	EA	Mg	ECEC	K (Cmolkg⁻¹)	Na	BS %	pH H₂O	P mg kg⁻¹	N %	OC %	Ca	EA	Mg	ECEC	K (Cmolkg⁻¹)	Na	BS %
Ot/ha RMA	6.97	15.8	0.06	0.85	3.2	1.6	0.13	0.89	0.3	5.34	9.4	6.1	20.52	0.07	0.37	2.0	i.0	0.13	0.08	1.8	9.6	33.44
10t/ha RMA	7.47	21.6	0.13	1.01	4.8	2.4	0.15	0.12	0.4	7.91	9.5	5.9	20.52	0.07	0.46	1.8	1.4	0.13	0.08	1.6	9.6	33.52
20t/ha RMA	8.23	28.5	0.24	1.09	5.6	2.0	0.23	0.17	0.6	8.56	9.3	5.4	21.45	0.04	0.33	2.4	1.0	0.13	0.06	1.0	9.6	37.40
LSD 0.05	0.47	3.16	0.29	0.19	1.34	0.34	NS	NS	NS	2.35	NS	0.25	NS	NS	0.37	NS	NS	NS	NS	NS	NS	1.58

RMA = Rice mill ash

Table 4 Effect of different fertility levels of RMA on the physical properties of the studied soil

Treatment	2013 planting season						2014 planting season					
	Sand %	Silt %	Clay %	TC	BD gcm⁻³	TP %	Sand %	Silt %	Clay %	TC	BD gcm⁻³	TP %
Ot/haRMA	78	6.50	15.2	LS	1.5	43	82	12	6	LS	1.38	47,92
10t/haRMA	74	5.50	15.2	LS	1.4	47	82	12	6	LS	1.45	45.28
20t/haRMA	80	4.80	15.2	LS	1.3	51	82	12	6	LS	1.21	54.34
LSD0.05	1.38	0.58	NS		0.09	2.87	NS	NS	NS		0.19	2.98

RMA = Rice mill ash; TC =Textural class; BD = Bulk density; TP = Total porosity

Effect of different fertility levels and intercrop system on maize grain, yield, soybean seed yield, pod yield (t/ha) and number of nodules and weight of nodules.

The result presented in Table 5 showed significant difference ($P < 0.05$) in all the parameter measured in both 2013 and 2014 cropping season except for pod weight in 2013 cropping season and number of nodules in 2014 cropping season. The sole maize (SM_O) showed higher in value (2.81 t/ha) compared to the intercrop maize (IMB_O), 2.64 t/ha. The plot amended with 10 t/ha RMA and 20 t/ha RMA varied in their yield results. SM_{20} recorded the highest maize grain yield of 6.96 t/ha, this was closely followed by SM_{10}, IMB_{20} and IMB_{10}. Soybean seed yield and pod weight showed a result variation of $SB_{20} > SB_{10} > SB_0 > IMB_{20} > IMB_{10} > IMB_0$. The highest number of nodules and weight of nodules were recorded in SB_{20} the next in rank is SB_{10} for the two parameters. No value was recorded for these two parameters in SB_0 and IMB_0. For the 2014 cropping season the trend of the result was almost the same with the 2013 planting season results. The highest maize grain yield was recorded in IMB_{10}, the next in rank was

SM_{10} and the least value of 0.72 t/ha obtain from SM_{20}. IMB_O recorded the least soybean seed and pod weight yield of 0.04 t/ha and 0.09 t/ha of which is 84.62% and 84.15% respectively decrease in value relative to IMB_{10} that recorded the highest (0.26 t/ha and 0.59 t/ha) of soybean seed and pod weight respectively. The result obtained from SB_{10}, IMB_{10}, SB_{20} and IMB_{20} showed statistically similar result for the two parameters. SB_{20} and IMB_{20} recorded the same value for the number of nodules with the highest value of 26.30 recorded by IMB_{10}.The least value weight of nodules was obtained from IMB_0 as against the highest value of 1.55 $_g$ recorded in IMB_{10}. In all the parameters the values obtain in first planting season (2013), showed higher values compared to the values recorded in the second planting season (2014).

Table 5: Effect of different fertility level and intercrop system on maize grain yield, soya bean seed, pod yield (t/ha), number of nodules and weight of nodules.

Treatment	2013 Planting Season						2014 Planting Season			
	Maize grain (t/ha)	Soya bean seed (t/ha)	Pod yield (t/ha)	No. of nodules	Weight of nodules	Treatment	Maize grain (t/ha)	Soya bean seed (t/ha)	Pod yield (t/ha)	No. of nodules
SM_0: SB_0	2.81	0.40	0.56	0	0	0.79	0.11	0.25	11.0	0.79
IMB_0	2.64	0.22	0.44	0	0	1.14	0.04	0.09	9.0	0.37
SM_{10}:SB_{10}	5.94	0.68	0.96	36.0	1.50	1.67	0.21	0.54	13.0	0.90
IMB_{10}	4.94	0.30	0.47	10.3	1.33	2.24	0.26	0.59	26.3	1.55
SM_{20}:SB_{20}	6.96	1.06	1.39	79.8	3.65	0.72	0.24	0.50	11.0	0.50
	5.25	0.38	0.49	13.7	1.31	1.43	0.18	0.46	11.0	0.55
IMB_{20}	1.62	0.60	NS	15.47	0.85	0.74	0.15	0.23	NS	NS
LSD 0.05										

Effect of different fertility levels of rice mill ash and intercrop system on equivalent and relative yield of maize and soybean and land equivalent ratio.

The equivalent yield result for maize and soybean showed an order 20 t/ha RMA > 10 t/ha RMA > 0 t/ha RMA (Table 6). The 0 t/ha RMA recorded the highest value in relative yield (0.95 t/ha) for maize and for soybean 20 t/ha RMA gave the highest of 0.52 t/ha, while 0.10 t/ha been the least value for relative yield of soybean was obtained from 0 t/ha RMA. The land equivalent ratio showed a result scenario of 0 t/ha RMA > 10 t/ha RMA > 20 t/ha RMA. The 2014-year planting season, the equivalent yield of maize and soybean indicated 10 t/ha RMA > 20 t/ha RMA > 0 t/ha RMA. The relative yield result for maize and soybean depicted 20 t/ha RMA and 10 t/ha RMA to have recorded the highest value of 1.98 t/ha and 1.24 t/ha respectively. While the land equivalent ratio showed an order of 20 t/ha RMA > 10 t/ha RMA > 0 t/ha RMA. The two seasons under study (2013 and 2014 season) varied greatly in the results generated and there was no consistent order in the value recorded for the parameters apart from equivalent yield value

of first planting season. The relative yield of maize and soybean and land equivalent ratio (LER) result of 2014 planting season showed an increased value relative to the 2013 planting season result. The percentage increase in relative yield of maize and soybean in 2014 planting season relative to 2013 planting season were; 34.03%, 38.06%, 60.61% and 72.22%, 60.48%, 30.67% for 0 t/ha RMA, 10 t/ha RMA and 20 t/ha RMA respectively.

Table 6: Effect of different fertility levels of rice mill ash and intercrop system on equivalent yield of maize and soybean and land equivalent ratio.

Treatment	2013 planting season					2014 planting season				
	Equivalent yield		Relative Yield		LER	Equivalent yield		Relative Yield		LER
	Maize	Soya bean	Maize	Soya bean		Maize	Soya bean	Maize	Soya bean	
0t/ha RMA	1.38	3.95	0.95	0.10	1.94	0.87	0.68	1.44	0.36	1.81
10t/ ha RMA	1.86	7.39	0.83	0.49	1.32	2.19	1.33	1.34	1.24	2.58
20t/ha RMA	2.32	7.89	0.78	0.52	1.31	1.08	0.96	1.98	0.75	2.74

DISCUSSION

The soil analysis taken before the commencement of the study is of evidence that the soil is deficient in plant nutrients as the parameters assessed were low except for available P that showed moderate level and high BS. The low-level value simply suggest that the soil is leached and strongly weathered resulting from high temperature and rain fall and rapid OM mineralization. Hence required to be ameliorated for efficient production. The reduction in value obtained for the parameters in 2014 planting season compared to 2013 planting season may be due to none addition of RMA in the 2014 planting season. While different in values may be attributed to differences in the nutrient content in the rates of RMA applied. The rise in soil pH of the amended relative to the control plots may be due to microbial decarboxylation of the RMA that releases certain exchangeable bases into the soil solution. Thus, increase the pH level of the soil and nutrient availability to the crop plants that led to increased yield recorded in

the study. The low value recorded for chemical parameters assessed in 2014 planting period compared to their relative value in 2013 year may be attributed to any or combination of the following factors; residual effect of 2013 planting season, none application of RMA, uptake of nutrients by the crops, high productivity and reduced decomposition of organic matter. The addition of RMA was observed to reduce the BD and increased the TP of the studied soil. This is very critical as the parameters ensures easy root penetration, development and proliferation as well as contain the required O_2 and water for soil microbes to survive in the soil.

The significant difference effect recorded in the maize grain yield and soybean seed yield indicated that intercropping system is positive and effective. However, the number of nodules and weight of nodules zero value recorded and non-significant effect in pod yield in 2013 planting year as well as number of nodules and weight of nodules in 2014 planting year could be due to competition of

light energy and chemical nutrients making the intercropping system not to be efficient on the 3 parameters. The shedding of soybean, disease pest and bush rat attack as explained in the on-farm observation may also have influenced the recorded results. The yield of maize and soybean were found to be increased in amended plots relative to the control plots, both 2013- and 2014-year planting. Significant different observed suggest higher content of nutrients due to enrichment of the amended soil with OM by the rice mill ash. This increased the soil ability to absorb and retain water and plant nutrient elements required for optimal plant growth and yield recorded in this study. The differences in values recorded could suggest differences in nutrient content and availability status in the type and rate of waste used. The 2014-year planting result values appeared to be reduced relative to 2013 planting in assessed parameters. This could be as a result of non-application of rice mill ash in the 2014 year of the crop production. Nonetheless, the rice mill ash and intercropping system showed strong residual effect on the maize production, number of nodules and weight of nodules of which the greatest recorded value was observed in IMB_{10}. The implication of the result is that without further application of the rice mill ash reasonable yield of maize can still be obtained. The pod yield result showed non-significant effect of soybean intercropped with maize with considerable reduction in pod yield in intercrop relative to sole and amended crop of which quantitatively the plot amended with 10 t/ha RMA gave the highest value. The observed significant difference in grain and seed yield result in both 2013- and 2014-year planting attest to the evidence that intercropping system and RMA influenced the assessed parameters. The equivalent yield result was found to be increased with level of rice mill ash in the 2013 planting season this might be due to higher nutrient content in the level of rice mill ash applied. The 2014 planting

season result however did not follow the same order and 10 t/ha showed strong residual effect among the other treatment. This might as well be due to different in the rate of decomposition of rice mill ash and nutrient release ability in the form required for the crop as well as competition among the crops in picking up the released nutrients. The findings are in line with the reports of Odiete et al. (2005), and Mutuo et al. (2000) who reported that the rate of application of ash increased yield and that plot received organic biomass had a higher residual effect and gave 15% yield increase above the control. The observed reduction in value of the maize and soybean by the virtue of their equivalent yield recorded might have been influenced by both external and internal factor. The external factor probably might be due to the selling price of the product at the conclusion of the study. On the internal factor, probably may be attributed to the disproportionality in balance in soil nutrient. When optimum ratio of bases exit in soil biological activity is increased of which will lead to more release of plant nutrients. Plant growing on such soil will be balanced in mineral levels. Nonetheless the result obtained showed that the study was very profitable as it agrees with findings of Bhagat et al. (2005) who recorded the lowest net returns under sole groundnut compared to intercrop in a study of groundnut/sweet corn intercropping at different fertility levels and row proportions. Also, in two (2) year study involving the performance of different hybrid maize varieties under intercropping system with groundnut, Alom et al. (2009) made similar remark. The relative yield of maize and soybean was observed to have decreased in the 2013 planting season relative to 2014 planting season. This probably indicate that the effect of intercropping was more effective in the 2014-year planting compared to 2013-year planting. The general growth patterns of crop in intercropping suggest that the main factor responsible for the

advantages is that the use of early resources by the growing soybean complements the use of late resources by the longer season maize crop. Regardless of the intercrop yield parameters, the LER result showed the intercropping system to be positive, beneficial and advantage.

CONCLUSION

Intercropping system and soil application of rice mill ash have shown to have significant effect on the soil parameters studied, yield of maize and soybean. An alternative to use of chemical fertilizer and pesticide. The rice mill ash at the rate of 20 t/ha performed better both in sole cropping and intercropping though its effect on yield declined in the 2014 planting season. The study confirmed that the way to achieve the aim of using organic waste to enhance fertility status of soil is to apply them to the soil in the right quantity and quality to match nutrient release and needs for crops. The yield of soybean is an added advantage that will complement any loss in yield of maize. Hence, the farmers in the locality are advised to embrace this package for effective crop production and zero tolerance of chemical inputs in the area.

ACKNOWLEDGEMENT

REFERENCE

Alom, M. S.; Paul, N. K.; Quayyum, M. A. Performance of different hybrid maize (Zea mays L.) and varieties under intercropping system with groundnut (*Arachis hypogeae L.*). *Bangladesh J. Agron. Res*. 2009, 34-94: 585-595.

Bhagat, S. B.; chavan, S. A.; Zogade, W. V.; Dahiphale, A. V. Intercropping groundnut and sweet corn at different fertility levels and row proportions. *India J. Crop Sci*. 2005, 1 (1-2), 151-153.

Black, C. A. Method of soil analysis part 1 physical mineralogical properties. *Amer. Soc. Agron*. 1965, Madison Wisconsin USA.

Mutuo, P. K.; Mukalama, J. P.; Agunda, J. On farm testing of organic and inorganic phosphorous sources on maize in western Kenya. *In*: Biology and Fertility of Tropical Soils, TSBF Report, 2000, Pp 22.

Nweke, I. A. In support of a well-planned intercropping systems in south eastern soils of Nigeria: A review. *African J. Agric. Res*. 2018, 13(26), 1320-1330. DOI: 10.5897/AJAR2017.12743.

Nweke, I. A. Potentials of intercropping systems to Soil - Water - Plant-Atmosphere. *Agric. Sci*. 2020, 2 (1), 31-38.
https://doi.org/10.30560/as.v2n1p31.

Odiete, I.; Chude, V. O.; Ojeniyi, S. O.; Okozi, A. A.; Hussaini, G. M. Response of maize to nitrogen and phosphorous sources in guinea savanna zone of Nigeria. *Niger. J. Soil Sci*. 2005, 15:90-101.

Journal of Agriculture & Forestry Research

Research Article   **Open access**

In Support of Biopesticides, Bioheat And Anaerobic Fermentation in Sustainable Agricultural Production in Nigerian Soils

Nweke Ikechukwu Aloysius[1]; Chukwuma Roseline Tochukwu[2]

[1]Department of Soil Science Chukwuemeka Odumegwu Ojukwu University

[2]Department of Soil and Land Resource Management, Nnamdi Azikiwe University, Awka, Nigeria

ARTICLE INFORMATION

ABSTRACT

The sustainability of crop production in Nigeria with much population increase and critical environmental challenges is very problematic. Intense rainfall and high temperature experienced in the area create good condition for various type of pathogens and pest to thrive and cause different kinds of diseases to crop plants. Thus, limiting production period for most crops in the area. Synthetic or chemical pesticides used to confront these disease problems have been found to have pronounced negative effect on human health, natural enemies, environmental and ecosystem balance. Some of the active ingredients of synthetic pesticides have been found to be carcinogenic, thus a threat to human life. While increased use of the synthetic pesticides have been found to cause disappearance of bees and some other useful insects responsible for pollination. Biopesticides offer better alternative to synthetic pesticides due to their low toxicity, biodegradability and very low persistence in the environment. They are readily available and inexpensive, unlike the synthetic that has not been sustainable at the farmer's level. Increased awareness of the public on the dangers pose by synthetic pesticides on the soil, safety and quality of food have hastened the use of biopesticides in agricultural production. This is very important for increased food production to checkmate the population increase as well as income generation and delivery of healthier food to the public.

INTRODUCTION

The sustainability of agricultural activities in Nigeria is herculean task as it faces a lot of challenges; the soils are fragile and prone to erosion and land degradation problems, population explosion that put pressure on available land that today some of the suitable land for crop production now play home to residential building, industries or even roads. Intense rainfall and temperature that have created different scenario or situation in soil such as soil infertility, multiple nutrient deficiency, low soil biodiversity, moisture stress, disease organism, disease and pest

infestation, toxic substances ecological imbalance etc. While inputs such as improved seeds and cultivars, synthetic pesticides, chemical fertilizer and other synthetic chemicals to confront these challenges are not within the reach of poor resource farmers that form the bulk of crop and food producers in Nigeria. Thus, the inputs whether in form of improved seeds and cultivars or synthetic chemicals has never been sustainable at the farmers level in Nigeria. In the works of Nweke, (2018ab) and Nweke, (2020abc) different ideas and solutions were proffered on how to meet up with most of the above challenges facing crop production in Nigeria using indigenous cultural practices. This particular paper again will try to x-ray the need for the farmers to anchor their knowledge, energy and resources to the use of our indigenous biopesticides for increased healthy growth of crops, yield and healthy food delivery to the populace. This is very important knowing fully well that most of these disease-causing agents and pest inhabit the soil, hence making them more difficult to control. Nematode for example inhabit the soil from where it attacks the underground part of the plant host making nutrient absorption, water uptake and all that dissolve therein impossible leading to the death of the plant. Pests and pathogens are capable of causing monumental damage to a wide range of crops, vegetables, cereals, grains, roots and tubers, flowers etc., making a farmer to be under penury. Sikora and Fernandez (2005) found out that in tropical and sub-tropical agriculture nematode cause great losses in vegetable crops. Maize one of the major crops cultivated across the globe is susceptible to a lot of diseases and pests causing great yield decline and nightmare to the farmers. According to Flet et al. (1996) maize crop is attacked by nematode causing root-knot disease, viral disease such as streak and dwarf mosaic, cob and tassel fungal diseases, bacteria diseases like stalk rot and

leaf streak and insect pest species such as aphids, leafhoppers, stalk borers, beetles, boll worms and weevils. Another important crop like cowpea have been noted by Adipola et al. (1999) and Edema (1995) to be attacked by virus disease like anthracnose (rust virus) and scab, bacteria disease like blight and insect pest such as aphids, thrips, pod borers and foliage beetle.

The use of synthetic chemical in the control of plant diseases is still a common practice in Nigeria and other developing countries and even to some extent developed countries. The only different is that in developed countries there is strict compliance to the type of synthetic chemicals that could be used for crop production. And even in sale of the farm produce a tag is placed on the produce to denote chemically produced or organically produced. In this situation the buyer is left with a choice on which product to buy. This is not obtainable in Nigeria and Africa at large. Although with the application of chemicals such as pesticides, fungicides, bactericides, nematicides etc., plant diseases can be controlled but the hazardous impacts of such products in human health and ecosystem are well known. With their excessive applications pest resistance may exist. Chemical control of most pests and plant diseases may be available and could extensively reduce the impact of plant diseases, but field application of synthetic chemicals may not always be desirable. Gill et al. (2012) opined that the mysterious or sudden disappearance of bees and some other insects important in pollination of flowers of agricultural crops was due to increased use of chemical pesticides. While global decline in frog population as noted by Bruhl et al. (2013) may be associated with intensified use of pesticides. Elyous et al (2010) in their studies observed that ground and surface water are contaminated, the ecosystem balance existing between soil-plant-microorganisms are very much disturbed with repeated application of

various synthetic chemicals under intensive agricultural activities or production. There has been a global awareness that excessive and improper use of chemicals is hazardous to the health of humans, animal,sthe and environment, there an extensive research for environmentally safe and easily biodegradable, biopesticides becthe omes best alternative. According to Gnanamanickam et al. (2002), biopesticides are natural in origin and have minimum adverse effect on the physiological processes of plants and are easily convertible into common eco-friendly organic materials. For the following authors, Radhakrishnan (2010), Akpheokhai et al. (2012) and Faye et al. (2012), are economical, biodegradable and biorenewable resources. Biocontrol is best option for disease and pest control in crop production and to cope with the dangers and losses at chemical control. Biopesticides can be derived or harnessed from microorganisms, plant parts or extracts and animals for pest and disease control. Radhakrishnan (2010) and Pendseet al. (2013) found biopesticides to be environmentally safe and ecologically feasible option for plant protection with great potential for promoting sustainable agriculture. Plant extract, essential oils, gums, resins etc. have been shown to exert biological activity against plant fungal pathogens in vitro and can be used as biofungicidal products (Fawzi et al., 2009; Jalili et al., 2010; Romanazzi et al., 2012). These products according to Chuange et al. (2007) are generally assumed to be more acceptable and less hazardous for the ecosystems and could be used as alternative remedies for treatment of plant diseases. Muthomi et al. (2017) found significant effective reduction against *Alternaria solani*; *Phythium ultinum*, *Rhzoctonia solani* and *Fusarium oxysporum* f. sp. Lycopersici *in vitro* study involving ethanolic plant extract of turmeric (*Curcuma longa*), lemon (*Citrus limon*), garlic (*Allium sativum*), pepper

(*Capsicum frutescens*) and ginger (*Zimgibar offcinals*) while turmeric was reported by the authors to be the most effective with a growth inhibition of up to 73% against *Alternaria solani*. In a study conducted at Igabariam southeast, Nigeria Chime et al. (2019ab) observed an increased plant biomass of Indian spinach infected with root knot nematode in soils treated with ginger rhizome extract and pawpaw leaf. Their study showed the potential of ginger extract and pawpaw leaf as biopesticides against root knot nematode that normally attack the Indian spinach at early stage of growth in the study area. Faye et al. (2012) using plant extract and Elyous et al. (2010) using plant extract and *Pseudomonas* spp. found significant reduction in root knot nematode in tomato production. While Pascual et al. (2002) observed suppression of *Pythium ultimum* in crop plant in soils treated with municipal waste compost and its humic fraction. The biopesticides were able to affect these reductions because of their ability to stimulate the defence mechanism of the plant and their physiological processes that make treated crops more resistant to the diseases and pests. Another important aspect of these natural biopesticides especially those applied inform of compost is that they improved the physicochemical and biological properties of the soil as can be found in the works of Randhawa et al. (2001), Pascual et al. (2002), Elyous et al. (2010), and Chime et al. (2019ab).

Biopesticides offer better alternative to synthetic pesticides due to their low toxicity, biodegradability and low persistence in the environment. The base materials for biopesticides are readily available and inexpensive. Data on toxicity levels, chemistry, active compounds and their compatibility with other methods of pests and disease management is needed to aid in formulation and commercialization. Globally, researchers have conducted studies on effectiveness of natural plant protection

products with significant results. There are also studies on effectiveness of biopesticides under controlled environments and field conditions with varying results. Further research is recommended to close the gaps in formulation of biopesticides. The present study, therefore aims to review and highlight on the following;

i) the various sources of biopesticides.

ii) their various active compounds or ingredients.

iii) their components mode of action on targeted pests.

iv) roles of biopesticides in sustainable agricultural production.

MATERIALS AND METHODS

Materials used for this study were the various work done in the area of synthetic pesticides, biopesticides, bioheat, anaerobic fermentation etc. These are published journal papers, books, seminar papers and student thesis and personal experience gathered. All were reviewed, discussed and conclusion drawn from the results of the various practices.

Synthetic chemicals and biopesticides at a glance

There are harmful effects associated with the use of synthetic pesticides such as toxicity and poisoning (Damalas, et al., 2015). Synthetic pesticides also lead to environmental pollution due to the non-biodegradable nature of their constituent compounds (Kekuda, et al., 2016. According to Parliman, (2001), degradation of metham sodium and other fumigants was reported to last up to over six months after application. In a report by PAN (2011), metham sodium pollutes the air and soil thereby affecting the population of natural enemies in the soil. Methyl bromide has been banned from agricultural use due to its negative impact on the environment. It is associated with depletion of ozone layer which contributes significantly to climate change (Morrissey, 2006). The constituent compounds of

chemical pesticides contaminate soils rendering them unsuitable for crop production (Kumari, et al., 2014). They also pollute surface and ground water, killing aqua life after inhalation and consumption (Maksymiv, 2015). Use of dichloro diphenyl trichloroethane (DDT) for instance led to poisoning of birds, marine species and humans. It has been reported to have carcinogenic properties leading to its ban from agricultural use (Harada, et al., 2016). After application, the active compounds of the synthetic pesticides are taken up and retained by crops. Consumption of such crops poses chronic health problems to humans due to the accumulated toxic chemical residues (Jantasorn, et al., 2016). Exposure to pesticides adversely affects the human population, directly or indirectly. For example, pesticides containing Malathion and Trichlorfon have been reported to cause reproductive complications in humans (Ghorab, et al., 2015). Exposure to some pesticides have also been reported to retard growth, induce chemical and structural changes in body organs as well as disturb immune responses. They also reduce resistance of animals to disease-causing pathogen infections (Maksymiv, 2015). Continuous exposure to pesticides such as chloropyrifos cause gene mutations, genetic damages, reproductive health problems and chronic diseases such as asthma, hypertension and cancer (Dey, et al., 2016; Alavanja, et al., 2015). Use of synthetic chemicals has raised numerous concerns due to their negative effects on the environmental, human health, natural enemies and ecosystem balance. Some of the active ingredients of synthetic pesticides have been found to be carcinogenic thus posing a threat to human life.

Biopesticides are products and by-products of naturally occurring substances such as insects, nematodes, microorganisms, plants as well as semiochemicals (Gasic and Tavonic, 2008). Based on the nature and

origin of the active ingredients, biopesticides fall into several categories such as botanicals, antagonists, compost teas, growth promoters, predators and pheromones (Semeniuc, et al., 2017). Plants and microorganisms are the major sources of biopesticides due to the high components of bioactive compounds and antimicrobial agents (Nefzi, et al., 2016). The active compounds in plants include phenols, quinones, alkaloids, steroids, terpenes, alcohols and saponins (Mizubuti, et al., 2007). Different plant families have varied antimicrobial bioactive compounds which include oil components such as α- and β-phillandrene, limonene, camphor, linalool, and β-caryophyellene and linalyl acetate depending on the plant family (Ali, et al., 2017; Vidyasagar et al., 2013). Microbial biopesticides include bacteria species such as *Pseudomonas, Bacillus*, *Xanthomonas, Rahnella* and *Serratia* or fungi such as *Trichoderma, Verticillium* and *Beauveria* species according to Kachhawa (2017). Biopesticides exhibit different modes of action against pathogens such as hyperparasitism, competition, lysis and predation according to Souza et al. (2007).

Plant growth promoting rhizobacteria protect plants from biotic and abiotic stresses and they also enhance plant growth and enhance formation of root hairs (Souza, et al., 2015). The most common species of plant growth promoting rhizobacteria include Agrobacterium, *Ensifer*, Microbacterium, *Bacillus, Rhizobium, Pseudomonas*, Chryseobacteria and Rhodococcus (Abbamondi, et al., 2016). They colonize the environment around the plant roots, fix nitrogen, increase phosphate solubilisation and plant yield (Compant, et al., 2009). Species of Pseudomonas and Bacillus have been used as biofertilizers with reports showing increase in plant growth, yield and phosphorous and zinc content in fruits and soils (Esitken, et al., 2009). Natural enemies including predators, pathogens and some insects are also used as biopesticides in management of insect pests. Parasitoids, wasps, beetles, lace wings, bugs and lady birds are used in management of destructive pests such as boll worms (*Helicoverpa armigera*) in important crops such as cotton (Knutson, et al., 2015; Wu, et al., 2005). Compost teas are filtrates of compost extracts and are similarly used as biopesticides (Ghorbani, et al., 2005).

Limitations and Challenges in the Use of Conventional Pesticides

Continuous use of synthetic pesticides leads to development of resistant plant pathogen strains leading to their resurgence. Farmers apply more chemicals in an effort to eradicate such pests (Birech, et al., 2006) (Halimatunsadiah, et al., 2016). In the process of managing target pests, synthetic pesticides kill non-target beneficial organisms such as pollinators, predators and antagonists thereby disrupting biodiversity (Prasad, et al., 2010; Ndakidemi, et al., 2016). In a study by Xavier, et al., (2016), application of Fenpyroximate on chilli peppers (*Capsicum annum L*) resulted in retention of its residues even after sun drying and processing. Similarly, spinosad (spinosyn A and spinosyn D), Indoxacarb and Deltamethrin containing insecticides used to control *Rhizoctonia dominica, Sitophilus oryzae* and *Trogoderma granarium* were found to be persistent for up to 120 days after application (Pandey, et al., 2016).

The horticulture sector in many developing countries has been particularly adversely affected by the use of synthetic pesticides. The European Union (EU) set out strict regulations regarding levels of pesticide residues and safety of agricultural produce exported to their markets. The use of pesticides containing Dimethoate on vegetables was banned by EU. Failure to comply with this regulation led to rejection and destruction of fresh vegetable consignments containing chemical residues

above the required limits (Business Daily 2014). Residues of the restricted chemicals should not exceed 0.02 parts per million (ppm) in a sample of vegetables. The percentage of inspection was increased to 10% on fresh produce at ports of entry into the European Union (Business Daily 2013). According to European Commission (2012), Maximum Residue Levels (MRLs) of unknown pesticides should not exceed 0.01 mg/kg and there was imposed a 10% sampling per consignment in fresh beans and pods. Interceptions of fresh produce almost ruined Kenya's export market reputation due to presence of traces of banned pesticides (Business Daily 2014). Following the guidelines made by the EU and the losses incurred due to rejection and destruction of fresh vegetable consignments, there was a reduction in volumes of horticultural exports. This negatively affected the livelihoods of small holder farmers who are the major producers of vegetable crops (Daily Nation 2014). This led to introduction of a cloud-based traceability system which uses a quick reference (QR) code and GPS coordinates to pinpoint the individual farmer whose consignment fails to comply with regulations (Daily Nation, 2016). This has resulted in increase of the cost of production and several farmers opted out of the export business.

Sources of biopesticides and their effect on causative agents

Biopesticides of botanical origin: Based on the method of extraction, botanical pesticides can either be plant extracts or essential oils (Vidyasagar, et al., 2013). They are obtained from plants parts such as leaves, barks, flowers, roots, rhizomes, bulbs, seeds, cloves or fruits which are either fresh or dried. Dried plant parts are preferred as this reduces water concentration resulting in higher yield of active ingredient (Chougule, et al., 2016). A Gas Chromatography-Mass Spectrometry (GC-MS) analysis was carried out on Citrus *sinensis* and d-limonene and myrcene were reported

as the major constituents of the oil component. The products were tested against a cereal leaf beetle (*Oulema melanopus*) on wheat and a mortality of up to 85% was reported on larvae observed in 48 hours (Zarubova, et al., 2014). Aqueous fruit extracts of *Withania somnifera* were tested for activity against *Fusarium oxysporum F.SP. radicis-lycopersici*, the causal agent of fusarium crown and root rot disease in tomatoes. According to Nefzi, et al. (2016) at a concentration of 2% the extracts inhibited growth of the fungal pathogen by up to 56%. In vitro experiment involving ethanolic plant extracts, turmeric (*Curcuma longa*), lemon (*Citrus limon*), garlic (*Allium sativum*), pepper (*Capsicum frutescens*) and ginger (*Zingiber officinale*) were reported to be significantly effective against *Alternaria solani, Pythium ultimum, Rhizoctonia solani and Fusarium oxysporum f.sp. lycopersici* (Muthomi et al., 2017). Turmeric (*Curcuma longa*) was reported to be the most effective with a growth inhibition of up to 73% against *Alternaria solani. Pseudomonas syringae p.v.* tomato was effectively managed in vitro by *Rhus coriaria, Eucalyptus globulus* and *Rosmarinus officinalis* (Bastas, 2015). *Eucalyptus globulus* was reported to be efficacious in preventing the bacterial speck of tomato (*Pseudominas syringae p.v.*) by up to 65% under greenhouse conditions. At 5% concentration, a mortality rate of up to 78% was reported on juveniles of root knot nematodes (*Meloidogyne sp*) by extracts of *Nerium oleander*. When the concentration was increased to 10% a mortality of between 65% - 100% was observed on second stage juveniles treated with extracts of *Eucalyptus sp, Cinnamomum verum, Nerium oleander, Azadirachta indica, Zingiber officinale* and *Allium sativum* (Salim, et al., 2016). The most common and already commercialized botanical pesticides are derived from neem (*Azadirachta indica*), pyrethrum (*Chrysanthemum cinerariifolium*), sabadilla

(*Schoenocaulon officinale*), and tobacco (*Nicotiana tabacum*) (Dar, et al., 2014).

The quality of extracts and oils is highly dependent on the solvent used and method of extraction (Odhiambo, et al., 2011). The solvents should be of low toxicity, able to dissolve as many compounds as possible, evaporate easily at low temperatures should preferably possess preservative properties (Javaid, et al., 2014). The choice of solvent is dictated by the target active compounds. Although water is the universal solvent, it extracts fewer antimicrobial compounds compared to other solvents (Bandor, et al., 2013). Organic solvents such as ethanol and methanol yield better extracts and their results are consistent. Other extraction solvents include dichlomethane, acetone, and hexane (Mahlo, et al., 2013). According to a study by Wetungu et al. (2014), methanol and hexane extracts from *Tarchonanthus camphoratus* gave higher growth inhibition capacity against *Escherichia coli, Salmonella typhi, Staphylocccus aureus, Proteus mirabilis, Candida albicans,* and *Klebsiella pneumoniae*. Methanol was also reported to be efficient in extracting seed components of *Morinda citrofolia* and the extracts showed antibacterial activity of up to 63% against *Escherichia coli* and *Pseudomonas* spp. (Sunder, et al., 2011). The differences among the different solvents are attributed to their polarity (Ahmad, et al*.,* 2009). The plant parts from which the extracts are obtained also influence the quality of the extracts.

Microorganisms as a source of biopesticides:

Microorganism-based biocontrol agents form the bulk of commercialized biopesticides and they include bacteria, viruses, fungi, nematodes, and protozoa **(**Koul, 2011). There are up to 175 reported microbial-based biopesticide active agents and they have been used in the management of pathogens, weeds, insects, and nematodes (Singh, 2014). The majority of the microbial biopesticides are used to manage soil-borne pathogens (Vinale, et al., 2008). Bacterial species that have been utilized as biopesticides include *Bacillus, Pseudomonas, Burkholderia, Xanthomonas, Enterobacter, Streptomyces, Serratia* and these are either obligate facultative or crystalliferous. Fungi used as biopesticides include species of *Trichoderma, Beauveria, Metarhizium, Paecilomyces, Fusarium, Pythium, Penicillim,* and *Verticillium. Steinernama* and *Heterarhabditis* are nematode species used to make biopesticides (Kachhawa, 2017). The mechanisms of action exhibited by microorganisms against plant pathogens include hyperparasitism, competition, and secretion of volatile compounds, antibiosis, and parasitism (Suprapta, 2012). According to Song, et al., (2012), the major source of microorganisms with pesticide activity on agricultural fields is where they co-exist with other microorganisms including pathogens and beneficial species. The rhizosphere is usually concentrated with various classes of important microorganisms. Other rich sources of microorganisms include hay, manure, cowshed, as well as straw (Beric, et al., 2012). Formulation of the microbial pesticides has a great contribution to the effectiveness of the resultant product and it is usually dependent on the substrate used. A study done by Adan et al. (2015) showed that a formulation of *Trichoderma harzianum* prepared in black gram bran, peat soil and water had a high level of activity against damping-off of eggplant seedlings caused by *Sclerotium rolfsii*. The activity was attributed to the high number of spores produced by the fungus.

According to Prasad and Syed (2010), exposure of *Helicoverpa armigera* to conidial suspension of *Beauveria bassiana* resulted in antifeeding habits, blackening of the body, and the larvae becoming sluggish and morbid. The fungus finally consumes the entire larval tissue resulting in its death. Beric

et al., (2012) reported that isolates of Bacillus showed antagonistic activity against rice pathogen, *Xanthomonas oryzae P.V. oryzae*, and the activity was attributed to the production of a bacteriocin by the bacterium. Treatment of wheat and rice plants with concentrations of *Chaetomium globosum* reduced the severity of wheat rust (*Puccinia recondite*) and rice blast (*Magnaporthe grisea*) by up to 80% (Park, et al., 2005). Late blight (*Phytophthora infestans*) on tomatoes was also controlled by *Chaetomium globosum* by up to 50% while mycelial growth of Pythium ultimum was inhibited in vitro in well diffusion assays. The activity of the fungus was attributed to the production of two types of *chaetoviridins,* A and B (Park, et al., 2005). These studies indicate that microbial biopesticides can be incorporated in integrated pest management for sustainable agriculture.

Predators and parasitoids as biopesticides:
A predator kills and feeds on prey while parasitoids grow on or inside their hosts and eventually kill them (Elzinga, et al., 2002). The predators include beetles (*Carabidae*), ladybirds (*Coccinellidae*), spiders, lacewings (*Chrysopidae*), and true bugs while parasitoids mainly consist of wasps and other hemipterans (Knutson, et al., 2015). These natural enemies are mainly found in the environment and are not evenly distributed. In order to have them in large numbers, they are either reared under controlled conditions and released into the fields or are multiplied in open fields containing the prey (Morales-Ramos, et al., 2014). The most common way of rearing these predators is by growing them on their preferred hosts. This is either done in screen houses or growth chambers where the host plants are first grown and then exposed to pest infestation (Silva, et al., 2010). The predators are then introduced and they are maintained by growing on the prey (Lee, et al., 1990). Alternatively, the predators can be grown in cylinders where they are supplied with the prey and all other

necessary conditions for growth are provided. An example is the mass rearing of *Phytoseiulus persililis* on *Tetranychus urticae Koch* (Morales-Ramos, et al., 2014). The optimum growth of predator mite, *Neoseiulus californicus*, was observed when grown on an artificial diet supplemented with eggs of *Ephestia kuehniella, Artemia franciscana* cysts, and maize bran (Khanamani, et al., 2017). Such artificial diets are important in the reproduction, development, and survival of the predators during rearing as well as reduction of production costs.

Predators can also be grown on egg masses of their prey or other suitable hosts which gives them a longer storage capacity. This has been employed in the management of mealy bugs using parasitoids (Steinberg, 2013). The predators can also be grown on other feeds such as rice bran as long as it provides the necessary nutrients to the insects (Fernando, et al., 2006). Due to economic concerns, these organisms are reared on artificial media with carefully evaluated nutritional needs and requirements. Their growth media ranges from beef and liver to crushed *lepidopteran pupae*. This provides a combination of hormones and nutrients needed by the predators for growth (Grenier, 2012). Artificial media provides as good nutrients as the host plants and reduces the cost of growing the plants. The artificial media is mostly used in laboratories and has been used for rearing *Trichogramma* and *Anastatus spp* (Grenier, 2009). An in vitro study by Xu and Enkegaard (2010) showed that *Amblyseius swirskii* predated on *Frankliniella occidentalis* and *Tetranychus urticae* nymphs with preference to their first instars. The predation rate on *T. urticae* was 4 - 6 nymphs in 12 hours. The authors reasoned that the outcome of the predation is highly dependent on several factors among them being the host plant traits. A synergistic effect on predation between *Amblyseius swirskii* and *Phytoseiulus persimilis* against

two-spotted spider mite (*Tetranychus urticae*) with a mortality rate of up to 86% was reported by Fiedler (2012). He further said that introduction of *Amblyseius californicus* and *Amblyseius degenerans* into a population of *Tetranychus urticae* under laboratory conditions recorded mortality of up to 72% within 15 days.

Formulation, production, and commercialization of biopesticides

Botanical pesticides are prepared from plants and plant parts obtained from the environment, natural or man-made (Dubey, et al*.,* 2016). The materials are cleaned of dirt or foreign materials and then extracted either using solvents or distillation to obtain extracts or essential oils, respectively (Goufo, et al*.,* 2008). The resultant extracts are then subjected to screening for activity in vitro against different pests using different methods such as disc diffusion, agar well diffusion, agar dilution, and poisoned food technique (Ademe, et al*.,* 2013; Jahangiriana, et al*.,* 2013). The most active botanicals are then evaluated for efficacy in managing pests and diseases under field conditions. The active constituents of the selected extracts are then identified for optimum formulation (Nashwa, et al*.,* 2012). Intensive laboratory and field trials conditions are carried out to ensure that the most efficacious combination of the active compounds, carrier materials, emulsifiers, surfactants and other components used in pesticide development are optimized. The efficacy report from the laboratory and field trials is used to request for registration of the product from the pest control products body.

Production of microbial pesticides follows the same procedure as botanicals, except that the antagonistic microorganisms are collected from sources like the cowshed, hayfields, rhizosphere, compost, and manure (Hassanein, et al*.,* 2010). They are isolated into pure cultures in the laboratory and maintained in agar slants (Sahu, et al*.,* 2014). In vitro efficacy trials are carried out following methods such as dual culture, agar discs diffusion and agar well diffusion (Karimi, et al*.,* 2012). The active microorganisms are multiplied on a suitable substrate in the laboratory and mixed with carrier materials, enhancers and stabilizers for field application (Naing, et al*.,* 2013). Repeated laboratory and field efficacy trials are conducted until the registration process begins).

Before the natural products are commercialized, they are usually tested in the laboratory and under field conditions for efficacy against the target pests. The active compounds are also identified using techniques such as thin-layer chromatography (TLC), high-performance liquid chromatography (HPLC), and gas chromatography-mass spectrometry (GC-MS) (Hossain, et al*.,* 2013; Araújo, et al*.,* 2014). Stabilizers and carrier materials are always added to the active compounds to enhance their applicability and longevity. Formulation of the active compounds should improve the stability of the compound as well as increase its efficiency and applicability. It should also reduce its degradability due to climatic factors such as heat, water and acids. Carrier materials majorly used include petroleum distillates, corn starch, talc, clays, and water. Emulsifiers such as soap are also added to the compounds during formulation and they are optimized to ensure effectiveness is not lost. Biopesticides of plant origin that have been formulated and commercialized for agricultural use include neem and pyrethrum (Khater, 2012) while microorganisms include species of *Bacillus* and *Trichoderma* (Cawoy, et al*.,* 2011).

Modes of action of biopesticides

Each type of biopesticide exhibits varied modes of action. Microbial pesticides act on pathogens by antagonism, hyperparasitism, antibiosis, and predation. Botanical pesticides inhibit the growth of pathogens,

modify their cellular structures and morphology, and exhibit neurotoxicity on insects. Botanicals also repel insects, suppress oviposition and feeding. Predators mainly kill the prey through parasitization or injection of toxic substances which eventually kill the prey. Semiochemicals are used to lure the target pests and they can then be managed through other means such as sterilization or death.

Extracts from plants belonging to the *Asteraceae* family have been reported to inhibit hyphal growth and induce structural modifications on the mycelia of plant pathogenic fungi (Vidyasagar, et al*.,* 2013). *Asteraceae* plants contain compounds such as flavonoids, coumarins alkaloids, and terpenoids which could lead to absolute fungal toxicity. Some compounds lead to changes in the cell wall as well as the morphology of cellular organelles (Iberê, et al*.,* 2014). In some instances, the bioactive compounds cause partitioning of fungal cell membranes making them permeable leading to leakage of cell contents. Plant bioactive compounds also lead to separation of the cytoplasmic membrane which leads to damage of the intracellular components and swelling of cells leading to eventual death (El-Wakeil, 2013). Compounds such as allicin found in garlic (*Allium sativum*) bulbs lead to suffocation of the pest due to effects on receptors of neurotransmitters (Baidoo, et al*.,* 2016). Phenolics and terpenoids build hydrophobic and ionic bonds which attack multiple of proteins in the insects leading to physiological malfunction (Rodino, et al*.,* 2012). Compounds in plant extracts and essential oils also interfere with receptor cells leading to malfunctioning of the nervous system and failure of coordination leading to the death of the insect (Moreira et al*.,*2007). Different classes of microorganisms have different modes of action. Hyperparasitism is one of the most reported modes of action on many biocontrol agents (Akrami et al*.,* 2011). The antagonist kills the pathogen or its

propagules while some attack the sclerotia or the hypha of the fungal pathogen. A single pathogen could be attacked by a number of biocontrol agents (Blaszczyk et al*.,* 2014). *Pasteuria penetrans* is an example of a biocontrol agent that parasitizes on root-knot nematodes of *Meloidogyne spp.* (Kokalis-Burelle, 2015). Species of genus *Trichoderma* exhibit a predation mode of action by producing enzymes that directly kill cell walls of the pathogens and colonize the environment therein.

Some microorganisms produce compounds that kill other microorganisms, a mechanism called antibiosis. This is most common with bacteria belonging to species of Pseudomonas, Agrobacterium, Bacillus, *Burkholderia, Pantoea* and it has also been reported in the fungus *Trichoderma spp*. (Mendoza, et al*.,* 2015). Sufficient quantities of antibiotics need to be produced for enhanced biocontrol. Some microbial species such as Bacillus cereus produce multiple compounds that could suppress more than two pathogens and this is effective in crop disease management (Pal, et al*.,* 2004). Other classes of microorganisms such as *Lysobacter* and *Myxobacteria* produce lytic enzymes which hydrolyze compounds leading to the suppression of pathogens (Xiao, et al*.,* 2011). *Beauveria bassiana* inhibits chitin development in insects by conidia attaching to the body of insects. After germination, the hypha penetrates through the cuticle and grows throughout the insect body eventually killing it (Prasad, et al*.,* 2010).

Semi chemicals such as female sex pheromones are used to lure the male insect pests which are then sterilized thereby decreasing their effectiveness. Upon mating with the sterile male insects, the females lay unfertilized eggs thereby reducing harmful insect populations (Refki et al*.,* 2016). Host location pheromones lure insects into sites with mass traps from where they may be sterilized or starved to death (Chermiti et al*.,*

2012). Predators may feed on the prey or a particular life stage of the prey such as nymphs or larvae (Xu, et al., 2010). The predator-prey ratio is of importance in balancing the populations of the pests as well as biodiversity (Rao et al., 2017).

Efficacy of different types of biopesticides

Synthetic pesticides are considered more effective than biopesticides in managing crop pests (Khan, et al., 2015). Their effectiveness sometimes has nonetheless not much significance in managing a particular population of pests as would the biopesticides (Ahmad, et al., 2007). Biopesticides in other instances perform better than synthetic pesticides when applied in the right regimes, concentrations, and appropriate frequencies (Shah, et al., 2013). Research reports across the world have presented different plants, microorganisms, and predators with potential as biopesticides. Natural enemies predate on insect pests which balance their population in the ecosystem. Such predators are important in agricultural systems (Rao et al., 2017; Kenis et al., 2017). The mechanisms used by predators to lure insects include scents and other attractants. Some of these scents, called pheromones, have been commercialized and are being used in the management of important crop pests such as *Tuta absoluta* (Refki et al., 2016). The commercial pheromones are baited to aid in luring the adult insects and then deactivating them by sterilization or starvation to death (Galko et al., 2016). Certain plants contain compounds which they use to protect themselves against pests and this ability has been explored by researchers in an effort to manage different crop pests (Rizvi et al., 2016). Some plants have been found to contain compounds that are effective against several pests including fungi and nematodes (Hussain et al., 2015; Sidhu et al., 2017). Some species of microorganisms have antagonistic properties towards other

species and are therefore effective as biopesticides (Aw et al., 2017).

Ngegba, et al., (2018) reported that extracts of neem (Azadirachta indica) and Mexican sunflower (*Tithonia diversifolia*) inhibited growth of rotting disease pathogens of tomato, *Aspergillus niger*, *Fusarium oxysporum*, and *Geotrichum candidium* by up to 100%. Extracts of castor seeds (*Ricinus communis*) effectively inhibited the growth of post-harvest pathogens *Penicillium oxalicum* and *Aspergillus niger* of yams *(Dioscorea alata)* in a dose-dependent poisoned food technique experiment (Patrice et al., 2017). Similar effects were reported by Devi et al. (2017) on post-harvest fungi including *Fusarium solani, Rhizopus arrhizus,* and *Sclerotium rolfsii* after using extracts from *Duranta erecta and Lasonia ineruis*. Methanolic extracts of *Chenopodium ambrosioides* exhibited antifungal activity against *Fusarium oxysporum f.sp. ciceris* a pathogen that causes wilt of chickpea (*Cicer arietinum*) by up to 50% (Minz et al., 2012).

A biopesticide formulation containing onion (*Allium cepa*) and ginger (*Zingiber officinale*) was evaluated for efficacy against tomato fruit worm (*Helicoverpa armigera*) and registered a 70% - 80% control (Sumitra, et al., 2014). During the study, yield increment was also observed on plants treated with the formulation compared to the untreated controls. Muzemu et al. (2011) reported over 50% reduction of rape aphids (*Brevicoryne brassicae*) and tomato red spider mites (*Tetranychus evansi*) by powder extracts of *Lippia javanica* and *Solanum delaguense.* Populations of *Megalurothrips sjostedti* were reduced by extracts of *Piper nigrum, Cinnamomum zeylanium,* and *Cinnamomum cassia* and were reported to be strong repellents (Abtew, et al., 2015). The number of larvae and pupa of *Helicoverpa armigera* were effectively reduced by extracts of Curcuma longa, *Allium sativum,* and *henge* (Ferula assa-foetida) in a study by Shah et al. (2013). Extracts of *Artemisia herbaalba,*

Eucalyptus camaldulensis and *Rosmarinus officinalis* soaked on leaves of broad bean (*Vicia faba*) caused a mortality of 60% - 100% of green peach aphid (*Myzus persicae*) after 24 hours of exposure in dose-dependent in vitro experiments (Nia et al*.,* 2015). In another study, topical application of *Azadirachta indica, Mangifera indica, Polyalthia longifolia, Annona squamosa,* and *Ficus benghalensis* caused a 100% mortality of bed bugs (*Cimex lectularius*) after 19 seconds of contact (Parte et al*.,* 2015). The effectiveness of plant extracts on insects is credited to the solvents used and their ability to extract major compounds with insecticidal properties (Oyedokun et al., 2011; Barbosa et al., 2013). *Bacillus subtilis, Pseudomonas putida,* and *Pseudomonas aeruginosa* were evaluated against *Fusarium oxysporum f. sp. ciceris* and reported to have better control in seed treatment and resulted in an increment in growth parameters (Karimi, et al*.,* 2012). Species of Bacillus have been reported to produce compounds effective against important fungal pathogens including *Rhizoctonia solani* and *Xanthomonas oryzae pv. oryzae* (Beric et al*.,* 2012; Islam et al*.,* 2012). Compounds from *Chaetomium globosum* have also been reported effective against important fungal pathogens of rice such as *Magnaporthe grisea* and *Puccinia recondita* (Park et al., 2005). Anitha and Rabeethet al. (2009), reported reduced severity of *fusarium* wilt of tomato after using *Streptomycesgriseus*. In a seeded media experiment, *Stenotrophomnas maltophilia*, *Bacillus subtilis* and *Pseudomonas aeruginosa* exhibited antagonism against *Erwinina carotovora* (Selim et al., 2016). A formulation consisting of compost tea extracts and poultry litter reduced the severity of bacterial wilt (*Ralstonia solanacearum)* of brinjals *(Solanum melongena)* (Islam et al., 2010). Higher efficacy was observed when the compost tea extract was applied as a soil drench and the poultry litter applied on the

soil which resulted in healthy plants and improved yield. A similar formulation reduced the incidence and severity of late blight (*Phytophtora infestans*) of potato *(Solanum tuberosum)* when the compost tea was applied as a foliar spray (Islam, et al*.,* 2013). Research by Pane et al. (2014) showed that a compost tea formulation containing wood chips improved the yield of lettuce (*Lactuca sativa var. gentilina*) and Kohlrabi or German turnip (*Brassica oleracea var. gongylodes*) when applied as a foliar spray. Semi chemicals have been employed in the management of insect pests. As reported by Chermiti and Abbes (2012), mass trapping by use of sex pheromones with water traps has been used in the management of *Tuta absoluta* by delaying initial attacks on tomato plants. Similarly, fruit flies (*Rhagoletis cingulata*) have been managed through semi chemicals such as sex pheromones, oviposition, host location, and mating pheromones (Sarles et al., 2015). According to Powell and Pickett (2003), these semi chemicals could be insect-plant induced or insect induced and the end result is enhanced parasitizing of the insect populations.

Predators of insect and microbial nature have been effectively used in management of insect pests. Species of *Amblyseius swirskii* have been used in the management of thrips, *Frankliniella occidentalis* and *Scirtothrips dorsalis* and spider mites (*Tetranychus urticae*) (Xu et al*.,* 2010; Arthurs et al., 2009). *Phytoseiulus persimilis* is an effective predator mite against spider mites (*Tetranyshus* spp.) (Rizvi et al., 2016). According to a study by Vá Squez et al. (2006), aphid predators (*Aphidius colemani*) were reported to be effective on *Aphis gossypii* on *crysanthemums* (*Dendranthema grandiflora*).

The role of biopesticides in sustainable agricultural production

Biopesticides are as effective as synthetic pesticides in the management of crop pests

(Birech, et al., 2006). Natural products are also eco-friendly since they are easily biodegradable and therefore do not pollute the environment according to Leng, et al. (2011). Okunlola, et al. (2014) stated that Consumer tastes and preferences fluctuate over time, and following the demand for organically produced food, this makes biopesticides suitable alternatives to synthetic pesticides. Biopesticides have very short pre-harvest intervals and are therefore safe to use on fresh fruits and vegetables (Khater, 2012). They are also target-specific and hence do not affect the beneficial organisms such as the natural enemies (Shiberu et al., 2016). They are effective in small quantities and their use promotes sustainable pest management and hence contributes towards sustainable agriculture, according to Nawaz et al. (2016).

Natural pesticides do not cause resistance build up among pests (Tadele et al., 2017). Availability of their source materials makes them inexpensive to attain since they are found within the natural environment and some of them are used for other purposes like food and feed (Srijita, 2015). Biopesticides are safe products both for the applicant and the consumer since they have no toxicity (Damalas et al., 2015). Therefore, biopesticides can suitably be incorporated in integrated pest management (IPM) which helps reduce the amounts of chemical pesticides used in the management of crop pests (Sesan et al., 2015). Natural products decompose quickly which makes them safer for use in the environment (Kawalekar, 2013). Pesticides from natural sources have very short re-entry intervals which guarantee safety for the applicant (Stoneman, 2010). Biopesticides are also used in the decontamination of agricultural soils through the introduction of important microbial species (Javaid, et al., 2016)

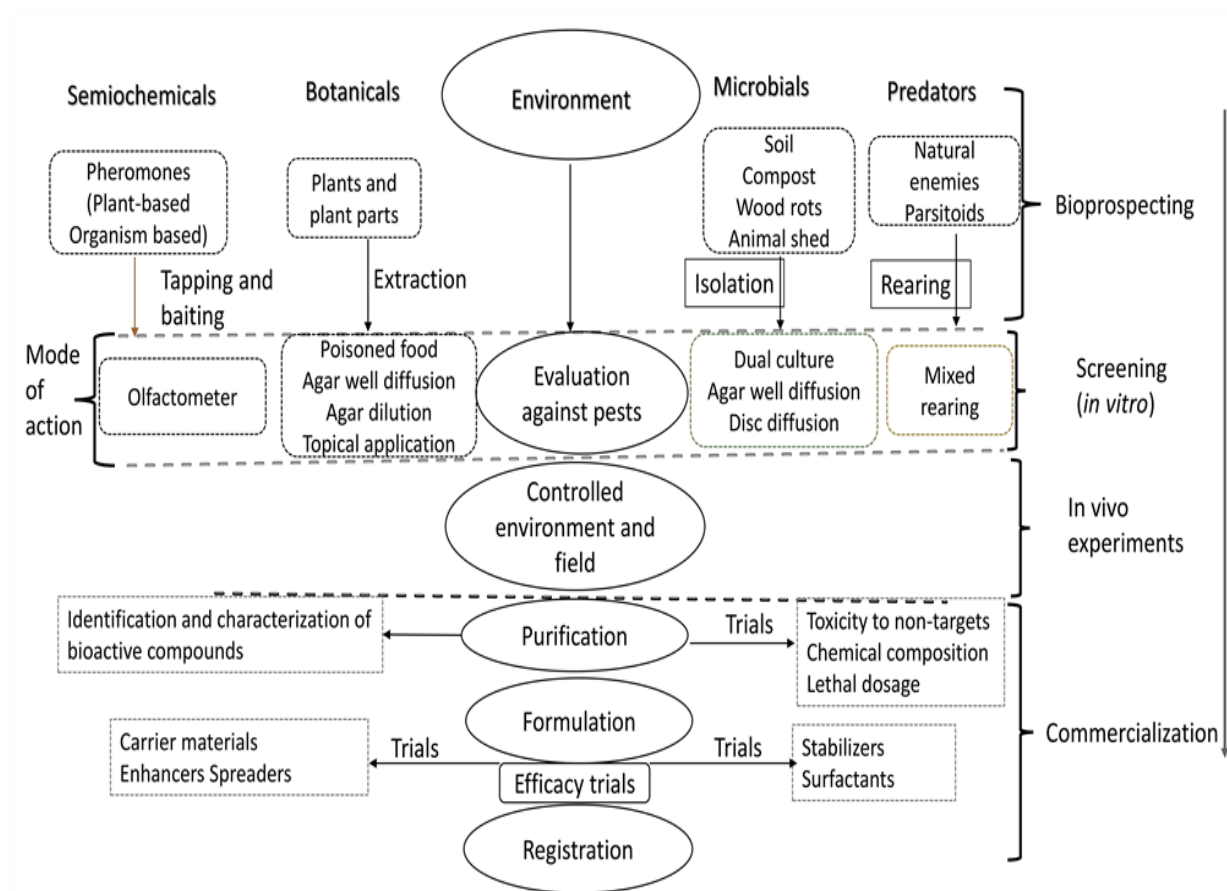*Limitations facing the use of biopesticides*

While biopesticides provide such advantages as a safe environment and healthy food for human consumption, there are factors that limit their full adoption as pest and disease management options. High doses of the constituent compounds are needed for efficacy under field conditions (Shiberu et al., 2016). The concentration of the bioactive compounds in plants is dictated by the environment under which they grow (Ghorbani et al., 2005). The constituent active compounds are also dictated by the diversity of plants and their varieties resulting in differences in the responses to pathogens (Sales et al., 2016). The quality of botanical extracts is also dependent on the method of extraction used (Sesan et al., 2015). During formulation, it is sometimes challenging to get the right proportions of the active and inert ingredients needed. There are also no standard preparation methods and guidelines for efficacy testing especially under field conditions (Okunlola et al., 2014). While the in vitro tests produce excellent results, there are always inconsistencies in the field due to low shelf life and sometimes poor quality of source materials or preparation methods.

Adoption of biopesticides of predatory nature needs a lot of consideration such as host crops and dispersal capability according to Gerson, (2014). Crop coverage and exposure time are essential and for small acreage, this could prove expensive since the application may be manual (Lanzoni et al., 2017). Registration of the products requires data on chemistry, toxicity, packaging, and formulation which is not always readily available (Gupta et al., 2010). The cost of producing a new pesticide product is usually high and has a lot of resource limitations (Stoneman, 2010). The lack of a readily available market makes it hard to invest in biopesticides (Stoneman, 2010). There are insufficient facilities and capital for the production of biopesticides, especially in slowly developing countries. The shelf life of

natural products is dependent on many factors such as temperatures and moisture which are sometimes difficult to control (Koul, 2011). Biopesticides also face high competition from synthetic pesticides and if the former were produced for a small agricultural activity, the costs may be relatively high and therefore not feasible. There is insufficient awareness about biopesticides especially among the small-scale growers, stake holders and policy makers. In the case of microbial pesticides, there is usually no trust in the value and use chain between producers, buyers and users and considering the risk of importation, synthetic pesticides appear reliable (Kumar et al., 2015).

Biopesticides cycle of forms, sources, formulations and mode of action on targeted pest

CONCLUSION

Despite the many challenges facing the adoption of biopesticides, they remain suitable alternatives to conventional pesticides. Stable products under field conditions will guarantee the utter effectiveness of biopesticides in crop pest management. Researchers should therefore work together with experts in the government and industry as well as farmers to provide stable, durable, and endurable formulations of biopesticides.

ACKNOWLEDGEMENT

with regard to the use of biopesticides in crop production.

REFERENCE

Abbamondi, G. R.; Giuseppina, T.; Nele, W.; Sofie, T.; Wouter, S.; Panagiotis, G.; Carmine, I.; Wesley, M. R.; Barbara, N.; Jaco, V. Plant Growth-Promoting Effects of Rhizospheric and Endophytic Bacteria Associated with Different Tomato Cultivars and New Tomato Hybrids. *Chem. Biol. Tech. Agric*. 2016, 1, 1-10.

Adan, M. J.; Baque, M. A.; Rahman, M. M.; Islam, M.; Jahan, A. Formulation of *Trichoderma* Based Biopesticide for Controlling Damping off Pathogen of Eggplant Seedling. Universal *J. Agric. Res*. 2015, 3, 106-113.

Adipala, E.; Omongo, C. A.; Sabiti, A.; Obou, J. E.; Edema, R.; Bua, B.; Atanya, A.; Nusbuga, E. N.; Oganga-Latigo, M. W. Pests and diseases on cowpea in Uganda experience from diagnostic survey, *African Crop Sci. J.* 1999, 4, 465-478.

Ademe, A.; Ayalew, A.; Woldetsadik, K. Evaluation of Antifungal Activity of Plant Extracts against Papaya Anthracnose (*Colletotrichum gloeosporioides*). *Pl. Path. Microbiol*. 2013, 10, 1-4. https://doi.org/10.4172/2157-7471.1000207.

Ahmad, A.; Alkarkhi, A. F. M.; Hena, S.; Lim, H. K. Extraction, Separation and Identification of Chemical Ingredients of *Elephantopus scaber L*. Using Factorial Design of Experiment. *Inter. J. Chem*. 2009, 1, 36-49. https://doi.org/10.5539/ijc.v1n1p36.

Ahmad, S.; Khan, I. A.; Hussain, Z.; Shah, S. I. A.; Ahmad, M. Comparison of a Biopesticide with Some Synthetic Pesticides against Aphids in Rapeseed Crop. Sahrad *J. Agri*c. 2007, 4, 1117-1120.

Akpheokhai, I. L.; Cole, A. C.; Fawole, B. Evaluation of some plant extracts for the management of *Meloidogyne incognita*

on soybean (*Glycine max*). *World J. Agric. Sci.* 2012, 8(4), 429-435.

Akrami, M.; Golzary, H.; Ahmadzadeh, M. Evaluation of Different Combinations of *Trichoderma* Species for Controlling Fusarium Rot of Lentil. *Afr. J. Biotech*. 2011, 14, 2653-2658.

Alavanja, M. C. R.; Ross, M. K.; Bonner, M. R. Increased Cancer Burden among Pesticide Applicators and others Due to Pesticide Exposure. *A Cancer J. Clinic*. 2013, 63, 120-142. https://doi.org/10.3322/caac.21170.

Ali, A. M.; Mohamed, D. S.; Shaurub, E. H.; Elsayed, A. M. Antifeedant Activity and Some Biochemical Effects of Garlic and Lemon Essential Oils on *Spodoptera littoralis* (*Boisduval*) (*Lepidoptera: Noctuidae*). *J. Entom. Zool. Stud*. 2017, 3, 1476-1482.

Anitha, A.; Rabeeth, M. Control of Fusarium Wilt by Bioformulation of *Streptomyces griseus* in the Green House Condition. *Afr. J. Basic Appl. Sci*. 2009, 1-2, 9-14.

Araújo, K. M.; Lima, A.; Silva, J. N.; Rodrigues, L. L.; Amorim, A. G. N.; Quelemes, P. V.; Santos, R. C.; Rocha, J. C.; Andrades, E. O.; Leite, J. R. S. A.; Mancini-Filho, J.; Trindade, R. A. Identification of Phenolic Compounds and Evaluation of Antioxidant and Antimicrobial Properties of *Euphorbia tirucalli L. Antiox id*. 2014, 3,159-175. https://doi.org/10.3390/antiox3010159.

Aw, K. M. S.; Hue, S. M. Mode of Infection of *Metarhizium* spp. Fungus and Their Potential as Biological Control Agents. *J. Fungi*. 2017, 30, 120, https://doi.org/10.3390/jof3020030.

Bandor, H.; Hijazi, A.; Rammal, H.; Hachem, A.; Saad, Z.; Badran, B. Techniques for the Extraction of Bioactive Compounds from *Labanese Urtica diotica*. *Amer. J. Phytomed. Clinic. Therapeut*. 2013, 6, 507-513.

Barbosa, F. S.; Leite, G. L. D.; Martins, E. R.; D'avila, V. A.; Cerqueira, V. M. Medicinal

Plant extracts on the Control of *Diabrotica speciosa* (Coleoptera: Chrysomelidae). *Brazil*. *J*. *Med*. *Pl*. 2013, 1, 142-149.

Bastas, K. K. Determination of Antibacterial Efficacies of Plant Extracts on Tomato Bacterial Speck Disease. *J*. *Turk*. *Phytopath*. 2015, 1-3, 1-10.

Beric, T.; Koji, M.; Stankovi, S.; Topisirovi, L.; Degrassi, G.; Myers, M.; Venturi, V.; Fira, D. Antimicrobial Activity of Bacillus sp. Natural Isolates and their Potential use in the Biocontrol of Phytopathogenic Bacteria. *Food Techn*. *Biotech*. 2012, 1, 25-31.

Birech, R.; Bernhard, F.; Joseph, M. Towards Reducing Synthetic Pesticides Imports in Favour of Locally Available Botanicals in Kenya. Proceedings International Agricultural Research for Development, Bonn, 2006, 8-12.

Blaszczyk, L.; Siwulski, M.; Sobieralski, K.; Lisiecka, J.; Jedryczka, M. *Trichoderma* spp.—Application and Prospects for Use in Organic Farming and Industry. *J*. *Pl*. *Protect*. *Res*. 2014, 4, 309-317.

Brühl, C. A.; Schmidt, T.; Pieper, S.; Alscher, A. Terrestrial pesticide exposure of amphibians: An underestimated cause of global decline. *Sci Rep.* 2013, 3, 1135.

Business Daily. Chemical Ban Hits Vegetable Exports to the EU Market. Business Daily, 14 February 2013.

Business Daily. Illegal Horticulture Exports Risk Kenya's EU Market. Business Daily, 26 May 2014.

Business Daily. Regulator Suspends Use of Pesticides on Vegetables. Business Daily, 13 October 2014.

Cawoy, H.; Wagner, B.; Fickers, P.; Ongena, M. Bacillus-Based Biological Control of Plant Diseases, Pesticides in the Modern World, Pesticides Use and Management 2011, Margarita Stoytcheva (Ed.), ISBN: 978-953-307-459-7, In Tech, Available: http://www.intechopen.com/books/pesticides-in-themodern-world-pesticides-use-and-management/bacillus-based-biological-control-of-plant-diseases.

Chermiti, B.; Abbes, K. Comparison of Pheromone Lures Used in Mass Trapping to Control the Tomato *Leafminer Tuta absoluta* in Industrial Tomato Crops in Kairouan (Tunisia). *EPPO Bulletin*, 2012, 241-248. https://doi.org/10.1111/epp.2561.

Chime E. U.; Nweke I. A.; Ibeh C.U.; Nsoanya L.N. Biopesticide and biofertilizer effect on some growth parameter of indian spinach and soil physical properties *Inter*. *J*. *Inform*. *Res*. *Rev*. (2019, 10(1), 6051-6054.

Chime E. U; Ibeh C.U; Nweke I. A.; Nsoanya L. N. Bioefficacy of some biopesticide agents and treated *pennisetum* biofertilizer against root- knot nematode (*meloidogyne incognita*) on Indian spinach (*basellaalba*) and soil chemical properties *Inter*. *J*. *Inform*. *Res*. *Rev*. 2019, 10(1), 6047-6050.

Chougule, P. M.; Andoji, Y. S. Antifungal Activity of Some Common Medicinal Plant Extracts against Soil Borne Phytopathogenic Fungi Fusarium oxysporum Causing Wilt of Tomato. *Inter*. *J*. *Dev*. *Res*. 2016, 3, 7030-7033.

Chuang, P. H.; Lee, C. W.; Chou, J. Y.; Murugan, M.; Shieh, B. J.; Chen, H. M. Antifungal activity of crude extracts and essential oil of *Moringa oleifera* Lam. *Biores*. *Techn.* 2007, 98, 232-236.

Compant, S.; Clément, C.; Sessitsch, A. Plant Growth-Promoting Bacteria in the Rhizo- and Endosphere of Plants: Their Role, Colonization, Mechanisms involved and Prospects for Utilization. *Soil Biol*. *Biochem*. 2009, 42, 669-678. https://doi.org/10.1016/j.soilbio.2009.11.024

Bio-Pesticides in Focus as Safety Concerns Reshape Export Trade. Daily Nation, 7 June 2014.

Boost for Horticulture as New System Set to Improve Quality. Daily Nation, 9 September 2016.

Damalas, C. A.; Koutroubas, S. D. Farmers' Exposure to Pesticides: Toxicity Types and Ways of Prevention. *Toxics*, 2015, 1, 1-10.

Dar, A.S.; Nisar, A. D.; Mudasir, A. B.; Mudasir, H. B. Prospects, Utilization and Challenges of Botanical Pesticides in Sustainable Agriculture. *Inter*. *J*. *Mole*. *Biol*. *Biochem*. 2014, 1, 1-14.

Devi, K. B.; Pavankumar, P.; Bhadraiah, B. Antifungal Activity of Plant Extracts against Post-Harvest Fungal Pathogens. *Inter*. *J*. *Cur*. *Microbiol*. *Appl*. *Sci*. 2017, 6, 669-679. https://doi.org/10.20546/ijcmas.2017.601.081.

Dey, K. R.; Choudhury, P.; Dutta, B. K. Impact of Pesticide Use on the Health of Farmers: A study in Barak Valley, Assam (India). *J*. *Environ*. *Chem*. *Ecotoxic*. 2015, 10, 269-277.

Dubey, M.; Thind, T. S.; Dubey, R. K.; Jindal, S. K. Efficacy of Plant Extracts against Tomato Late Blight under Net House Conditions. *Ind*. *J*. *Ecol*. 2016, 1, 375-377.

Edema, R. Investigation into factors affecting diseases occurrence and farmer control strategies on cowpea in Uganda M.Sc Thesis Mackerel University Kampala, 1995, pp100.

El-Wakeil, N. E. Botanical Pesticides and their Mode of Action. *Gesunde Pflanzen*, 2013, 65, 125-149. https://doi.org/10.1007/s10343-013-0308-3.

Elyousr, K. A. A.; Khan, Z.; Award, E. M. M.; Moneim, M. F. A. Evaluation of plant extracts and *Pseudomonas spp* for control of root-knot nematode, *Meloidogyne incognita* on tomato. *Nematropica.* 2010, 40, 289-299.

Elzinga, J. A.; Biere, A.; Harvey, J. A. The Rearing of the Gregarious Koinobiont Endoparasitoid Microplitis tristis (Hymenoptera: Braconidae) on Its Natural Host Hadena bicruris (Lepidoptera: Noctuidae). Proceedings Section Experimental and Applied Entomology of the Netherlands Entomological Society, 2002, 13, 109-115.

Esitken, A.; Yildiz, H. E.; Ercisli, S.; Donmez, M. F.; Turan, M.; Gunes, A. Effects of Plant Growth Promoting Bacteria (PGPB) on Yield, Growth and Nutrient Contents of Organically Grown Strawberry. *Scientia Horticultura e*, 2009,124, 62-66. https://doi.org/10.1016/j.scienta.2009.12.012

European Commission. Amending Annex I to Regulation (EC) No 669/2009 Implementing Regulation (EC) No 882/2004 of the European Parliament and of the Council as Regards the Increased Level of Official Controls on Imports of Certain Feed and Food of Non-animal Origin. *Official J*. *Eur*. *Uni*. 2012, L. 350/44. 20/12/2012.

Fawzi, E. M.; Khalil, A. A.; Afifi, A. F. Antifungal effect of some plant extracts on *Alternaria alternata* and *Fusarium oxysporum*. *Afr. J. Biotech.* 2009. 8(11), 2590–2597.

Fernando, L.C.P.; Aratchige, N. S.; Kumari, S. L. M. L.; Appuhamy, P. A. L. D.; Hapuarachchi, D. C. L. Developmet of a Method for Mass Rearing of Neoseiulus baraka, a Mite Predatory on the Coconut Mite, Aceria guerreronis. *J. Coconut Res. Inst. Sri Lanka*, 2006, 16, 22-36.

Fiedler, Z. Interaction between Beneficial Organisms in Control of Spider Mite Tetranychus urticae (Koch.) J. Pl. Protect. Res., 2012, 2, 226-229. https://doi.org/10.2478/v10045-0.12-0035-2.

Flett, B. C.; Bensch, M. J.; Smit, E.; Fourier, H. A field guide for identification of maize diseases in South African Agricultural Research Council potchefstoom 1996.

Galko, J.; Nikolov, C.; Kunca, A.; Vakula, J.; Gubka, A.; Zúbrik, M.; Rell, S.; Konopka, B. Effectiveness of Pheromone Traps for the European Spruce Bark Beetle: A Comparative Study of Four Commercial Products and Two New Models. *Lesnícky Casopis-Forestry J.*, 2016, 62, 207-215. https://doi.org/10.1515/forj-2016-0027.

Gasic, S.; Tanovic, B. Biopesticide Formulations, Possibility of Application and Future Trends. *J. Pest*. *Phytome*d. (*Belgrade*), 2013, 2, 97-102.

Gerson, U. Pest Control by Mites (acari): Present and Future. *Acarologia,* 2014, 4, 371-394. https://doi.org/10.1051/acarologia/20142144.

Ghorab, M. A.; Khalil, M. S. Toxicological Effects of Organophosphates Pesticides. *Inter*. *J. Environ*. *Monito*. *Anal*. 2015, 4, 218-220. https://doi.org/10.11648/j.ijema.20150304.13

Ghorbani, R.; Wilcockson, S.; Leifert, C. Alternative Treatments for Late Blight Control in Organic Potato: Antagonistic Micro-Organisms and Compost Extracts for Activity against Phytophthora infestans. *Potato Res*. 2005, 48, 181-189. https://doi.org/10.1007/BF02742375

Gill, R. J.; Rodriguez, O. R.; Raine, N. E. Combined pesticide exposure severely affects individual and colony level traits in bees. *Nat*. 2012, 491:105–108

Gnanamanickam, S. S. Biological control of crop diseases. Marcel Dekker Inc., New York, USA, 2002, 468 p.

Goufo, P.; Mofor, T. C.; Fontem, D. A.; Ngnokam, D. High Efficacy of Extracts of Cameroon Plants against Tomato Late Blight Disease. *Agron. Sust. Dev.* 2008, 4, 567-573. https://doi.org/10.1051/agro:2008036.

Grenier, S. In Vitro Rearing of Entomophagous Insects - Past and Future Trends: A Mini review. *Bulletin Insectology*, 2009, 1, 1-6.

Grenier, S. Artificial Rearing of Entomophagous Insects, with Emphasis on Nutrition and Parasitoids-General Outlines from Personal Experience. *Karaelmas Sci*. *Eng*. *J*. 2012, 2, 1-12. https://doi.org/10.7212/zkufbd.v2i2.97.

Gupta, S.; Dikshit, A. K. Biopesticides: An Ecofriendly Approach for Pest Control. *J. Biopesticides*, 2010, 1, 186-188.

Halimatunsadiah, A. B.; Norida, M.; Omar, D.; Kamarulzaman, N.H. Application of Pesticide in Pest Management: The Case of Lowland Vegetable Growers. *Inter*. *Food Res*. *J*. 2016, 1, 85-94.

Harada, T.; Takeda, M.; Kojima, S.; Tomiyama, N. Toxicity and Carcinogenicity of Dichlorodiphenyltrichloroethane (DDT). *Toxicol. Res*. 2016, 32, 21.

Hassanein, M. N.; Abou, Z. M. A.; Youssef, A. K.; Mahmoud, A. D. Control of Tomato Early Blight and Wilt using Aqueous Extract of Neem Leaves. *Phytopathologia Mediterranea*, 2010, 49, 143-151.

Hossain, M. A.; ALsabari, K. M.; Weli, A.M.; Al-Riyami, Q. Gas Chromatography-Mass Spectrometry Analysis and Total Phenolic

Contents of Various Crude Extracts from the Fruits of Datura metel L. *J. Taibah Uni*. *Sci*. 2013, 7, 209-215. https://doi.org/10.1016/j.jtusci.2013.06.004.

Hussain, F.; Abid, M.; Shaukat, S.; Farzana, S.; Akbar, M. Anti-Fungal Activity of Some Medicinal Plants on Different Pathogenic Fungi. *Pakis*. *J. Bot*. 2015, 5, 2009-2013.

Iberê, F.S.; Oliveira, R. G.; Soares, I. M.; Alvim, T. C.; Ascêncio, S. D.; Martins, D. T .O.; Evaluation of Acute Toxicity, Antibacterial Activity and Mode of Action of the Hydro Ethanolic Extract of Piper umbellatum L. *J. Ethnopharma*. 2014, 151, 137-143. https:// doi.org/10.1016/j.jep.2013.10.011.

Islam, M. R.; Jeong, Y. T.; Lee, Y. S.; Song, C. H. Isolation and Identification of Antifungal Compounds from Bacillus subtilis C9 Inhibiting the Growth of Plant Pathogenic Fungi. *Mycobiology,* 2012, 1, 59-66. https://doi.org/10.5941/MYCO.2012.40.1.059.

Islam, M. R.; Mondal, C.; Hossain, I.; Meah, B. M. Organic Management: An Alternative to Control Late Blight of Potato and Tomato Caused by Phytophthora infestans. *Inter*. *J. Theo*r. *Appl*. *Sci*. 2013, 2, 32-42.

Islam, M. R.; Mondal, C.; Hossain, I.; Meah, B.M. Compost Tea as Soil Drench: An Alternative Approach to Control Bacterial Wilt in Brinjal. *Archiv*. *Phytopath*. *Pl*. *Protect*. 2014, 12: 1475-1488. https://doi.org/10.1080/03235408.2013.847654.

Jahangiriana, H.; Haron, M. D. J.; Mohd, H. S. I. A.; Roshanak, R.; Leili, A. D. Y. A. E.; Majid, R. C.; Nazanin, V. Well Diffusion Method for Valuation of Antibacterial Activity of Copper Phenyl Fatty Hydroxamate Synthesized from Canola and Palm Kernel Oils. *Digest J. Nanomater*. *Biostruct*. 2013, 3, 1263-1270.

Jalili-Marandi, R.; Hassani, A.; Ghosta, Y.; Abdollahi, A.; Pirzad, A.; Sefidkon, F. *Thymus kotschyanus* and *Carumcopticum* essential oils as botanical preservatives for table grape. *J. Med. Pl. Res.* 2010. 4(22), 2424- 2430.

Jantasorn, A.; Moungsrimuangdee, B.; Dethoup, T. In Vitro Antifungal Activity Evaluation of Five Plant Extracts against Five Plant Pathogenic Fungi Causing Rice and Economic Crop Diseases. *J. Biopest*. 2016, 1, 1-7.

Javaid, A.; Rehman, A. H. Antifungal Activity of Leaf Extracts of Some Medicinal Trees against *Macrophomina phaseolina*. *J. Med*. *Pl. Res*. 2011, 13, 2858-2872.

Javaid, M. K.; Ashiq, M.; Tahir, M. Potential of Biological Agents in Decontamination of Agricultural Soil, 2016, https://doi.org/10.1155/2016/1598325.

Kachhawa, D. Microorganisms as a Biopesticides. *J. Entom*. *Zoo*. *Stud*. 2017, 3, 468-473.

Karimi, K.; Amini, J.; Harighi, B.; Bahramnejad, B. Evaluation of Biocontrol Potential of Pseudomonas and Bacillus spp against Fusarium Wilt of Chickpea. *Aust*. *J. Crop Sci*. 2012, 6, 695-703.

Kawalekar, J. S. Role of Biofertilizers and Biopesticides for Sustainable Agriculture. *J. Bio Innov*. 2013, 2, 73-78.

Kekuda, P.T. R.; Akarsh, S.; Nawaz, S. A. N.; Ranjitha, M. C.; Darshini, S. M.; Vidya, P. In Vitro Antifungal Activity of Some Plants against *Bipolaris sarokiniana* (Sacc.) Shoem. *Inter*. *J. Cur*. *Microbiol*. *Appl*. *Sci*. 2016, 6, 331-337. https://doi.org/10.20546/ijcmas.2016.506.037.

Kenis, M.; Hurley, B. P.; Hajek, A. E.; Cock, M. J. W. Classical Biological Control of Insect Pests of Trees: Facts and Figures. *Biological Invasions*, 2017, 19, 3401-3417. https://doi.org/10.1007/s10530-017-1414-4.

Khan, A. I.; Hussain, S.; Akbar, R.; Saeed, M.; Farid, A.; Ali, I.; Alam, M.; Shah, B. Efficacy of a Biopesticide and Synthetic Pesticides against Tobacco Aphid, Myzus persicae Sulz. (Homoptera, Aphididae), on Tobacco in Peshawar. *J. Entomol. Zoo. Stud*. 2015, 4, 371-373.

Khanamani, M.; Fathipour, B.Y.; Talebi, A. A.; Mehrabadi, M. Evaluation of Different Artificial Diets for Rearing the Predatory Mite Neoseiulus californicus (Acari: Phytoseiidae): Diet Dependent Life Table Studies. *Acarologia*, 2017, 2, 407-419. https://doi.org/10.1051/acarologia/201 74165.

Khater, H. F. Prospects of Botanical Biopesticides in Insect Pest Management. *Pharmacologia*, 2012, 12, 641-656.

Knutson, A. and Ruberson, J. Field Guide to Predators, Parasites and Pathogens Attacking Insect and Mite Pests of Cotton. In: Smith, E.M., Ed., Texas Cooperative Extension, TX Publication, 2015, Pp136.

Kokalis-Burelle, N. Pasteuria penetrans for Control of Meloidogyne incognita on Tomato and Cucumber, and M. arenaria on Snap Dragon. *J. Nematol*. 2015, 3, 207-213.

Koul, O. Microbial Biopesticides: Opportunities and Challenges. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 2011, 6, 056. http://www.cabi.org/cabreviews.

Kumar, S. Singh, A. Biopesticides: Present Status and the Future Prospects. *J. Fert. Pest*. 2015, 2, 1-2. https://doi.org/10.4172/2471-2728.1000e129

Kumari, A.; Kumar, K. N. R.; Rao, C. H. N. Adverse Effects of Chemical Fertilizers and Pesticides on Human Health and Environment. Proceedings National Seminar on Impact of Toxic Metals, Minerals and Solvents leading to Environmental Pollution. *J. Chem. Pharma. Sci*. 2014, 3, 150-151.

Lanzoni, A.; Martelli, R.; Pezzi, F. Mechanical Release of *Phytoseiulus persimilis* and *Amblyseius swirskii* on Protected Crops. *Bull. Insectol.* 2017, 2, 245-250.

Lee, W.; Ho, C.; Lo, K. Mass Production of Phytoseiids: Evaluation of Eight Host Plants for the Mass-Rearing of *Tetranychus urticae* and *T. kanzawai Kishda* (*Acarina: Tetranychidae*). *Agric. Sci. China*, 1990, 2, 121-132.

Leng, P.; Zhang, Z.; Pan, G.; Zhao, M. Applications and Development Trends in Biopesticides. *Afr. J. Biotech*. 2011, 86, 19864-19873.

Mahlo, S. M.; Chauk, H. R.; McGaw, L. J.; Eloff, J. N. Antioxidant and Antifungal Activity of Selected Plant Species Used in Traditional Medicine. *J. Med. Pl. Res*. 2013, 33, 2444-2450.

Maksymiv, I. Pesticides: Benefits and Hazards. *J. Vasyl Stefanyk Precarpathian Nat. Un*i. 2015, 1, 70-76. https://doi.org/10.15330/jpnu.2.1.70-76.

Mendoza, J. L. H.; Pérez, M. I. S.; Prieto, J. M. G.; Velásquez, J. D. Q.; Olivares, J. G. G.; Langarica, H. R. G. Antibiosis of Trichoderma spp Strains Native to Northeastern Mexico against the Pathogenic Fungus *Macrophomina*

phaseolina. *Brazil. J. Microbiol*. 2015, 4, 1093-1101. https://doi.org/10.1590/S1517-838246420120177

Minz, S.; Samuel, C. O.; Tripathi, C. S.; The Effect of Plant Extracts on the Growth of Wilt Causing Fungi Fusarium oxysporum. *J. Pharm. Biol. Sci*. 2012, 1, 13-16. https://doi.org/10.9790/3008-0411316.

Mizubuti, G. S. E.; Junior, V. L.; Forbes, G. A. Management of Late Blight with Alternative Products. *Pest Tech*. 2007, 2, 106-116.

Morales-Ramos, J. A.; Rojas, M. G. A Modular Cage System Design for Continuous Medium to Large Scale in Vivo Rearing of Predatory Mites (*Acari: Phytoseiidae*) 2014, https://doi.org/10.1155/2014/596768.

Moreira, M. D.; Picanco, M. C.; Barbosa, L. C. A.; Guedes, R. N. C.; Campos, M. R.; Silva, G. A.; Martins, J. C. Plant Compounds Insecticide Activity against Coleoptera Pests of Stored Products. *Pesquisa Agropecuária Brasile ira*, 2007, 7, 909-915. https://doi.org/10.1590/S0100-204X2007000700001.

Morrissey, W. A. Methyl Bromide and Stratospheric Ozone Depletion. CRS Report for Congress, 2006, 1-6.

Muthomi, J. W.; Lengai, G. M. W.; Wagacha, J. M. Narla, R. D. In Vitro Activity of Plant Extracts against Some Important Plant Pathogenic Fungi of Tomato. *Aust. J. Crop Sci*. 2017, 6, 683-689. https://doi.org/10.21475/ajcs.17.11.06.p399.

Muzemu, S.; Mvumi, B. M.; Nyirenda, S. P. M.; Sileshi, G. W.; Sola, P.; Chikukura, L.; Kamanula, J. F.; Belmain, S. R.; Stevenson, P. C. Pesticidal Effects of Indigenous Plant Extracts against Rape Aphids and Tomato Red Spider Mites. African Crop Science Conference Proceedings, 2011, 10, 171-173.

Naing, W. K.; Anees, M.; Nyugen, H. X.; Lee, S. Y.; Jeon, W. S.; Kim, Y. S.; Kim, H. M.; Kim, Y. K. Biocontrol of Late Blight Diseases (*Phytophthora Capsici*) of Pepper and the Plant Growth Promotion by *Paenibacillus chimensis* KWNJ8. *J. Phytopath*. 2013, 2, 164-165.

Nashwa, S. M. A., Abo-Elyousr, A. M. K. Evaluation of Various Plant Extracts against the Early Blight Disease of Tomato Plants under Green House and Field Conditions. *Pl. Prot. Sci*. 2012, 2, 74-79. https://doi.org/10.17221/14/2011-PPS.

Nawaz, M.; Mabubu, J. I.; Hua, H. Current Status and Advancement of Biopesticides: Microbial and Botanical Pesticides. *J. Entomol. Zoo. Stud*. 2016, 2, 241-246.

Ndakidemi, B.; Mtei, K.; Ndakidemi, P.A. Impacts of Synthetic and Botanical Pesticides on Beneficial Insects. Agric. Sci. 2016, 7, 364-372. https://doi.org/10.4236/as.2016.76038.

Nefzi, A.; Abdallah, B. A. R.; Jabnoun-Khiareddine, H.; Saidiana-Medimagh, S.; Haouala, R.; Danmi-Remadi, M. Antifungal Activity of Aqueous and Organic Extracts from *Withania somnifera L*. against *Fusarium oxysporum f.sp. radicislycopersici*. *J. Microbial Biochem. Techn*. 2016 8, 144-150. https://doi.org/10.4172/1948-5948.1000277

Ngegba, P.M.; Kanneh, S. M.; Bayon, M. S.; Ndoko, E. J.; Musa, P. D. Fungicidal Effect of Three Plants Extracts in Control of Four Phytopathogenic Fungi of Tomato (Lycopersicum esculentum L.) Fruit Rot.

Inter. *J*. *Environ*. *Agric*. *Biotechn*. 2018, 1, 112-117. https://doi.org/10.22161/ijeab/3.1.14.

Nia, B.; Frah, N.; Azoui, I. Insecticidal Activity of Three Plants Extracts against Myzuspersicae (Sulzer, 1776) and Their Phytochemical Screening. *Acta Agric*. *Slovenica*, 2015, 2, 261-267. https://doi.org/10.14720/aas.2015.105.2.09.

Nweke I. A. In support of a well-planned intercropping systems in south eastern soils of Nigeria: A review. *Afr*. *J*. *Agric*. *Res*. 2018, 13(26), 1320-1330 DOI:10.5897/AJAR2017.12743

Nweke I. A. Residual effect of organic waste amendment on soil productivity and crop yield-A review. *Greener J*. *Agric*. *Sci*. 2018, 8(9), 209-218. DOI: 10.15580/GJAS.2018.9.090618129

Nweke, I. A. Soil testing a panacea to crop yield and agricultural sustainability – a case for farmers of south eastern, Nigeria. *J*. *Agric*. *Sci*. 2020), 2(2), 7-14. https://doi.org/10.30560/as.v2n2p7

Nweke, I. A. Potentials of intercropping systems to soil - water - plant-atmosphere. *J*. *Agric*. *Sci*. 2020, 2(1), 31-38. https://doi.org/10.30560/as.v2n1p31

Nweke I. A. Alley cropping for soil and agricultural sustainability in south eastern soils of Nigeria. *Sumerianz J*. *Agric*. *Veter*. 2020, 3(1): 1-6.

Odhiambo, A. J.; Siboe, G. M.; Lukhoba, C. W. Dossaji, F. S. Antifungal Activity of Crude Extracts of Selected Medicinal Plants Used in Combination in Lake Victoria Basin, Kenya. *Pl*. *Prod*. *Res*. *J*. 2009, 13, 35-43.

Okunlola, A. I.; Akinrinnola, O. Effectiveness of Botanical Formulations in Vegetable Production and Bio-Diversity Preservation in Ondo State, Nigeria. *J*. *Hortic*. *For*. 2014, 1, 6-13.

Oyedokun, A.V.; Anikwe, J. C.; Okelana, F. A.; Mokwunye, I. U.; Azeez, O. M. Pesticidal Efficacy of Three Tropical Herbal Plants' Leaf Extracts against *Macrotermes bellicosus*, an Emerging Pest of Cocoa, *Theobroma cacao L*. *J*. *Biopest*. 2011, 2, 131-137.

Pal, K. K.; McSpadder, G. B. Biological Control of Plant Pathogens. *The Pl*. *Health Instr*. 2006, 10, 1-25. https://doi.org/10.1094/PHI-A-2006-1117-02.

Pandey, S.; Gill, R. S.; Mandal, K. Persistence and Efficacy of Spinosad, Indoxacarb and Deltamethrin against Major Insect Pests of Stored Wheat. *Pest*. *Res*. *J*. 2016, 28, 178-184.

Pane, C.; Palese, A. M.; Celano, G.; Zaccardelli, M. Effects of Compost Tea Treatments on Productivity of Lettuce and Kohlrabi Systems under Organic Cropping Management. *Italian J*. *Agron*. 2014, 3,1-4. https://doi.org/10.4081/ija.2014.596.

PAN https://www.pan-europe info/old Resources/Reports/PAN 2011, report%20on/%20essential%20use%20 of%20Metam.pdf

Park, J. P.; Gyung, J. C.; Kyoung, S. J.; He, K. L.; Heung, T. K.; Kwang, Y. C.; Kim, J. C. Antifungal Activity against Plant Pathogenic Fungi of Chaetoviridins Isolated from Chaetomium globosum. *FEMS Microbiol* . *Letters*, 2005,252, 309-313. https://doi.org/10.1016/j.femsle.2005.09.013.

Parliman, D. J. Soil Analyses for 1,3-Dichloropropene (1,3-DCP), Sodium N-Methyldithiocarbamate (Metam-Sodium), and Their Degradation

Products near Fort Hall, Idaho, September 1999 through March 2000. Water-Resources Investigations Report 01-4052, 2001 https://pubs.usgs.gov/wri/2001/4052/report.pdf.

Parte, S. G.; Kharat, A. S.; Mohekar, A. D.; Chavan, J. A.; Jagtap, A. A.; Mohite, A. K.; Patil, R. N. Efficacy of Plant Extracts for Management of Cimex lectularius (Bed Bug). *Inte*r. *J. Pure Ap*pl. *Biosci*. 2015, 3, 506-508.

Pascual, J. A.; Hernandez, T.; Garcia,C.; Lerma, S.; Lynch, J. M. Effectiveness of municipal waste compost and its humic fraction in suppressing *pythiumultimum*. *Microbial Ecol.* 2002, 44, 59-68.

Patrice, A. K.; Séka, K.; Francis, Y. K.; Théophile, A. S.; Fatoumata, F.; Diallo, H. A. Effects of Three Aqueous Plant Extracts in the Control of Fungi Associated with Post-harvest of Yam (*Dioscorea alata*). *Inter*. *J. Agro*n. *Agri*c. *Res*. 2017, 3, 77-87.

Pendse, M. A.; Karwander, P. P.; Limaye, M. N. Past, present and future of neuropathogenic fungi as bioagent to control plant-parasitic nematodes. *J. Pl. Protect. Sci.* 2013, 5(1), 1-9.

Powell, W.; Pickett, J. A. Manipulation of Parasitoids for Aphid Pest Management: Progress and Prospects. *Pest Manag. Sci.* 2003, 59,149-155. https://doi.org/10.1002/ps.550.

Prasad, A.; Syed, N. Evaluating Prospects of Fungal Biopesticide Beauveria bassiana (Balsamo) against Helicoverpa armigera (Hubner): An Eco-Safe Strategy for Pesticidal Pollution. *Asian J. Experi. Biol. Sci*. 2010, 3, 596-601.

Radhakrishnan, B. Indigenous botanicals preparations for pest and disease control in tea. *Bul. UPASI Tea Res. Found.* 2010, 55: 31-39.

Randhawa N.; Sakhuja P. K.; Singh I. Management of root- knot nematode Meloidogyne incognita in tomato with organic amendments. *Pl. Dis. Res.* 2001, 16: 274–276.

Rao, K.S.; Vishnupriya, R.; Ramaraju, K. Efficacy and Safety Studies on Predatory Mite, Neoseiulus longispinosus (Evans) against Two-Spotted Spider Mite, Tetranychusurticae Koch under Laboratory and Greenhouse Conditions. *J. Entom. Zoo. Stud*. 2017, 4, 835-839.

Refki, E.; Sadok, B. M.; Ali, B. B.; Faouzi, A.; Jean, V. F.; Rudy, C. M. Effectiveness of Pheromone Traps against *Tuta absoluta*. *J. Entom. Zoo. Stud*. 2016, 6, 841-844.

Rodino, S.; Butu, A.; Butu, M.; Cornea, C.P. In Vitro Efficacy of some Plant Extracts against Damping off Disease of Tomatoes. Journal of International Scientific Publications: *Agric. Food*, 2012, 2, 240-244.

Romanazzi, G.; Lichter, A.; Gabler, F. M.; Smilanick, J. L. Recent advances on the use of natural and safe alternatives to conventional methods to control postharvest grey mold of table grapes. *Postharvest Bio. Techn.* 2012, 63:141–147.

Sahu, D. K.; Khare, C. P.; Patel, R. Eco-Friendly Management of Early Blight of Tomato Using Botanical Plant Extracts. *J. Ind. Poll. Cont.* 2014, 2, 215-218.

Sales, M. D. C.; Costa, H. B.; Fernandes, P. M. B.; Ventura, J. A.; Meira, D. D. Antifungal Activity of Plant Extracts with Potential to Control Plant Pathogens in Pineapple. *Asian Pacific J. Trop. Biomed*. 2016, 1, 26-31. https://doi.org/10.1016/j.apjtb.2015.09.026.

Salim, H. A.; Salman, I. S.; Ishtar, I. M.; Hatam, H. H.; Evaluation of Some Plant Extracts for their Nematicidal Properties against

Root-Knot Nematode (*Meloidogyne sp*). *J. Gen. Environ. Res. Conserv.* 2016, 3, 241-244.

Sarles, L.; Verhaeghe, A.; Francis, F.; Verheggen, F. J. Semiochemicals of Rhagoletis Fruit Flies: Potential for Integrated Pest Management. *Crop Protect*. 2015, 78, 114-118. https://doi.org/10.1016/j.cropro.2015.09.001.

Selim, H. M. M.; Gomaa, N. M.; Essa, A. M. M. Antagonistic Effect of Endophytic Bacteria against Some Phytopathogens. *Egyptian J. Bot*. 2016, 1, 74-81.

Semeniuc, C. A.; Pop, C. R.; Rotar, A. M. Antibacterial Activity and Interactions of Plant Essential Oil Combinations against Gram-Positive and Gram-Negative Bacteria. *J. Food Anal*. 2017, 25: 403-408. https://doi.org/10.1016/j.jfda.2016.06.002

Sesan, T. E.; Enache, E.; Iacomi, M.; Oprea, M.; Oancea, F.; IacoPenicilliummi, C. Antifungal Activity of some Plant Extract against Botrytis cinerea Pers. in the Blackcurrant Crop (Ribes nigrum L). *Acta Scientiarum Polonorum Technologia Alimentaria,* 2015, 1, 29-43.

Shah, J. A.; Inayatullah, M.; Sohail, K.; Shah, S. F.; Shah, S.; Iqbal, T.; Usman, M. Efficacy of Botanical Extracts and a Chemical Pesticide against Tomato Fruit Worm (*Helicoverpa armigera*). *Sarhad J. Agric*. 2013, 1, 93-96.

Shiberu, T.; Getu, E. Assessment of Selected Botanical Extracts against *Liriomyza* Species (*Diptera: Agromyzidae*) on Tomato under Glasshouse Condition. *Inter. J. Fauna Bio. Stud*. 2016, 1, 87-90.

Sidhu, S. H.; Kumar, V.; Madhu, M. R. Eco-Friendly Management of Root-Knot Nematode, *Meloidogyne javanica* in Okra (*Abelmoschus esculentus*) Crop.

Inter. J. Pure Appl. Biosci. 2017, 1, 569-574. https://doi.org/10.18782/2320-7051.2507.

Sikora R. A.; Fernandez E. Nematode parasites of vegetables, 2005, p. 319–392. In: "Plant- Parasitic Nematodes in Sub- tropical and Tropical Agriculture" (M. Luck, R.A. Sikora, J. eds)

Silva, F. R.; Moraes, G. J.; Gondim, M. G. C.; Knapp, M.; Rouam, S. L.; Paes, J. L. A.; Oliveira, G. M. Efficiency of *Phytoseiulus longipes* Evans as a Control Agent of *Tetranychus evansi* Baker & Pritchard (*Acari: Phytoseiidae: Tetranychidae*) on Screen house Tomatoes. *Neotropical Entomology*, 2010, 6, 991-995. https://doi.org/10.1590/S1519-566X2010000600022.

Singh, H. B. Management of Plant Pathogens with Microorganisms. Proceedings of the Indian National Science Academy, 2014, 2, 443-454. https://doi.org/10.16943/ptinsa/2014/v80i2/55120.

Song, C. H.; Islam, R. M. D.; Jeong, Y. T.; Lee, Y. S. Isolation and Identification of Antifungal Compounds from Bacillus subtilis C9 Inhibiting the Growth of Plant Pathogenic Fungi. *Mycobiology,* 2012, 1, 59-66.

Souza, R.; Ambrosini, A.; Passaglia, L. M. P. Plant Growth-Promoting Bacteria as Inoculants in Agricultural Soils. *Gen. Mol. Bio*. 2015, 4, 401-419. https://doi.org/10.1590/S1415-475738420150053.

Srijita, D. Biopesticides: An Eco-friendly Approach for Pest Control. *World J. Phar. Pharmaceut. Sci*. 2015, 6, 250-265.

Steinberg, S. (2013) Novel Technologies in Mass Rearing of Beneficial Arthropods. Proceedings of the Annual Biocontrol Industry Meeting, Bael, 1-28.

Stoneman, B. Challenges to Commercialization of Biopesticides. Proceedings Microbial Biocontrol of Arthropods, Weeds and Plant Pathogens: Risks, Benefits and Challenges. National Conservation Training Center, Shepherdstown, WV, 2010

Sumitra, A.; Kanojia, A. K.; Kumar, A.; Mogha, N.; Sahu, V. Biopesticide Formulation to Control Tomato *Lepidopteran* Pest Menace. *Cur*. *Sci*. 2014 7, 1051-1057.

Sunder, J.; Singh, D. R.; Jeyakumar, S.; Kundu, A.; Kumar, A. Antibacterial Activity in Solvent Extract of Different Parts of *Morinda citrifolia* plant. *J. Pharmaceut*. *Sci*. *Res*. 2011, 8, 1404-1407.

Suprapta, D. N. Potential of Microbial Antagonists as Biocontrol Agents against Plant Fungal Pathogens. *Inter. Soc. Southeast Asian Agric. Sci. J*. 2012, 2, 1-8.

Taye, W.; Sakhuja, P. K.; Tefera, T. Evaluation of plant extracts on infestation of root-knot nematodes on tomato (*Lycopersicon esculemtum* Mill). *J. Agric. Res. Develop.* 2012, 2(3): 86-91.

Vidyasagar, G. M.; Tabassum, N. Antifungal Investigations on Plant Essential Oils: A Review. *Inter. J. Phar. Pharmaceut.* Sci. 2013 2, 19-28.

Vinale, F.; Krishnapillai, S.; Ghisalbertic, L. E.; Marraa, R.; Wooa, L. S.; Loritoa, M. *Trichoderma*-Plant-Pathogen Interactions. *Soil Bio. Biochem*. 2008, 40, 1-10. https://doi.org/10.1016/j.soilbio.2007.07.002.

Wetungu, M. W.; Matasyoh, J. C.; Kinyanjui, T. Antimicrobial Activity of Solvent Extracts from the Leaves of *Tarchonanthus camphoratus* (Asteraceae). *J. Pharmacog. Phytochem.* 2014, 1, 123-127.

Wu, K.; Lin, K.; Miao, J.; Zhang, Y. Field Abundances of Insect Predators and Insect Pests on δ-Endotoxin-Producing Transgenic Cotton in Northern China. Second International Symposium on Biological Control of Arthropods, Davos, 2005, 362-368

Xavier, G.; Chandran, M.; Naseema, B. S.; Mathew, T. B.; George, T.; Vijayasree, V.; Pratheeshkumar, N.; Kumar, S. V. Persistence of Fenpyroximate in Chilli Pepper (*Capsicum annum* L.) and Soil and Effect of Processing on Reduction of Residues. *Pest. Res. J.* 2016, 2, 145-151.

Xiao, Y.; Wei, X.; Ebright, R.; Wall, D. Antibiotic Production by Myxobacteria Plays a Role in Predation. *Journal of Bacteriology*, 2011, 18, 4626-4633.https://doi.org/10.1128/JB.05052-11.

Xu, X.; Enkegaard, A. Prey Preference of the Predatory Mite, *Amblyseius swirskii* between First Instar Western Flower Thrips *Frankliniella occidentalis* and Nymphs of the Two-Spotted Spider Mite *Tetranychus urticae*. *J. Insect Sci*. 2010, 149, 1-11. https://doi.org/10.1673/031.010.14109.

Zarubova, L.; Lenka, K.; Pavel, N.; Miloslav, Z.; Ondrej, D.; Skuhrovec, J. Botanical Pesticides and Their Human Health Safety on the Example of Citrus sinensis Essential Oil and *Oulema melanopus* under Laboratory Conditions. *Mendel Net*, 2014, 330-336.

Research Article

A Study on Problems on Kiwi Cultivation and Marketing at Solukhumbu District, Nepal

Aavash Adhikari [1]*, Sovit Parajuli[1], Arjun Subedi[1], Purushottam Dhungana[1], Krishna Prasad Thapaliya[2]

[1]*Faculty of Agriculture, Agriculture and Forestry University, Chitwan, Nepal*

[2]*Center for Development Studies and Rural Sociology, Agriculture and Forestry University Rampur, Chitwan, Nepal*

	ABSTRACT
	As a promising high-value fruit crop, Kiwi is getting popularity among the Nepalese farmers for having comparative advantage both in terms of climatic suitability and having export potential. A sound understanding of the problems faced by the Kiwi growers can help concerned authorities to devise further plans and programs to further potentiate the production and income from Kiwi cultivation. The research was conducted in Solududhkunda Municipality and Thulung Dudhkoshi, Nechasalyan Rural Municipality of Solukhumbu district of Nepal, with the objective of ranking the major problems of Kiwi cultivation and marketing in those areas. A survey research design was used for the study. Primary data for the household survey were collected using a semi-structured questionnaire as well as KII was also used. Household-level data from 90 households (30 households from each municipality) were sampled using a simple random sampling technique. Descriptive statistics were used for the analysis of data. The average area under Kiwi cultivation was found 23 ropani, the average plant per farmer was 198 and the average age of the Kiwi was 2.94 years. 26 % of the respondents have their family members involved in foreign employment and 76% of respondent's major occupation was found to be agriculture. 65% of the farmers haven't got any training on Kiwi cultivation and 67% of the farmer haven't done soil tests of the field. Lack of funds to build cemented T-bar pillar was found to be a major problem while lack of knowledge on cultivation practices, lack of quality saplings, marketing was ranked respectively. Similarly, problems on marketing were found to be: 1. lack of transportation facility, 2. lack of cold storage, 3. lack of knowledge on value addition and product diversification, 4. untimely payback of money

respectively. Subsidy for T-bar pillar system, training on cultivation practices, and establishment of cold storage is of an immediate need to strengthen the Kiwi production in the area.

INTRODUCTION

Kiwi fruit is a new commodity to Nepalese farmers. It's been just a few years that farmers have adopted commercial Kiwi farming. Kiwi can be grown from 1200-2400 m asl. where fruits like peach, pear, and apricot can be grown. The hilly region of Nepal has great potential for Kiwi cultivation. More profitability than other crops, huge potential for the national and international market, medicinal and nutritional value and a good source of employment are the main reasons behind the motivation of farmers for Kiwi cultivation. Due to the emigration of youth for trekking businesses foreign employment, the labor shortage is the main problem for growing cereal crops (AKC Solukhumbu) and hence many hectares of fertile land are kept barren in the mid-hills. Farmers have started to cultivate Kiwi in such barren land and hence the demand for Kiwi sapling is increasing day by day.

Kiwi is one of the most traded fresh fruit with 104 exporting and 118 importing countries, where New Zealand is the largest exporter (Mani, Kundra, & Haque, 2018). The total area, productive area, production, and yield of Kiwifruit in Nepal are 551ha, 186ha, 719 mt, and 4 mt/ha, respectively (MOAD, 2016/17). Most of the high hills and mountainous regions are substantially potential for Kiwi cultivation, but its cultivation is limited to some districts. Solukhumbu is one of the districts having a high potential area for Kiwi production.

Nepal has adopted Kiwi farming commercially in Ilam since 2007 and in Kavre as well, but it was introduced in Nepal nearly 40 years ago (ICIMOD, 2013). ICIMOD (International Centre for Integrated Mountain Development) has been doing its research about Kiwi fruit in Godawari. Kiwi farming, especially in Ilam has spread so rapidly that 1400 Kiwi farmers from 36 VDCs are engaged in it. The government has developed 'Boach Horticultural Farm' in Dolakha district with its increasing popularity (Thapa, 2010). A pilot program called 'Commercial Kiwi Promotional Program' has been implemented by the government in five districts, namely Ilam, Dolakha, Lamjung, Parbat and Dadeldhura (Thapa, 2010). The Federation of Nepalese Chamber of Commerce and Industry (FNICC) has selected Makawanpur and Ilam for its One Village One Product (OVOP) program (Poudel, K. P. 2012).

We were talking about the worldwide scenario, in 2018, approx. 4.3M tones of Kiwi fruit were produced worldwide; increasing by 4.4% against the previous year (Trade, 2019). China constitutes the country with the largest quantity of Kiwi fruit production, accounting for about half of the total production. New Zealand (437K tonnes) ranked third in terms of total production with a 10% share (Trade, 2019).

The primary appeal of the Kiwifruit is its uniqueness, its distinctive fresh flavor which becomes more aromatic when it ripens. It is a rich source of minerals such as potassium, magnesium, calcium, phosphorous, along with crude fiber and, more importantly, dietary fiber, and is renowned for its strong laxative properties. Containing over 20 essential nutrients and a range of vitamins, the Kiwifruit comes near the top of fruits classed as superfoods (Latocha, 2017). It is one of the richest sources of vitamin C with up to 430 mg/100 g fresh weight (FW) and is

considered the richest dietary source of myo-inositol (up to 982 mg/100 g FW) (Latocha, 2017). Further, containing up to about 1301.1 mg/100 g FW phenolics and significant amounts of essential minerals of potassium, calcium, and zinc; the Kiwifruit rates very highly as a 'Healthy Food'. Researches have pointed to Kiwifruit being a promising treatment for some cancers and health issues involving the gastrointestinal system, hypercholesterolemia and certain cancers. It is also renowned for having the benefits of maintaining healthy skin tone and texture, reducing blood pressure, and preventing heart diseases and stroke. Also, Kiwifruit is a good source of folate for pregnant women (Borah, 2018).

Table 1: Top 10 Kiwifruit producing countries (2018)

Rank	Country	Production (MT)
1	China	2035158
2	Italy	562188
3	New Zealand	414261
4	Iran (Islamic Republic of)	266319
5	Greece	265280
6	Chile	230267
7	France	61920
8	Turkey	53201
9	USA	34290
10	Portugal	34057

Source: (FAOSTAT, 2018)

Kiwifruit, previously known as Chinese gooseberry, is also described as "King of Fruits" due to its high vitamin C content (Xu & Zhang, 2003). It originated from China and was introduced to the world market from New Zealand. At present, the top 10 Kiwifruit-producing countries in the world are China, Italy, New Zealand, Chile, Greece, France, Turkey, Iran, Japan and the United States of America. The history of commercial farming of Kiwifruit in Nepal is not so long. It has been only 15-20 years of commercial farming in Nepal. It is believed to have been introduced in Nepal during the Swiss project in some lands of Charikot and Jiri of Dolakha district during the 1980s (Dhakal, 2018).

Due to the growing nutritional concern of the consumers and its potential national and international market, Kiwi cultivation has become a recent trend in the Solukumbu district. The government has recently established a Kiwi zone in the district comprising of 1 municipality and 2 rural municipalities under Prime Minister Agriculture Modernization Project (PMAMP). To increase the efficacy of the project, the programs launched by the project must address the prevailing problems of the farmer's field. This study aims to enlist and rank the problem as per their severity so that PMAMP and other concerned authorities can design effective programs to address it.

Kiwi being a care-intensive crop and Solukhumbu being a geographically difficult area formulating and launching programs for Kiwi cultivation in the area can be a cumbersome task. This study will help

governmental, non-governmental, and other organizations who want to work in the field of Kiwi in Solukhumbu district as they will know the major constraints of the Kiwi production in the area after this study. The objective of the study was to enlist and rank the problem of Kiwi cultivation and marketing as per severity and intensity as well as to provide the report of farmers problems to related governmental, non-governmental bodies working for Kiwi and hence assist them in planning and implementation of programs for next fiscal year.

According to the project implementation unit office of Kiwi Zone (2020) under the Prime Minister Agriculture Modernization Program implemented by MoAD in Solukhumbu district, Hayward, Alison, and Montie are the wide cultivated varieties of Kiwi fruit. It is also known that all the Kiwi fruits are being consumed locally in Nepal due to their nutritional benefits. There are 81 registered Farmers groups/cooperatives/farms/companies involved in Kiwi cultivation in the Solukhumbu district.

Table 2. Farmers groups/cooperatives/farms/companies involved in Kiwi cultivation in Solukhumbu district

S.N	Firm name	Address
1	Dudhkunda Krishi Byabasaya Firm	Solu Du Na Pa
2	Himali Public Falfaul Nursury Firm	Solu Du Na Pa
3	Sherpa Bahuodesya Krishi Firm	Solu Du Na Pa
4	Didi Bahni Krishi Firm	Solu Du Na Pa
5	Kyamje Krishi Firm	Solu Du Na Pa
6	Lama Byabasaik Krishi Firm	Solu Du Na Pa
7	P T L Pashu Firm	Solu Du Na Pa
8	Sagarmatha Bahuodesya Krishi Firm	Solu Du Na Pa
9	Sekarshingh Krishi Firm	Solu Du Na Pa
10	Dudhkund Dudghda Ootoadak Krishi Firm	Solu Du Na Pa
11	Smart Poultry Firm Tatah Dana Ootpadan	Solu Du Na Pa
12	Himalai Jadibuti Odpadan Krishi Firm	Solu Du Na Pa
13	Everest Bahuodesya Krishi Firm	Solu Du Na Pa
14	Chinkpu Byabassaik Krishi Tatha Pashu Firm	Solu Du Na Pa
15	Jaleswari Bahuodesya Krishi Firm	Solu Du Na Pa
16	Sherpa Krishi Tahta Jadibuti Ekritik Krishi Firm	Solu Du Na Pa
17	Yamadin Byabasaya Krishi Tahta Pashu Firm	Solu Du Na Pa
18	Sherpa Agro Firm	Solu Du Na Pa
19	Sherpa Krishi Firm0	Solu Du Na Pa
20	Nima Hrt Firm	Solu Du Na Pa
21	Chinakpu Krishi Firm	Solu Du Na Pa
22	Laliguras Misrit Krishi Samuha	Solu Du Na Pa
23	Dudhkundsa Heude Krishi Falful Firm	Solu Du Na Pa
24	Suryamukhi Falful Tarkari Odpadan Krishak Amuha	Solu Du Na Pa
25	Bishal Himali Falful Firm	Solu Du Na Pa

26	Surke Nahuodesya Krsihsi Firm	Solu Du Na Pa
27	K B Krishi Tatha Pashu Firm	Solu Du Na Pa
28	Syarkhumbu Krishi Firm	Solu Du Na Pa
29	Gorakhani Kiei Firm	Solu Du Na Pa
30	Tapting Ok Jadibitu Prasodhan Kendra0	Solu Du Na Pa
31	Grisma Bahuodesya Krishi Firm	Solu Du Na Pa
32	Iccha Bahuodesya Krishi Tatha Pashu Firm	Solu Du Na Pa
33	Ajambari Krishi Firm	Solu Du Na Pa
34	S S Jadibuti Firm	Solu Du Na Pa
35	DSP Krishi Firm	Solu Du Na Pa
36	Pk Pashupanxi Palan Tahtha Otpaadan Kendra	Solu Du Na Pa
37	Pinasa Bahuodesya Krishi Firm	Solu Du Na Pa
38	Arun Krishi Firm	Solu Du Na Pa
39	Sagarmatha Bahuodesya Krishi Firm	Solu Du Na Pa
40	Bishwas Adhunik Kishi Firm	Solu Du Na Pa
41	Matribhumi Yuba Organic Bahuodewsya Krishi Firm	Solu Du Na Pa
42	Sherpa Organic Kiwi Firm	Solu Du Na Pa
43	Jwalamai Agro Firm	Solu Du Na Pa
44	Menuka Bahuodesya Krishi Firm	Solu Du Na Pa
45	C G Krishi Firm	Solu Du Na Pa
46	Sujansashi Krishi Tatha Pashu Firm	Solu Du Na Pa
47	Salme Krishi Firm	Solu Du Na Pa
48	Organic Krishi Firm	Solu Du Na Pa
49	Falamkhani Bahuodesya Krishi Firm	Solu Du Na Pa
50	Everset Bhaisi Palan Tatha Krishi Firm	Solu Du Na Pa
51	Firms from Thulung dudhkoshi rural municipality	Address
52	Gaurab Bahuodesya Krishi Farm	Thulung Dudhkoshi
53	Deusa Krishi Ban Pra Li	Thulung Dudhkoshi
54	Jalim Krishi Farm	Thulung Dudhkoshi
55	Surja Masu Pasal Taha Kiwi Firm	Thulung Dudhkoshi
56	Highand Organic Krishi Firm	Thulung Dudhkoshi
57	Kangel Bahuudesya Krishi Firm	Thulung Dudhkoshi
58	Amrit Krishi Firm	Thulung Dudhkoshi
59	Thakumala Organic Krishi Firm	Thulung Dudhkoshi
60	Jaya Laxmi Bahuodesya Krishi Firm	Thulung Dudhkoshi
61	Dudhkoshi Krishi Firm	Thulung Dudhkoshi
62	Karma Sherpa Fancy Stores	Thulung Dudhkoshi
63	Nayabasti Krishi Firm	Thulung Dudhkoshi
64	Om Agroforestry Enterprise	Thulung Dudhkoshi
65	Himalayana Krishi Bikas Tatha Prasodhan	Thulung Dudhkoshi
66	Nawajyoti Krishak Samuha	Thulung Dudhkoshi
67	Firm Name from Nechasalyan rural municipality	Address
68	Sarobar Falful Tatha Tarkari Form	Nechasalyan Gapa 1

69	Yadeemchyo Kiwi Fal Tatha Pasupalan Form	Nechasalyan Gapa 4
70	Jalapadevi Bahuudhesya Krishi Form	Nechasalyan Gapa 3
71	Aatmanirbhar Mahila Krishak Samuha	Nechasalyan Gapa 3
72	Gita Bahuudhesya Krishi Form	Nechasalyan Gapa 3
73	Bhandari Bahuidhesya Krishi Form	Nechasalyan Gapa 3
74	Chaur Gaun Kiwi From	Nechasalyan Gapa 1
75	Nawajyoti Mahila Tatha Purus Mishrit Krishak Samuha	Nechasalyan Gapa 5
76	Sunaulo Mahila Tatha Purus Mishrit Krishak Samuha	Nechasalyan Gapa 5
77	Chamlaboot Tarkari Krishak Samuha	Nechasalyan Gapa 4
78	Laliguras Krishak Samuha	Nechasalyan Gapa 1
79	Shree Himalayan Organic Krishi Tatha Pashupalan Form	Nechasalyan Gapa 5
80	Sagarmatha Krishi Tatha Falful Kendra	Nechasalyan Gapa 2
81	Chhatra Bahuudhesya Krishi Form	Nechasalyan Gapa 2

Bhandari N. B, & Aryal M, 2015; A study on the average cost of production and gross profit of fruit farming in Nepal during 2014/15, carried out by MoAD; Agribusiness Promotion and Marketing Development Directorate, Market Research, and Statistics Management Program, Hariharbhawan, Lailtpur, informs us that annual variable cost for Kiwi farming increases every year by 10%. The benefit-cost ratio of fruits ranges from 1 to 5. It means the profit is 5 times more than the total cost. Suppose there is a total cost of Rs 1,00,000 then, the profit will be Rs 5,00,000 for a 5 B/C ratio. It depends upon the fruit type and life span. In the study, it was found that Kiwi has a higher B/C ratio, followed by banana and papaya. Kiwi is new fruit for Nepal and has a higher farm-gate price per Kg. B/C ratio of the fruits crop varied from 1.86 to 3.66, showing their relatively higher level of profitability in terms of investment (Economic Aspects of Fruit and Vegetable Production, 1992).

METHODOLOGY

LEE Site and Sub-sector

The study was carried out in Solukhumbu district which is one of the high hilly districts of Province 1. The district is surrounded by Sankhuwasabha in the east, Bhojpur in the south-east, Khotang and Okhaldhunga in the south, Province No. 3 in the west and Tibet (China) in the north. The total land area of the district measures 3,312 km2 (331 200 hectares), with the highest elevation of the district being 8,848 meters (29,029 ft) (Mt. Everest) and the lowest elevation is 600 meters (2,000 ft) (Tuintar) above sea level. Solukhumbu is divided into 8 local level units, 1 unit is urban and 7 are rural. They are further divided into wards. Solukhumbu is the single-seat constituency for the parliamentary constituency and a double seat for the provincial constituency. Under the Prime Minister Agriculture Modernization Project, Solukhumbu district has allocated 3 zones viz. Kiwi, Ginger/Turmeric, and Citrus zone. The study was mostly concentrated in the Kiwi zone covering 1 municipality and 2 rural municipalities comprising many wards.

The study was focused on the problems of Kiwi cultivation and marketing in the Solukhumbu district. Kiwi is the most important fruit crop in the district. Among the exported fruit crops from the district, Kiwi holds the first position. The total area under Kiwi in the fiscal year 2074/75 is 85 ha of the total 92000 ha cultivable land of Solukhumbu (AKC Profile).

Unit of Analysis

The primary unit of analysis was the household of the whole population of Kiwi

growers in Solukhumbu district, only those residing on the Kiwi zone of PMAMP viz. Solududhkunda municipality, Nechasalyan and Thulung Dudhkoshi rural municipality were studied.

The population of the Case Study

Kiwi being the profitable fruit crop in the district, the population involved in the Kiwi sector is increasing day by day (PMAMP profile). The total population in the Kiwi sector is comprised of a large number of farmers. A complete enumeration of all the farmers was constrained by time factors, money and energy. Therefore, owing to constraints, a definite number of respondents are selected via simple random

sampling which is representative of the whole population. The commercial Kiwi growers and the cooperatives involved in the Kiwi zone comprise the sampling frame. Among these, simple random sampling was conducted to select the farmers in the survey. As the Kiwi zone site comprises 1 Municipality and 2 Rural Municipality, at least 30 commercial growers from each of 3 Municipalities (Solududhkunda, Thulung Dudhkoshi and Nechasalyan) was surveyed. A total of 90 commercial growers were surveyed. The concerned authority from each municipality's area was interviewed for additional information.

Figure 1: Map showing the study area in Solukhumbu district

Research Design

A questionnaire was prepared and pretested with 5 farmers from each municipality. Problems faced by the farmers were enlisted down and necessary correction in the questionnaire was done. After Interviewing with key informants and analyzing the problems from the test survey, major 5 problems were selected and included in the

new questionnaire to be ranked by the farmer.

The enlisted 5 major problems were given for farmers to rank them from1-5 as per their severity. After the problem was ranked by the farmer, it was allocated a certain number based upon its rank and the total sum of marks received by the problem was calculated to determine the final severity of the problem.

Table 3. Problem rank given by farmers.

Rank of the problem as given by the farmers	Allocated Mark
5	1
4	0.8
3	0.6
2	0.4
1	0.2

Observation and Observation Methods

A total of 90 Kiwi growing farmers were observed via the following methods

Questionnaire survey

The actors (private firms, cooperatives, farmers groups, and concerned governmental authorities) involved in the survey were asked a series of open and close-ended questions that aided in the collection of some useful data regarding the various problems encountered in the production and marketing of the Kiwi fruit.

Key Informants' Interview

Key informants such as the coordinator of the Kiwi zone committee, local leaders, AKC, DDC, ASC, cooperative members, collectors, and traders were interviewed regarding the present scenario of Kiwi cultivation in the area, the major problem they are suffering, current production and price trend, etc.

Data Analysis Techniques

Data analysis involves making sense of the large volume of information collected from field research. Hence, reducing voluminous text by coding and classifying the related concepts is important for systematic recording and retrieval for later use. Data collected from the questionnaire survey; key informant interview was analyzed using statistical software like MS Excel.

RESULTS AND DISCUSSION

Sources of income

The major source of income of the respondents was found to be agriculture. 76% of the total respondent's state agriculture as their major occupation, whereas only 24% of respondent household income relies on non-agriculture-related fields. This data is higher than the national population involved in agriculture, i.e., 65.67% (CBS, 2011).

Status of foreign employment

The result shows that Out of 90 people, 24, i.e., 26.66%, people have their family members abroad for foreign employment, whereas 66 people, i.e., 73.33% people do not have any of their family members involved in foreign employment. It suggests that there is manpower available in the study area to work in agriculture.

Availability of electricity

Being geographically challenging district some places of Solukhumbu are still out of access to electricity. Of the total respondent, 34% lacks electricity in their field and only 66% have access to electricity. This hinders the operation of electrical equipment like water pumps, electric sprayers, mills, etc.

Soil testing

The result shows that very few farmers (33%) regularly test their soil whereas, the majority of farmers (67%) do not perform regular soil testing.
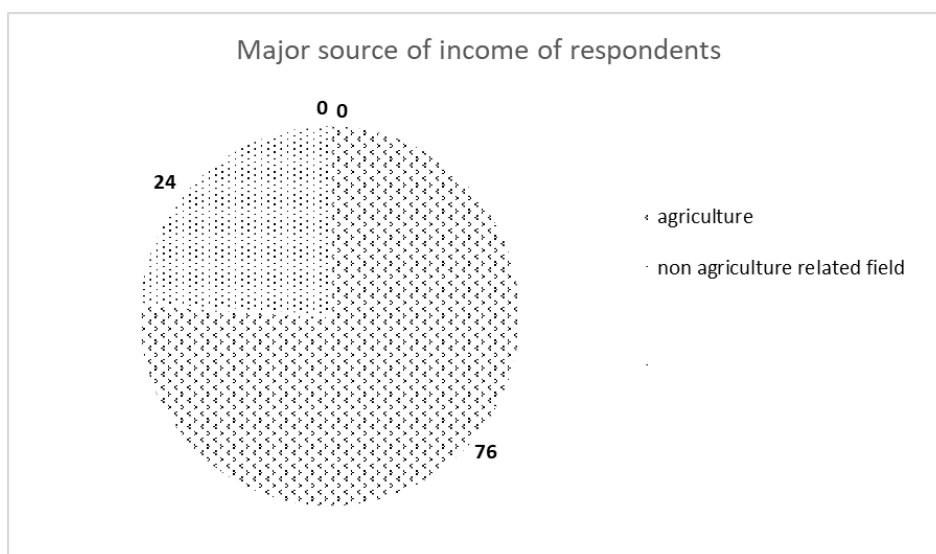
Figure 2: Major source of income of respondents

Figure 3: Status of foreign employment

Training on Kiwi cultivation

The result shows that only 35% of the growers have received training on Kiwi cultivation, whereas 65% of farmers are growing Kiwi without any pieces of training. It was evident during the field visit that most of the Kiwi orchard was poorly managed and training pruning was not done.

Major problems on Kiwi cultivation

Among the many problems of Kiwi cultivation in Solukhumbu district, the most severe are selected and ranked as below. Kiwi being a vine crop, needs a cemented T bar pillar system for support. Among other problems, it was found to be most severe (total score 82), followed by knowledge on Kiwi

cultivation practices (66.2). Lack of Quality sapling ranks third with a score of 36.6. This has compelled farmers to use saplings of poor graft compatibility and of unknown variety. The other problems in the area were found to be hailstorm damaging the crop, threats from wild animals, lack of irrigation, mechanization in agriculture and unavailability of chemical fertilizers.
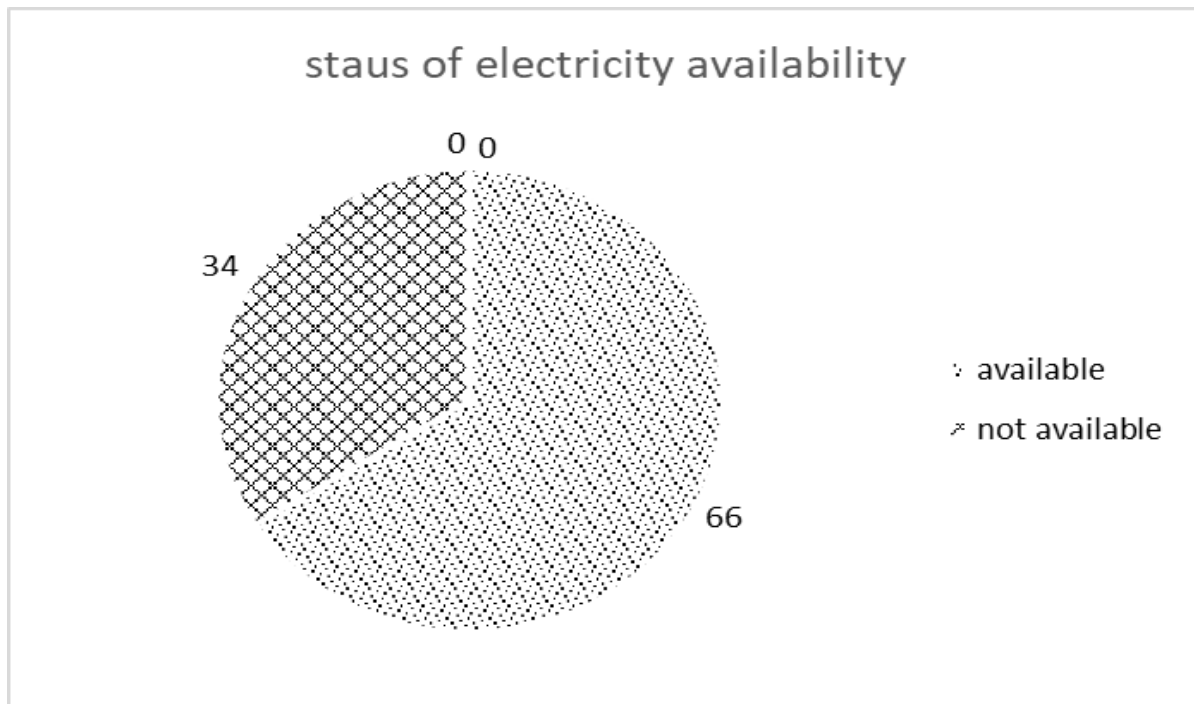
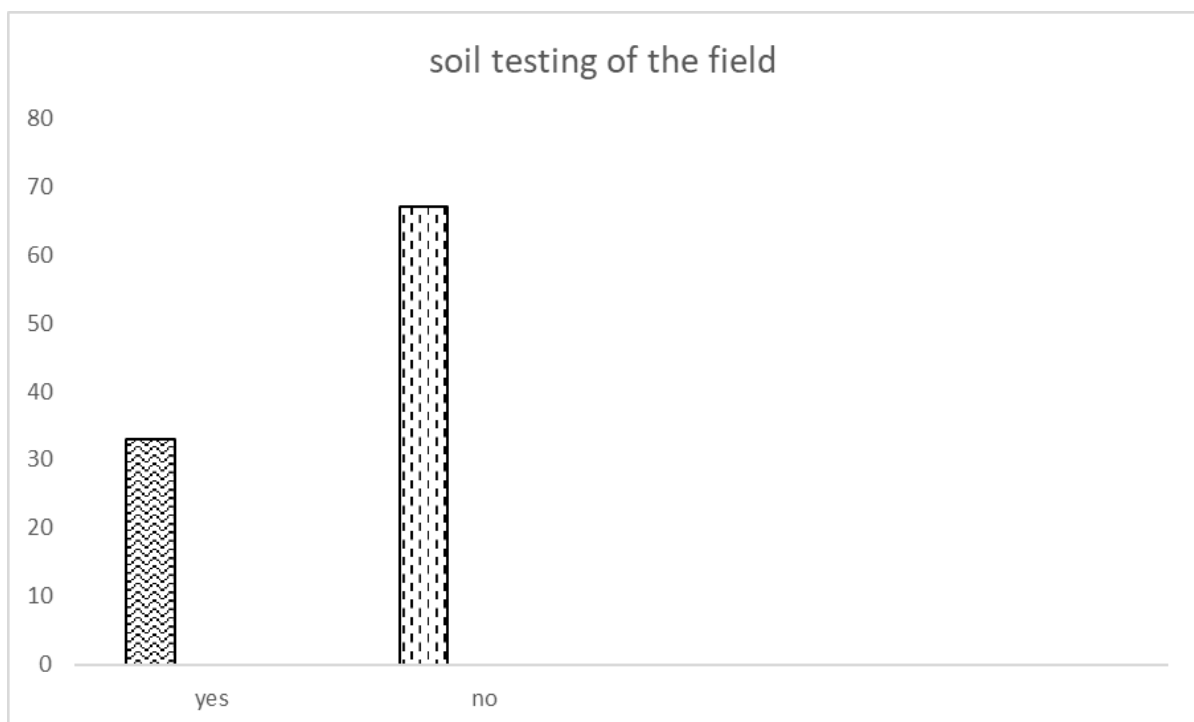

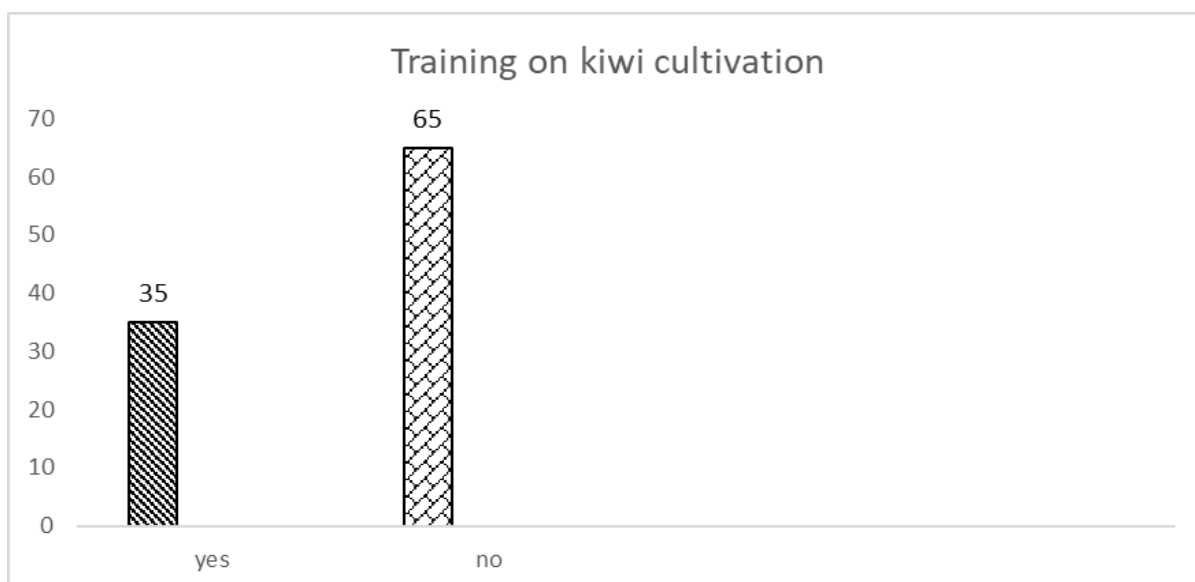**Figure 4: Availability of electricity**

Figure 5: Soil testing of field

Figure 6: Training on Kiwi cultivation

Table 3: Major Problem on Kiwi cultivation

S.N	Name of Problem	Total Score Received
1	T bar pillar construction	82
2	Lack of Knowledge on cultivation practices	66.2
3	Unavailability of Quality sapling	36.6
4	Marketing	49.4
5	Others	35.8
Total		270
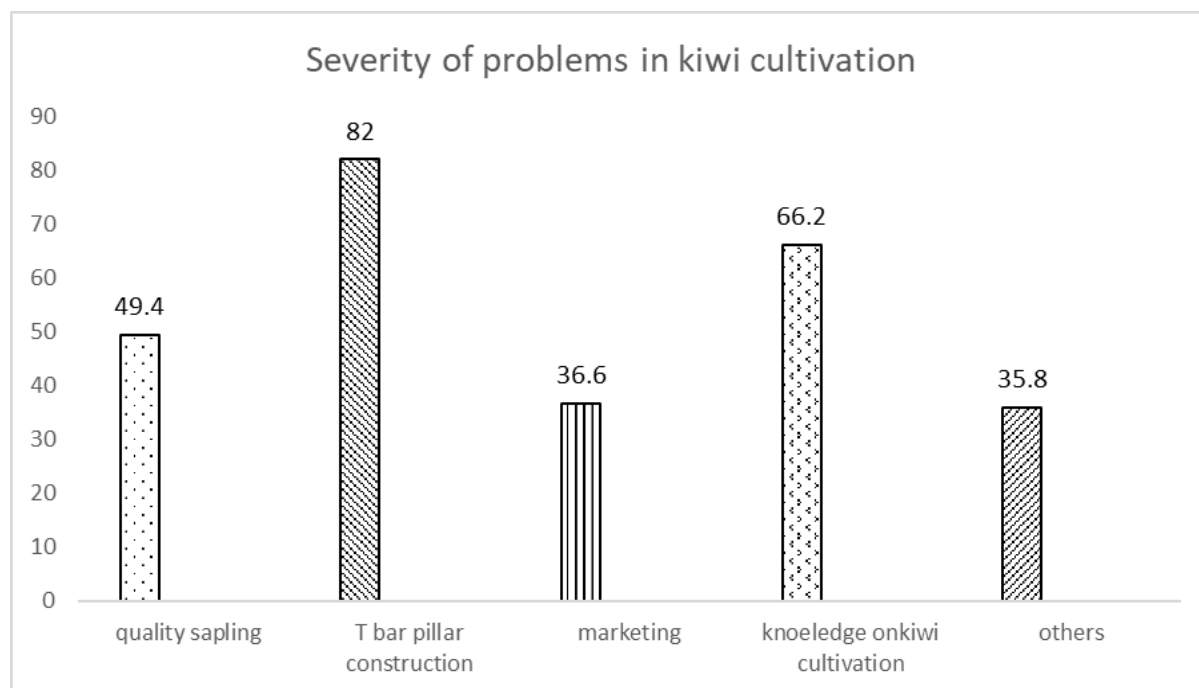
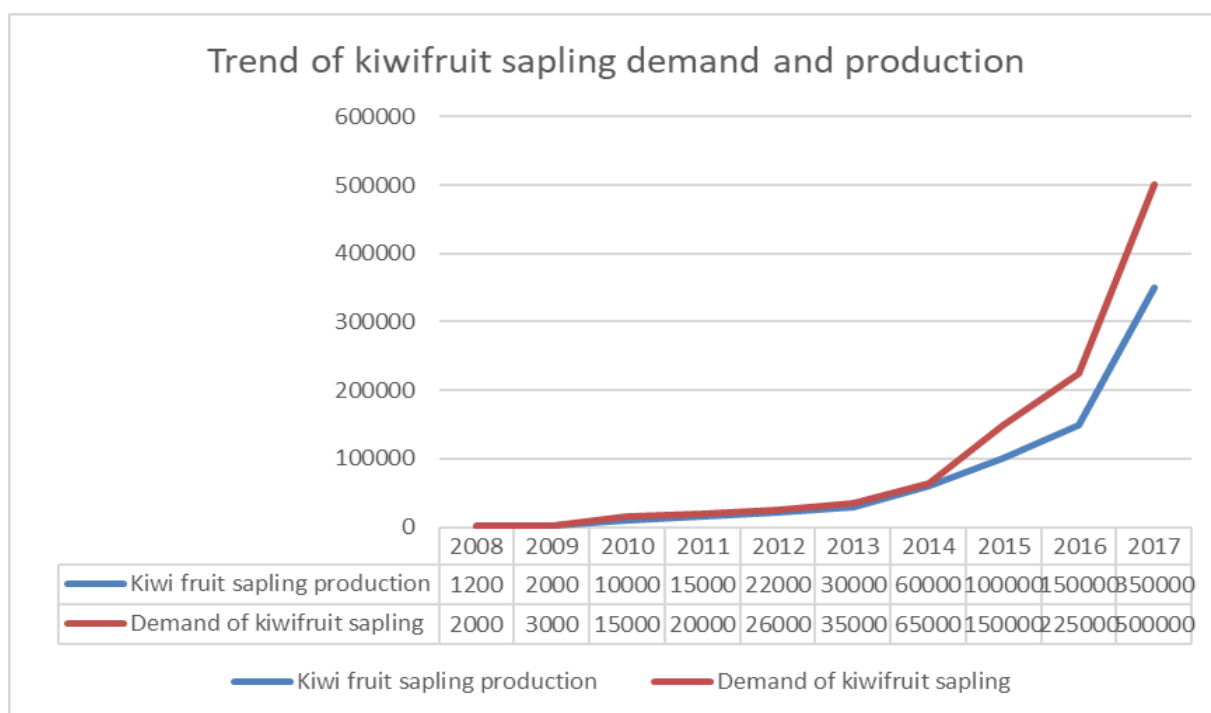**Figure 7: Severity of problem in Kiwi cultivation**

Figure 8: Trend of Kiwifruit demand and production

Source: Field Survey 20117/18, (Manandhar L.K., 2017, A Study of Kiwifruit Production and Marketing- A case of hill districts of Nepal.)

The T bar pillar system in the Kiwi vineyard is built from reinforced cement concrete (R.C.C), GI pipes, and wires. Being a rural area where transportation costs are too high, the cost of those ingredients is too expensive. The estimated cost of construction of T bar in the 1 ropani land area is NRs. 1,23,920 (PMAMP Solukhumbu 2020) which is greater than the per capita income of Nepalese people US $ 1004 – NRs. 1,06,333 annually (2018). Farmers of Solukhumbu district who are relying upon subsistence agriculture are unable to afford this. They were making wooden and bamboo pillar systems, but they lasted only for a couple of years.

Similarly, Kiwi being a new crop to farmers they lack the know-how of its cultivation like training pruning, grafting, intercropping, etc. Only 35 % of farmers have received training on the cultivation practices of Kiwi. 65% of growers are managing their orchards without any former pieces of training. This was also evident during the farmer's field visit during the study as the orchard was poorly managed and plants were in dilapidated condition.

The quality saplings of Kiwi fruits are expensive and difficult to find. During the study, some farmers reported that they had bought Kiwi saplings from abroad, viz. China, Italy, etc. As grafting saplings are only recommended for commercial Kiwi farming, the lack of farmer's knowledge on grafting and lack of screen house to grow saplings is causing this huge gap between demand and supply (AKC Solukhumbu).

Among other problems of Kiwi, cultivation marketing lies in the fourth position as per its severity (score 49.4). Within many problems related to marketing, lack of transportation was the main problem with a score of 80.6, followed by lack of storing facility, i.e., cold storage (score 76.8). The third-ranked problem of marketing was the lack of knowledge on post-harvest processing for value addition and product diversification (score 52.8). The untimely return back of the

money was the fourth problem with a score of 37.8. These problems are followed by some other problems related to marketing

like lack of crates for harvest and storing, the role of middle man, price fluctuations, etc.

Table 4: Major problem in Kiwi marketing

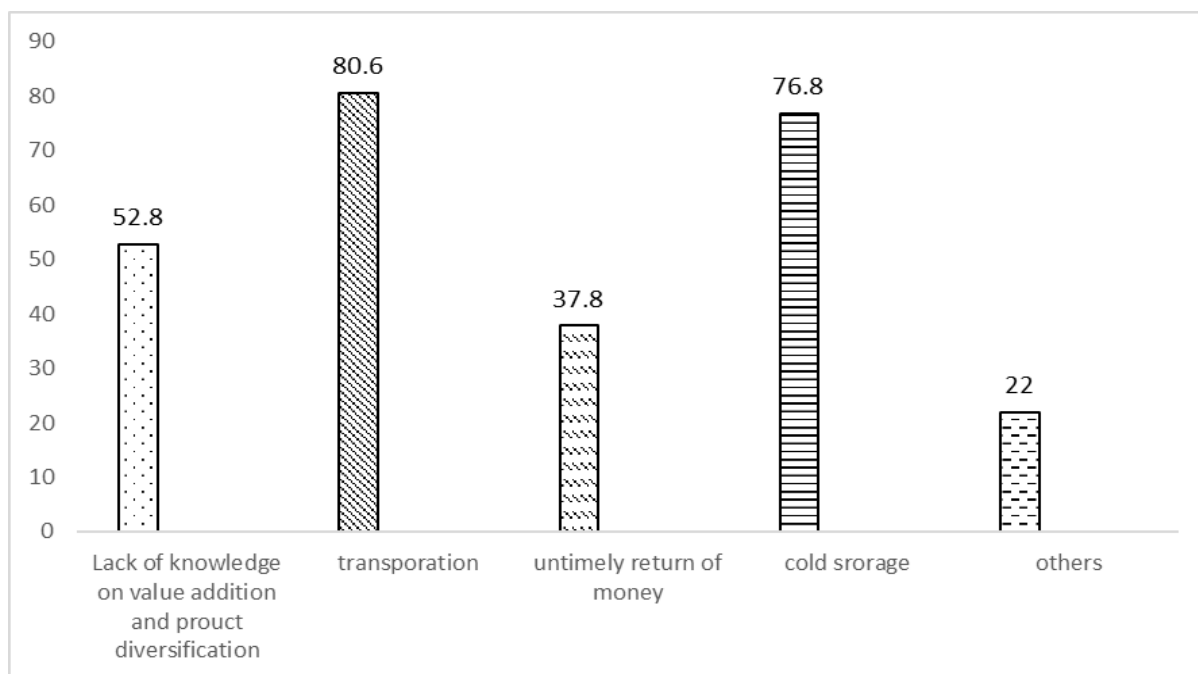| S.N	Name of the problem related to marketing	Total Score Received
1	Transportation	80.6
2	Cold storage	76.8
3	Lack of knowledge on post-harvest processing, value addition and product diversification.	52.8
4	Untimely return of money	37.8
5	Others	22
Total		270

Figure 9. Severity of problems of Kiwi marketing

The average age of Kiwifruit among the respondents was found to be 2.94 Years, while the economic bearing age of the plant is 4 years (Shrestha C.M). So, as the majority of plants are under the economic bearing age, the supply of Kiwifruit in the market is not high. But within few years after the plants reaching economic bearing age, the supply of the Kiwi is going to be too high which will disrupt the present balance of demand and supply. So measures should be taken from right now so that the balance is kept and price fluctuation is minimize

Transportation has got the highest score among all other problems of Kiwi marketing. This can be attributed to the fact that geographical constraints pose a huge burden on transportation. The average time required for the farmer to reach a related municipality is 99 minutes. Also, the average time to reach the nearest market from the farmer's house is 90 minutes. This suggests that the Kiwi growing area is quite far from related markets and municipalities. But the Kiwi field seems close to the road network (25 minutes walking time). 35.5% of respondent's field

was linked to the seasonal road, 34.4 % of respondent's field was linked with gravel road, 17 % field was linked with peach road and 13% of the total field was out of reach from any road networks.

As the roads are seasonal, the transportation of Kiwi via public vehicles is too costly which can't be offered by the farmer. If they carry Kiwi themselves on doko to sell in the market they have to stay in hotels for several days which is costly too. So geographical constrain impose a huge challenge on Kiwi marketing.

Table 5: Access to infrastructure

S.N	Statements	Average time (min)
1	Municipality/rural municipality to field	99
2	Road to field	25
3	House to market	90
4	Market to field	99

Table 6: Status of roads near to the field

S.N	Type of road	No. of farmers	%
1	Seasonal	32	35.5
2	Gravel	31	34.4
3	Peach	15	17
4	Out of access to roads	12	13

The cost of a single cold storage establishment is about 15 lakh (PMAMP Solukhmumbu), which can store products from one municipality, so to cover all the Kiwi growing areas, we need to construct 3 of them, which will cost about 45 lakhs. This is a huge sum of money without proper subsidy from the government and related bodies, which can't be constructed.

As the majority of the farmer hasn't received any training regarding Kiwi, they lack knowledge on value addition of the product. Different measures of product diversification like jam Mada, juice, wine preparation from Kiwi can fetch a higher price than raw fruit itself. With proper training on these things market of Kiwi fruit can be widened and farmers can fetch a higher price.

Being rural area barter system of economy is still prevalent in the area (DDC Solukumbu). So, if farmers sell Kiwi to their local neighbors, they won't get payback in time. So instead of targeting the local market, the farmers should target the national and international market for their product.

CONCLUSION

The major problems of Kiwi cultivation were found to be the establishment of the T bar pillar system followed by lack of knowledge on Kiwi cultivation practices, quality sapling unavailability, marketing of Kiwi, and others, respectively. Within marketing, the major problems were lack of transportation facility followed by the cold storage facility, lack of knowledge on value addition and product diversification, untimely payback of the money, and others respectively. The study suggests that for promoting Kiwi, the cultivation government should bring programs like subsidy on T bar pillar construction, training for farmers on cultivation practices of Kiwi, subsidy for screen house construction for Kiwi nursery

which will address the growing demand of quality sapling, etc. On the marketing side, if a vehicle is given to farmers groups/cooperatives for Kiwi transportation, it will be a great relief to them. The establishment of cold stores and training to farmers on post-harvest processing for value addition and product diversification can spread the market of Kiwi at the national as well as international level.

REFERENCES

Annual Report. Fruits Development Directorate (FDD). 2016, Kirtipur, Kathmandu, Nepal.

Annual Report. Directorate of Soil Management.2016, Hariharbhawan, Lalitpur, Nepal.

Annual Progress Report. Agriculture Service Center. (2076), Solukhumbu, Nepal.

Dhakal, S.An Introduction of Kiwifruit and cultivation Technology. (2018), Charikot: Temperate fruits rootstock development centre.

Dhakal, S. An Introduction of Kiwifruit and cultivation Technology. (2018), Charikot: Temperate fruits rootstock development centre.

FAO. (2019). http:// www.fao.org/nepal/fao-in-nepal-at-a-glance/en/.

J., M. Kiwifruit Production and Marketing in Nepal (1987).

Kiwifruits. w ww.Wikipedia.com.

: MoALD. Statistical information on Nepalese Agriculture. Ministry of Agriculture and Livestock Development. (2017), Kathmandu, Nepal.

Shrestha C.M. A Study of Kiwifruit Cultivation, A Case of Hill District of Nepal. 2013).

Research Article   **Open access**

The Effectiveness of Psycho-Education Training in The Management of Depression Among Menopausal Rural Farmers in Ibadan Less City, Nigeria

Falaye, Ajibola Omolola[1] and Tokede, Abiodun Morenike[2]

[1]Professor of Developmental Psychology
[2]Ph.D Student of Developmental Psychology
Department of Counselling and Human Development Studies, University of Ibadan

ARTICLE INFORMATION

ABSTRACT

Depression is detrimental to the well-being of human beings. Reports have shown that menopausal rural farmers in Ibadan less city exhibited a bothersome level of depression. Previous scholarly works on depression have centered on their prevalence and causes among women, with little attention and interventions, to using Psycho-education Training (PET). This study, therefore, was designed to determine the effectiveness of PET in the management of depressive symptoms among menopausal rural farmers in Ibadan less city. The moderating effects of self-esteem and life events were also examined. The study adopted the pretest-posttest control group quasi-experimental design. The purposive sampling procedure was adopted. Two local government areas (Ido and Ona-ara) in Ibadan, from the existing six, were randomly selected. Two rural areas (Ajobo and Butubutu) were purposely selected based on the prevalence of menopausal depression. The instruments used were a self-developed Life events scale (α = .71), Rosenberg Self-Esteem (α = .71) and Beck Depression (α = .95) inventories. Participants who scored 10-20 on the Fann Patient Health Questionnaire-9 Depression Screening tool were selected. The participants were randomly assigned to PET (17) and control (15) groups. The intervention lasted 10 weeks. Data were analyzed using the Analysis of covariance and Scheffe posthoc test at 0.05 level of significance. The participants' age was 48.3 ± 3.56 years, and 45% were married. There was a significant main effect of treatment in the management of depressive symptoms in menopausal rural farmers. The participants in PET had the lowest mean score

on depressive symptoms (16.88) followed by those in the control (34.267) groups. Self-esteem had a significant main effect on depressive symptoms. Participants with high self-esteem (25.203) benefited more than did their counterparts with low self-esteem (25.812). There was no significant main effect of life events in the management of depressive symptoms. There was a significant interaction effect of treatment and self-esteem on depressive symptoms. Psycho-education training was effective in managing depression among menopausal rural farmers in Ibadan less city. Developmental, counseling, and clinical psychologists should adopt these interventions for managing depression among menopausal rural farmers.

INTRODUCTION

Peri-menopause is a developmental stage in women around the immediate time around menopause, it is often marked by longer cycles, severe and protracted hemorrhage. Menopausal transition or peri-menopause is the period between the onset of irregular menstrual cycles and the last menstrual period. These menstrual irregularities are caused by a decrease in ovarian follicle function and occur within 12 consecutive months of amenorrhea (lack of menstruation). It is a period that is characterized by dwindling hormones that are responsible for reproduction (Steiner, D'Aloisio, DeRoo, Sandler, and Baird, 2010) resulting in abnormalities in menstruation and massive flow cum series of amenorrhea, fertility impairment, hot flashes, and sleeplessness. These indications may occur four (4) years before menstruation ceases with a peri-menopausal average age of 47.5 years (Joseph, Nagaraj, and Saralaya, 2014). In menopause transition, levels of estrogen decrease with invariable increments in intensities of follicle-stimulating hormone (FSH) and luteinizing hormone (LH). With the tendency of risk of increasing from early to late peri-menopause, and reducing towards post-menopause, peri-menopausal is a stage of life that is prone to a greater susceptibility for depression.

Depression is the most rampant cause of debilitating conditions and a major contributor to the disease burden globally. The worldwide prevalence of depression has been increasing in recent years (GBD 2015). Globally, a greater percentage of women suffer from depression than men (WHO, 2018) Depression is a major predictor of quality of life and survival, accounting for approximately 50% of mental illnesses and 12% of being an inpatient in the hospital (Kuo, Tran, Shah, 2015). Farming is the predominant occupation of rural dwellers, both male, and female predisposes the menopausal farmer to depression as a result of the exposure to a number of work conditions that are generally considered unfavorable. Such conditions include long working hours under harsh conditions, no opportunity for leave or vacation, monotonous tasks, and a low standard of living. All these conditions put together with the bothersome physiological symptoms of peri-menopause may make victims more vulnerable to depression.

Depression left without intervention, impairs the victim's mental health which in turn reduces productivity on the farm. It also has an adverse effect on victims' interpersonal relationships causing marital distress- a major negative life event in women that can bring about many more complications like poor parenting, brutality, stigmatization,

alcoholism, drug abuse, loneliness, and other psychological and health issues. A high level of depression puts victims at greater cardiovascular risk and poor reasoning ability to degenerate to further health issues. The height of depression is when the victim begins to suffer from hallucinations, hearing strange voices which can lead to insanity or delusion, and finally suicide. This claims about a million people's lives annually (WHO, 2017).

At the cry of the present regime of the Nigerian government for economic diversification from crude oil to Agriculture, the mental well-being of the peri-menopausal farmer must be managed for better production. Very limited research is available on the mental health of female farmers, but there is some evidence to suggest that female farmers experience more psychological distress than their male colleagues, (Kallioniem Simola, Kymalianen, Vesala and Louhelainen, 2009). Mental illness appears to be particularly stigmatizing in farming communities, and farmers seem reluctant to contact the health care system for help for mental health problems (Kallioniem, Simola, Kinnunen, and Kymäläinen, 2011).

Antidepressants that provide temporary relief which alongside has side effects on users are used to treat this illness. These drugs are not readily available to peri-menopausal rural farmers because of their cost. The unavailability of mental health practitioners cum mental health facilities in the rural environment are also of major disadvantages to the peri-menopausal farmer. Hence the need for alternative therapy. Psychotherapy, which has not been commonly used in treating depression amongst women in Nigeria (Okeize, 2003) remains the only potent and cost-efficient therapy available for managing depression in menopausal rural farmers. Various interventions, such as mind-based cognitive

therapy, problem-solving therapy, self-help therapy, interpersonal therapy, and speech therapy have been used to prevent or manage mental issues, however, this current study used Psycho-education training with life events and self-esteem as moderating variables

The main objective of the study is to evaluate the effectiveness of this intervention on the depression of the respondents and determine the main effect of life events and self-esteem in the management of depression among menopausal rural farmers in Ibadan less city, Nigeria.

METHODOLOGY

A total of 32 peri-menopausal farmers was purposively selected from the female farmers' group in two local government area in Ibadan less city, Nigeria. 17 participants from Ajobo community in Ido local government area and 15 from Butubutu settlement from Ona-ara local government area. The inclusion criteria were: a) participants identified as female rural farmers, age range 40-55 years, peri-menopausal i.e. experiencing irregularity in the pattern of their monthly cycle (menstruation) but the seizure of the monthly cycle, was not up to twelve months (12) months at a stretch, the irregularity or seizure of their monthly cycle was not due to surgery, scored within the range of 10-20 on the Patient Health Questionnaire (PHQ-9) and able to respond to Yoruba or English language and showed readiness to participate in the study. Initial assessment included socio-demographic characteristics (age, marital status, educational level, number of children, administration of the Beck Depression Inventory scale (BDI), The Rosenberg self-esteem scale, and the self-developed life-event scale for menopausal farmers with a reliability index of 0 .71.
All study variables were entered in a study database. All patients evaluated who met the

inclusion criteria were assigned into a group. The 17 participants in Ajobo were assigned into the experimental group and received ten (10) sessions of training on Psycho-education training as outlined. The time allotted to each session was one (1) hour at most, per week. The 15 participants in Butubutu were assigned to the control group, where they did not receive any type of treatment but were exposed to three (3) sessions of thirty minutes each on Importance of Tree Planting.

This study is a pretest-posttest, control group quasi-experimental design. The Beck Depression Inventory was used to ascertain the depressive symptoms of the participants in the pretest and posttest stages. When administered on student and patients' samples, Beck, Steer, and Brown (1988) confirmed that the scale has sufficient internal consistency. As suggested in the manual published by the developers, a normal score is between 1-10; a "Mild Mood Disturbance" score is 11-16; a "Borderline Clinical Depression" is 17-20; a "Moderate Depression" is between 21-30; a score of 31-40 is named "Severe Depression" while "extreme Depression" represents scores above 40. All participants of this study scored above 21 which indicates that they are at least reasonably depressed prior to the beginning of the treatment program.

In measuring the life events of the menopausal rural farmers, the researcher developed the Life Event Questionnaire (LEQ) with 50 items. The researcher pilot tested the questionnaire on twenty (20) menopausal rural female farmers. The researcher finally came up with 27-items yielding a reliability index of 0 .71. On the Life event scale, respondents marked the life events or changes that have occurred during the past years and with the impact of the event on a 5-point scale, ranging from Not applicable, less effect, some effect, moderate effect, and great effect.

To assess the Self-Esteem of the menopausal rural farmers, the self-esteem scale constructed by Rosenberg (1965) was adapted. The scale was pilot tested amongst twenty menopausal rural farmers, among the various others who attended the Agro-farming system workshop in the Forestry Research Institute of Nigeria (FRIN), Jericho, Ibadan. The reliability index is 0.71.

PROCEDURE FOR DATA COLLECTION

The researcher obtained an introduction letter from the department to the local authority to gain approval. Upon receiving ethical approvals from the local heads, the researcher trained research assistants (a number of Masters' degree students of Guidance and Counselling Department, University of Ibadan). The research assistants were briefed about the questionnaire filling procedures that were involved. The screening instrument was administered to the participants with the help of the research assistants, who guided the menopausal rural farmers in filling the screening instrument. Respondents were guided in filling questionnaires before and after the treatment package for depression. Information was given to participants in the language they best understood, which is Yoruba.

Thereafter there was session training respectively with the participants. The study was carried out in four phases: Pre-sessional and orientation stage, Pretest stage, Treatment stage, and Posttest stage. The pre-sessional activities include the screening, recruitment, and assignment of participants to the experimental group and a control group. Also, the researcher intimated the participants with the study. The pretest stage is the stage when the researcher administered the instruments which are the depression scale, self-esteem scale, and life events scale before the treatment. The treatment stage is the stage when the

participants (only those in the experimental group) were exposed to the ten (10) therapeutic sessions (psycho-education training).

The posttest stage is the stage when the participants were exposed to the same instrument that was given at the pretest stage after the successful completion of the therapeutic sessions. Adequate arrangements were made in organizing a suitable venue for the training sessions of the menopausal rural farmers. The researcher made provisions for incentives and remunerations throughout the sessions to motivate the participants and for their consistency and cooperation.

SUMMARY OF TREATMENT PACKAGES

Experimental Group 1: Psycho-Educational Training: The goal of Psycho-Educational Training is to improve knowledge and coping skills in clients, enabling the clients to work more effectively to address the challenges of living with depressive symptoms in the developmental human life-span stage.

Session One: General orientation and administration of instrument to obtain pretest scores

Session Two: Elucidating on the concept, menopause – symptoms, and causes

Session Three: Briefing on the symptoms and causes of depression in menopause

Session Four: Discussion on problem-solving skills training and communication skills training

Session Five: Explanation on self-assertive skills training.

Session Six: Experimentation of the above-listed training in the fourth and fifth sessions.

Session Seven: Discussion on diet and nutrition

Session Eight: Explaining and taking practical classes on physical exercises and relaxation therapy

Session Nine: Roleplay

Session Ten: Revision of all activities in the previous session and administration of instrument for post-treatment measures

Control Group

Session 1: Topic: Administration of Pretest Instrument

Session 2: Topic: Giving a talk on the importance of Tree Planting.

Session 3: Topic: Administration of posttest instrument on the 8th week.

Data were analyzed using Analysis of Covariance (ANCOVA) because of the involvement of Pretest and Posttest. ANCOVA was also used to determine the main effect and interaction effect of the independent and moderating variables on the dependent variable (depression of menopausal rural farmers). Also, descriptive statistics like simple percentage was used to analyze the information that was collected on bio-data.

RESULTS AND DISCUSSION

The result in Table 1 presents the outcomes of research findings on the socio-demographic variables of menopausal rural farmers in the study area. The result shows that 17 of the participants constituting 53.1% representing the treatment group (Psycho-education therapy) are from Ido Local Government Area, while the remaining 15 participants 46.9% representing control groups are from Ona-Ara Local Government Area. Though participants from the Local Government Areas are not the same number, the disparity is minimal. The study shows that

46.9% of the respondents are between the ages of 46-48 followed by 25% between the ages 40-42. Ages 43-45 and 49-50 have the least with 15.6% and 12.5% respectively. The implication of this study is that ages 46 and 48 years constituted the highest percentage of peri-menopause among female farmers in the area.

Table 1: Frequency of socio-demographic of respondents, study on the effectiveness of Psycho-education training in the Management of Depression among Menopausal Rural Farmers in Ibadan, Nigeria

Local Government (N=32)	N (%)	Educational Qualification (N=32)	N (%)
Ido LGA	17 (53.1)	No Formal Education	14 (43.8)
Ona-Ara LGA	15 (46.9)	Primary	10 (31.2)
Age range (N=32)		Secondary	6 (18.7)
40-42	8 (25)	NCE	2 (6.3)
43-45	5 (15.6)	**Marriage Type (N=32)**	
46-48	15 (46.9)	No Marriage	5 (15.6)
49-50	4 (12.5)	Monogamy	9 (28.1)
Marital Status (N=32)		Polygamy	18 (56.3)
Single	3 (9.4)	**No of Children (N=32)**	
Married	17 (53)	1-3	11 (34.4)
Separated	7 (22)	4-6	19 (59.3)
Widow	5 (15.6)	7+	2 (6.3)

Source: Field Study, 2020

The result also showed that 53% of the respondents are married, 22% are separated, 15.6% are widowed and 9.4% are single. The largest percentage are married, this is not surprising because the peri-menopausal age is advanced age, in which a woman must have entered into marriage at one point in time. This is followed by those who are separated from their spouses; this is an indication that a failed marriage or an absentee spouse can be an indicator of depression in women. This is in line with the findings of Williams (2003) that individuals with failed marriages experience an increase in depression. In terms of educational qualification, 43.8% of respondents had no formal education, 31.2% had primary education, 18.7% had secondary education, and the remaining 6.3% respondents are NCE holders. By implication, the majority are non-literates, this shows that farming is a job that can be practiced easily without formal education.

The result of the socio-demographic variables of the respondents further revealed that the majority of the respondents 56.3% are into polygamy, while. 28.1% are into monogamous marriage. In addition, 15.6% do not have any form of marriage. Therefore, respondents that are into polygamy constituted most of the sample used in the study. As stated above the implication of this study is that the rural farmers' husbands married more than one wife. This may be a life event leading to depression or vice versa. Polygamy itself may have an impact on self-esteem, which has an inverse relationship with depression. In like manner, not having entered into any form of matrimony at the age of 40 can be really bothersome to a rural menopausal farmer leading to depression. This is in line with Whisman (2001) in a cross-sectional study that marital dissatisfaction is

associated with depression. The table showed that 59.3% of the respondents have four to six (4-6) children, while 34.4% have one to three (1-3) children. The least, 6.3% percentage have seven and above children.

Table 2: Analysis of Covariance (ANCOVA) of Pretest-Posttest Interaction Effects of Management of Menopausal Depression among Participants in the Treatment Groups, Life Event and Self-esteem

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2780.046[a]	11	252.731	298.692	.000	.994
Intercept	3.414	1	3.414	4.035	.058	.168
PREDEPRESSION	111.877	1	111.877	132.223	.000	.869
TRTGRP	1229.798	1	1229.798	1453.443	.000	.986
SELTEEM	1.783	2	.891	1.054	.367	.095
LEVENT	.872	1	.872	1.030	.322	.049
TRTGRP * SELTEEM	1.096	2	.548	.647	.534	.061
TRTGRP * LEVENT	.296	1	.296	.350	.561	.017
SELTEEM * LEVENT	3.433	2	1.717	2.029	.158	.169
TRTGRP * SELTEEM * LEVENT	1.222	1	1.222	1.445	.243	.067
Error	16.923	20	.846			
Total	22847.000	32				
Corrected Total	2796.969	31				
a. R Squared = .994 (Adjusted R Squared = .991)						

Psycho-education Therapy
Hypothesis One: There is no significant main effect of treatment (Psycho-education Therapy) in the management of depression among menopausal rural farmers in the Ido local government area. To test this hypothesis, Analysis of Covariance (ANCOVA) was adopted to analyze the post-test scores of the participants on their level of depression using the pretest scores as a covariate to ascertain if the post-experimental differences are statistically significant. The summary of the analysis is presented in table 3.

Table 2 showed that there was a significant main effect of treatment in the management of depression among menopausal rural farmers in Ido local government area (F (1, 18) = 1453.443, p < .05, η^2= .986). This implies that there was a significant impact of the treatment (Psychoeducation therapy) in the groups' posttest scores in the management of depression among menopausal rural farmers in the Ido local government area. Therefore, the null hypothesis which stated that there is no significant main effect of treatment in the management of depression among menopausal rural farmers in the Ido local

government area was rejected; table 3 also shows the contributing effect size of 98.6%.

The result of hypothesis 1 confirms that there is a significant main effect of treatment in the depression management of participants. This means that there is a significant difference in the mean scores of depressions among participants that were exposed to Psycho-education Training (PET) when compared to the Control Group. Hence hypothesis one was rejected. It was therefore concluded that there is a significant main effect of treatments in the depression of the participants. This implies that PET is effective in the management of depression of participants.

The result of the hypothesis also gave credence to the research of Mahan, Swan, and Macfie (2018) that administered Psycho-education Training (PET) on an anxious and depressed 22years old woman for 18 sessions. After a 1month follow-up, the evaluation revealed a sustained reduction in anxiety and depression after baseline readings. The implication is that Psycho-education Training (PET) when used alone or in combination with other interventions will reduce depression and other mental health issues in individuals, as it takes care of issues revolving interpersonal life of the depressed individual.

Hypothesis Two: There is no significant main effect of life events in the management of depression among menopausal rural farmers in the Ido local government area.

Table 3 further indicated that there was no significant main effect of life events in the management of depression among menopausal rural farmers in Ido local government area (F (1, 20) = 1.030, p > .05, η^2= .049). Hence, the null hypothesis was not rejected. This denotes that there was no significant main effect of life events in the management of depression among menopausal rural farmers in the Ido Local Government area.

The study gives support to a study conducted by Horacek, Rozehnalova, Rosslerova, and Ales (2010) on the influence of stressful life events on the development of depression and treatment response in the population of higher age. N=3184, the patients recorded less stressful life events associated with depressive symptoms. However, the findings of this study is contrary to the outcome of Zhou and Chen (2017) which examined the relationship of life events on depression in 301 students for 12-weeks. Adverse life events were found to enhance the development of depressive symptoms, in depression therapy.

Hypothesis Three: There is no significant main effect of self-esteem in the management of depression among menopausal rural farmers in the Ido local government area.

Table1 demonstrated that there was no significant main effect of self-esteem in the management of depression among menopausal rural farmers in Ido local government area (F (2, 20) = 1.054, p > .05, η^2= .095). Therefore, the null hypothesis was rejected. The mean score of low self-esteem participants (estimated mean = 25.812), moderate self-esteem participants (estimated mean = 28.722) and high self-esteem participants (estimated mean = 25.203). This implies that participants with high self-esteem benefited most in the psychoeducation therapy compared to other groups, this was followed by participants with low self-esteem and finally followed by participants with moderate self-esteem.

The result of the findings of Martisen, Rasmussen, and Neumer (2021) also buttressed the result of this hypothesis. In the study individuals, with self-reported anxiety and depression were put in treatment and control groups, for 10 weeks using a cluster-randomized design. Individuals who were in the experimental group experienced improved self-esteem and quality of life, then reported lower

depression. The implication is that treatment enhances self-esteem thereby reducing depression. The study result is also in tandem with the study of Hilbert, Goerigk, Padberg, Nadjiri, Ubleis, Jobst, Dewald-Kaufmann, Falkai, Buhner, Naumann, and Sarubin (2019) that treated depression, to improve self-esteem in psychiatric patients. After 5 weeks of therapy, there was a reduction in depressive symptoms, especially in patients with more improved self-esteem. The result of this recent hypothesis is consistent with the stated past findings, reinforcing the fact that boosting self-esteem will bring about a reduction in the depression of victims. Hence attention must be given to enhancing positive self-esteem.

CONCLUSION

The study investigated the effectiveness of PET in reducing depression in menopausal rural farmers in Ibadan less city, Nigeria. Life events and self-esteem were employed as moderating variables. In line with this, the participants were taken through the training programs, relevant data were collected and analyzed using appropriate statistical tools to bring out the results. The findings showed that PET was effective in reducing depression in menopausal rural farmers. As implied from the study. It was also established that depression in menopausal rural farmers does not differ along the line of the participants' life events.

Based on the findings of this study, it was concluded that the ultimate goal of reducing depression in female rural farmers at this menopausal transition stage may become impossible if no timely psychological intervention is made available to them. The interventions used in the study have shown efficiency and relevance in the reduction of depression in menopausal rural farmers in Ibadan less city, Nigeria. This, therefore, calls for the establishment of preventive and curative measures of counseling and

psychological services in the city of Ibadan, Nigeria.

RECOMMENDATIONS

It is recommended that
* Since Psycho-education training (PET) was found to be effective in reducing depressive symptoms of menopausal rural farmers, a concerted effort should be put in place by counseling, developmental psychologists, and other related professionals to adopt the therapy when handling issues related to depression.
* Standard mental and counseling centers should be established in the rural areas, which will employ the service of professional psychiatrists, counseling, clinical and developmental psychologists.

REFERENCES

GBD. Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the global burden of disease study 2015. Lancet 2016;388:1545602. doi:10.1016/S01406736(16)316786 CrossRefPubMedGoogleScholar

Hilbert, S., Goerigk, S., Padberg, F., Nadjiri, A., Ubleis, A., Jobst, A., Dewald-Kaufmann, J., Horacek, Rozehnalova, Rosslerova and Ales. The influence of stressful life events on development of depression and treatment; Response in the population of patients in higher age. The analysis of the post-marketing observational study of antidepressant escitalopram. *Psychiatry*, 2010, 106 (5) 311-317.

Joseph, N.; Nagaraj, K.; Saralaya, V.; Nelliyanil, M. and Jagadish, R. P.

Assessment of menopausal symptoms among women attending various outreach clinics in South Canara District of India. *J. Midlife Health.* 2014, 5: 84-90.

Kallioniemi, M. K, Simola, A. J. K, Kymalainen, H. R, Vesala, H. T, and Louhelainen, J. K. Mental symptoms among Finnish farmentrepreneurs. *Ann Agric Environ Med*, 2009; 16:159–168.

Kallioniemi, M. K, Simola, A., Kinnunen B. and Kymäläinen, H. R. Stress in farm entrepreneurs. In: Langan-Fox J, Cooper CL, eds. Handbook of Stress in theOccupations. Cheltenham, UK: *Edward Elgar*, 2011:381–402.

Kuo, D. C., Tran, M.; Shah, A. A. 2015. Depression and the suicidal patient. *Emerg Med Clin North Am*, 2015;33:765-78.doi:10.1016/j.emc.2015.07.005G oogle Scholar

Mahan, R. M.; Swan, S. A. and Macfie, J. Interpersonal Psychotherapy and Mindfulness for treatment of major depression with anxiety distress. *Clinical Case Study*, 2018, 17(2): 104-119 sagepub.com/home/ccs

Martisen, K. D.; Rasmussen, L. M. P. Neumer, S. Change in quality of life and self-esteem in a randomized controlled CBT study for anxious and sad children: can targeting depressive symptoms improve functional domains in schoolchildren?. *BMC Psychology*, 2021. 9 (8) https://doi.org/10.1186/s40359-021-00511-y

Steiner, A. Z.; D'Aloisio, A. A.; DeRoo, L. A.; Sandler, D. P.; Baird, D. D. Association of intrauterine and early-life exposures with age at menopause in the Sister Study. *Am. J. Epidemiol*, 2010, 172(2):140–148.

Whisman, M. A. 2001. The association between depression and marital dissatisfaction. *In*: Beach SRH, editor. Marital and family processes in depression. A scientific foundation for clinical practice. Washington, DC: America psychological association, 2001, pg 3-24 (Google Scholar)

Williams, K. Has the future of marriage arrived? A Contemporary examination of gender, marriage and psychological well-being. *Journal of health and social behavior*. 2003, 44: 470-487.

World Health Organization. Depression (Fact sheet), 2018, Retrieved 2018, August 3rd, omhttp://www.who.int./news-room/fact-sheet/detail/depression

Zhou, L.; Chen, J. Life event and hopelessness depression: The influence of affective experience. *PLUS ONE*, 2017, 12(11): e0187898. doi:10.1371/journal.pone.0187898

Research Article　　　　　　　　　　　　**Open access**

Use of Different Bio Rational Compounds for Storage- product Pests Control

Sovit Parajuli[1]*, Aavash Adhikari[1], Devesish Bhandari[1], Sandip Paudel[1], Purushottam Dhungana[1], Dipesh Oli[1]

[1]*Faculty of Agriculture, Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal*

ARTICLE INFORMATION

ABSTRACT

Development of insecticidal and fungicidal resistance, damage to non-target organisms, and treating acute and chronic effects to humans and the environment have created a need to embrace bio rational measures over chemical control against storage-product pests. Several species and strains of pests affect storage grains resulting in qualitative and quantitative loss. The losses of such pests have been found to be about 9%in developed countries and up to 20% in developing countries. The study assessed the bio rational measures such as the use of microbial, pheromones and food attractants, natural enemies, botanicals, and biological control that can be adopted alternately over chemical pesticides to suppress and control such storage-product pests. Rice weevil (Sitophilus oryzae), Khapra beetle (*Trogoderma granarium*), Angoumois grain moth (*Rhyzopertha dominica*), Pulse beetle (*Callosobruchus chinensis*), Red flour beetle (*Tribolium castaneum*), Potato tuber moth (*Phthorimaea operculella*), Long headed flour beetle (*Latheticus oryzae*) are some storage-product pests. Different pests, including Weevil (*Sitophilus* spp.), Lesser grain borer (Rhyzopertha dominica), Drugstore beetle (*Stegobium paniceum*), Cowpea weevil, (*Callosobruchus* spp.), and Angoumois grain moth (*Sitotroga cerealella*), were effectively controlled using a parasitoid Theocolax elegans. Application of essential oils of Cymbopogon citratus (Stapf) and Cymbopogon nardus (Rendle) for the control of Cowpea bruchid (*Callosobruchus maculatus* (F.) on rice grains (Oryza sativa) showed retardation of their oviposition and F1 emergence compared to a controlled experiment. 100% mortality to *Sarocladium oryzae* and *R. dominica* was observed after the application of Cucurbita

maxima leaf extract against them within 3 days of treatment. The use of such bio rational compounds is inevitable to ensure food security and agricultural sustainability.

INTRODUCTION

The majority of the world population is dependent on agro-based enterprise in a direct and indirect way. A number of pests affect the crops starting from their early vegetative stage to flowering, fruiting, and harvest stage. Even after the harvest, these commodities are time and again affected by a wide range of pest categories, including bacteria, fungus, insects, rodents, and birds. Storage pests are those pests that are responsible for causing damage and thus, decrease the nutritive and economic value of the stored commodities. Approximately one-third of the global food production worth above $100 billion per annum is damaged due to more than 20,000 species of field and storage pests (Shukla & Toke, 2013) and (Yankanchi et al., 2014) highlighted that about 20-30% qualitative and quantitative loss is caused by tropical storage-grain insects and 5-10% by temperate A number of pest control strategies have been practicing with some questions raised each time about their effectiveness and consequences. The interaction of grains with insect pests is more compared to other pest categories. A number of stored products have been controlled using chemical insecticide (Arthur & Rogers, 2003), but due to limitation of scale or due to lack of adequate chemical control, interest in biological control measures is increasing. A number of biological pest control strategies are made available on a commercial scale (Prozell & Scholler, 2003). Stored grains and products are one of the major areas where such bio-control strategies are practiced. Pyralid moths are controlled using parasitoids (Stengard & Hansen 2005). In the same way,

stored product beetles are also controlled using parasitoids alike (Scholler et al., 2006). Storage-product pests have created harm to the stored products by not only damaging the product and making it unfit to consume but also creating a huge economic loss. According to (Hagstrum & Flinn, 1995), such insect pests can have a great impact on stored grains and processed products from an economic perspective. (Campbell, Arthur, & Mullen, 2004) mentioned that these insects do not require a large amount of food as food accumulated on cracks and crevices, inside machinery, and under the floor is sufficient to feed them. It also makes it humans difficult to clean and manage such waste. The use of chemical pesticides can act as a check mechanism but unfortunately cannot be sustainable practice as a number of insect pests may develop resistance to them (Subramanyam & Hagstrum, 1995). The use of pesticides in agriculture has resulted in four-fold problems through trophic levels: health-related problems, environmental problems, yield loss due to non-target pesticide application resulting in pesticide-induced pests' resurgence, and finally, the financial burden to the farmers (Koirala et al., 2009). Due to the effects of pesticide use, farmers experience the symptoms of headache, eye burning sensation, skin irritation, teary eyes, weakness, and other infirmities and discomfort (Atreya, 2012). Further, effects of exposure to pesticides result in acute illnesses such as headache, skin irritation, respiratory and throat discomfort (Yassin, 2002). Long-term exposure to pesticides causes serious health issues such as chronic cancer, endocrine disruption, and neurological effects (EPA, 1999). Similarly, low-dose long-term

exposure to pesticides is linked to health-related issues like immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer (Gupta, 2004).

Storage-grain pests create economic loss as well as decrease the nutritional value of the stored products making them unfit to consume (Padin et al., 2002). The losses of such pests have been found to be about 9% in developed countries and up to 20% in developing countries (Philips & Throne, 2010). Developed countries have a number of infrastructures, a scientific environment for evaluation, and systematic policies enough to handle the havoc of such pests which developing countries lack. Biological pesticides can be alternative to chemical pesticides in a number of ways. The use of biological control measures may be more effective for pests of stored products as they may hide inside the storage room under sacs, types of machinery, holes, and other places difficult to access, and chemical control is difficult to carry out. The focus has been given to controlling stored bulk grains using a number of biological control measures. The potential of parasitic wasps like Theocolax elegans and *Anisopteromalus calandrae* to suppress and control a number of pest populations in bulk-grain storage in an effective way can be an example (Scholler & Flinn, 2000). Apart from that, *Beauveria bassiana*, Sorokin, *Nosema* spp., *Vuillemin*, *Mattesia* spp. and *Metarhizium anisopliae* have also been investigated and experimented with. But a limited field testing of such organisms has been carried out (Brower et al., 1995). Similarly, in the United States, the bacterium Bacillus thuringiensis (Bt) has been used as a grain-protectant and in India, it has been used to control Indian meal moth larvae (Brower et al., 1995). Lepidopteran pests are also challenging for the stored grain pests and a number of biocontrol agents have been practiced on them. Lepidopteran larvae that have been

attacking stored grains are controlled effectively using the bacterium Bacillus thuringiensis, however, resistance has also been revealed (McGaughey & Beeman, 1988). Moth on stored products like nuts and fruits, particularly dry fruits, has been controlled using a Granulosis virus available on a commercial scale in the market (Vail, 1991).

A number of strategies apart from the biocontrol measures against storage-grain pests have been carried out, some of which include physical control (inert dust, ionizing radiation, light, and sound), thermal control (low-temperature control, high-temperature disinfection), ozonization, and fumigation. (Fields & Muir, 1996) mentioned that inert dust has been found effective in controlling a number of storage insects in North America and Africa. Diatomaceous Earth (DE), the fossilized remains of the diatoms, was made a chemical modification and Calcium Diatomaceous Earth showed the highest repellent, insecticidal and ovicidal effect against *Callosobruchus maculates* (Abd-El-Aziz & Sherief, 2010). (Valizadegan et al., 2009) reported that the use of ionizing radiation can be an effective and environment-friendly technique to manage storage-grain pests. Similarly, low temperature diminishes feeding behavior and fecundity and lowers the survival of storage pests (Logstaf & Evans, 1983). (Rajendran & Sriranjini, 2008) mentioned that phosphine and methyl bromide are two common fumigants used for storage pest control. Due to the less knowledge and concern about storage grain pests and their extent of damage, poor countries are still lagging behind. Synthetic insecticides and fumigants are major chemical control measures with greater effectiveness against stored-grain insects (Zettler & Arthur, 2000); (Benhalima et al., 2004). The use of such chemical pesticides, however, causes damage to consumers' health and environment and increases insecticidal

resistance. The use of biological methods creates minimum to no chance of environmental hazards (Edde, 2012).

MATERIALS AND METHODS

A number of literature reviews regarding the harms and resistance mechanisms of insect pests due to chemicals and several ecological control measures were also studied. Journal articles, review articles, conference papers, the internet, e-newspapers, book, and book sections were the source of secondary information.

RESULTS AND DISCUSSION

Storage Pests

The cumulative effect of all the storage pests is responsible for causing damage to the stored grains and other products. Insects are the major threats to the stored products, particularly grains. In fact, they interact and associate with the crops at the early stage, causing damage during the crop stand and during the storage alike. There are hundreds of species of insects causing the infestation of stored products. Rice weevil, maize weevil, Indian meal moth, Rice moth, Khapra beetle, etc., are some major grain insect pests. Alternaria, Fusarium, and *Drechsclora* are some fungi affecting grains during higher moisture states. Aspergillus and Penicillium are important fungi causing damage to the crops in the storehouse and at fields alike. Fungi degrade the quality of grains in many ways. (Multon, 1988) mentioned that such fungi are responsible for degrading the baking quality of wheat grain.

Several species of Rice weevil such as Sitophilus oryzae, S. zeamais and S.granarius have been found to be serious storage grain-pests of various crops such as rice, wheat, sorghum, maize, and barley. Khapra beetle (Trichoderma granarium) is another serious storage grain-pest of cereal crops like sorghum, maize, and barley. Pulse beetle (*Callosobruchus chinensis* and

Callosobruchus maculates) is found to create huge damage on several stored products of pulses, beans, and grains (Ahmad, 1983).

The quality of the stored grains is impacted to a greater extent by rodents, particularly mice and rats. Damage to the storage structures, electrical installations, and water pipes has been reported (Smith, 1995). Mus musculus of the house mouse, Rattus norvegicus or the brown rat and *Rattus rattus* or the black rat affect field and stored-grain in many ways. According to (Lund, 1994), the nature, biology, and habitat of these rats have been extensively studied. Apart from these, other ground or tree squirrels affecting stored grains include *Citellus* spp., *Tamias* spp., *Xerus* spp., *Funiscurus* spp., and *Halosciurus* spp. (Smith, 1995).

Loss Assessment

Loss of the stored grains may be due to several storage pests, including insects, mites, fungus, and rodents. Consumption of grains or produces by insects involves not only direct kernel consumption but also detritus accumulation rendering it unfit for human consumption. They also damage grains for oviposition, making holes in grains. About 5-10% loss due to insects have been estimated which in the case of the tropics reach up to 30%. This has resulted in an annual loss of $200 million in the net value of the storage crops in the USA (Weaver & Petroff, 2004). In developing countries, the Pulse beetle (*Callosobruchus chinensis* L) has caused a huge qualitative and quantitative loss (Abrol, 1999; Alam 1971). The damage caused by pests results in a quantitative loss (decrease in the weight of stored grains), qualitative loss (decrease in size, unappealing shape, and accumulation of pest's wastes), as well as decreased viability of the seed. Psocid pests are annoying and problematic for godowns and storehouses (Kleith & Pike, 1995). They are found to cause visible grain damage and their loss (about 3% in a storage

period of 6 months). *Prostephanus truncates* is a serious pest of corn, particularly unhusked corn in East and West Africa, causing greater damage (GASGA, 1987). One of the less-studied but greater threats to storage products is a mite. The quantitative loss caused by mites has not been documented properly (Kent, 1991). (Fleurat-Lessard, 1988) mentioned that they feed the germ part of the stored grains and release storage fungi and bacteria. Different species of fungi (Aspergilus) such as *Aspergilus halophilicus*, *A. restrictus*, *A. glaucus*, *A. candidus*, *A. ochraceus*, and *A. flavus* kill the germ of the grain and cause discoloration (Sauer et al., 1992). *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae) is a serious pest of cowpea (Boeke et al., 2004), causing its greater damage.

Biorationals For Storage-Product Pests Control

Microbials: Different forms of microbial or microbial pesticides have been used to limit the effect of a number of stored grain pests, particularly insects. Metabolites of an Actinomycete bacterium, *Saccharopolyspora spinosa* have been used to derive common bacterial insecticide Spinosad (an insecticide derived from bacteria *Saccharopolyspora spinosa*). Stored wheat grains suffering huge loss due to insects have been effectively controlled using that bacterial insecticide (Flinn et al., 2004). Spinosad loses its insecticidal property within a week when it is exposed to Ultra Violet rays of the sun, so it is difficult to use in open field conditions. But it has been mentioned that in a stored environment not exposed to sunlight; it can retain its insecticidal activity up to 12 months, making it effective to control lesser grain borer (*Rhyzopertha dominica* F.) and the Red flour beetle (*T. castaneum* Herbst) (Fang *et al.*, 2002). Complete control and progeny suppression of the F1 at grain beetle (*Cryptolestes pusillus* Schonherr), the confused flour beetle (*T. confusum*), and the

rusty grain beetle (*Cryptolestes ferrugineus* Stephens) have been observed by the use of 1mg of Spinosad per kg of wheat under stored condition.

Pheromones: Any chemical that is secreted or excreted by an individual organism and that triggers a response in members of the same species are termed as pheromones. As biorational compounds, pheromones can act as important controlling agents for a number of storage grain pests, particularly insects. They act as hormones outside the body of the organism that secrete it and create an effect on the organism receiving it. (Phillips *et al*., 2000) suggested that slow-release formulations of pheromone lures in the monitoring traps are available for about 20 different species of stored-product insects. Interpunctella, the cigarette beetle (*Lasioderma serricorne* F.; Coleoptera: Anobiidae), the Red and Confused flour beetles (*T. castaneum* and *Tribolium confusum* Jacquelin du Val, respectively), and the Warehouse beetle (*Trogoderma variabile* Ballion; Coleoptera: Dermestidae) are some major insects for which pheromones are used. Placement of the pheromones is a crucial aspect in order to make them effectively work. Responding beetles passed through a corrugation tunnel to the cup of oil and were killed due to suffocation in an experiment conducted (Barak & Burkholder, 1985). *P. interpunctella* males were attracted to pheromone-baited traps on flat landing sites, as mentioned by (Nansen et al., 2004).

Natural Enemies for Stored-product pest Application or release of any particular natural enemy depends upon the history and background information of the pest. Important considerations such as knowledge about lifecycle, behavior, mode of feeding, and so on are crucial before releasing any natural enemy for its control. Some natural enemies or predators kill their prey immediately after the attack, while some need to have a close bio systemic connection

to killing the prey. The former comes under generalists and the latter under specialists. The Pirate warehouse bug (*Xylocoris flavipes*) preys on eggs and larva of insects feeding on the stored products (Arbogast, 1975) and comes under the generalist. Another example of such is the Histerid beetle (*Teretriosoma nigrescens*) which feed on beetles (Rees, 1985) According to (Poschko, 1993), such beetle feed on several families of the harmful beetle and thus, protecting stored grains and products from insect damage. (Wajnberg & Hassan, 1994) stated that egg parasitoids of *Trichogramma* Westwood are one of the potential generalist parasitoids used widely in the study of its potential on field crops. Different pests, including Weevil (*Sitophilus* spp.), Lesser grain borer (*Rhyzopertha dominica*), Drugstore beetle (*Stegobium paniceum*), Cowpea weevil, (*Callosobruchus* spp.), and Angoumois grain moth (*Sitotroga cerealella*), have been effectively controlled using a parasitoid *Theocolax elegans.* (Flinn, 1998) (Flinn & Hagstrum, 2001). Storage situation is one of the factors determining which type of natural enemy is to be used and how it needs to be handled and implemented. The association of generalists and specialists' predators for the control of different insect pests is preferred as the pest complex for several species is encountered while considering the storage pest control (Press et al., 1982).

Botanicals

Plant-derived chemical compounds used for repellent, a deterrent for feeding and oviposition, disruption of the biochemistry, physiology, and behavior of insect pests are called botanicals. A number of spices crops like chili, garlic, turmeric, ginger, etc., and botanicals such as neem, bakaino, century plant, and, chinaberry, lac tree, etc., have been used effectively for insect pest control. (Shukla et al., 2007), (Srinivasan, 2008) mentioned that a number of plant products had been successfully tested with a good degree of result to act as a protectant against a number of stored-grain insect pests. Pigeon pea for 8 months against damage of pulse beetle experimented on neem seed oil@1% (volume/weight), mahua oil @1%(volume/weight), and oil of neem seed @4%(weight/weight) where they were proved to be repulsive and potent oviposition inhibitor. (Singal & Chouhan, 1997). Essential oils were also found to have a satisfying alternative against chemical insecticides for the control of coleopteran insect pests on stored grains. (Pérez et al., 2010). (Kirubal et al.,2008) mentioned that *C. chinensis* (L.) oviposition and F1 emergence were prevented on the red gram treated with 0.2%(v/w) ginger grass oil. Similarly, application of essential oils of *Cymbopogon citratus* (Stapf) and *Cymbopogon nardus* (Rendle) for the control of Cowpea bruchid (*Callosobruchus maculatus* (F.) on rice grains (*Oryza sativa*) showed retardation of their oviposition and F1 emergence compared to a controlled experiment. (Paranagama et al., 2003). 100% mortality to Sarocladium oryzae and *R. dominica* was observed after the application of Cucurbita maxima leaf extract against *Sarocladium oryzae* and *R. dominica* within 3 days of treatment (Rajasekharreddy and Usha Rani, 2010).

(Ho, 1995) mentioned that garlic (*Allium sativum*) has shown the repellent property to *Tribolium castaneum* and its oil was effective for killing *T. castaneum* and *Sitophilus zeamais*. Besides, it was also found to be effective to repel *T. castaneum* and *S. zeamais*. Turmeric (*Curcuma longa*) was found effective for repelling a number of stored insects. A number of storage pests are killed when 2% turmeric powder is mixed with rice and wheat (Jilani & Su, 1983). Almost every part of Neem (*Azadirachta indica*) is pesticide and its seed kernel is more effective. *Trogoderma granarium* is best controlled using neem products and pulse weevil is also controlled using 0.5% neem oil where it acts as a surface protectant (Ketkar,

1987) Oil of lac tree (*Schleichera trijuga*) is used as a surface protectant against pulses weevil where its extract is used as a repellant and insecticidal against adult of *S. zeamais* and eggs of *T. castaneum* (Ketkar, 1987). Teotia & Tewari (1971) suggested that leaf and drupe powders (1 and 4%) of chinaberry (*Melia azedarach*) protect wheat against *S. cerealella*. Black pepper (Piper nigrum) is found to inhibit the development of F1 of *Callosobruchus chinensis* (Morallo-Rejesus et al., 1990). Also, the Clove tree (*Syzygium aromaticum*) has been found to repel a number of stored grain pests including *T. castaneum* (Grainge & Ahmed, 1998). Several botanicals have been found to be effective against stored product pests such as Century plant (*Agave americana*) (Grainge & Ahmed, 1988); Undi (*Calophyllum inophyllum*) against pulse weevils (Ketkar, 1987); and Indian privet (*Vitex negundo*) against stored grain-pests (Ahmed & Koppel, 1987).

Biological Control: A number of entomopathogenic fungi, nematodes, bacteria, predators, parasitoids, and wasps are used as biological control of several storage-product pests. (Weaver & Petroff, 2004) suggested that the commercial availability of biological control agents is limited except when scaled up for organic production. Entomopathogenic fungi (EPF), among different biological control measures, are effectively used as promising commercial products against a variety of insects under open field conditions such as termites (Rath, 2000). Unfortunately, not much progress has been made regarding their commercial availability under storage conditions. (Kaur et al., 2014) mentioned that conidia of the entomopathogenic fungus have been used in the dry or mixed form (with rice grain) against stored-grain insects. An experiment conducted by (Sedehi et al., 2014) for different isolates caused moderate to high mortality at their different stages (immature stage and adult stage). The conidia of a *Beauveria bassiana* were suspended in a mixture of corn oil and mineral oil and applied against *Sitophilus zeamais* where oil suspension formulation among different formulations showed a higher effect. (Batta et al., 2010) suggested that, *Sitophilus granarius*, *Rhyzopertha dominica*, *Sitophilus oryzae,* and *Tenebrio molitor* were effectively controlled using liquid formulations of entomopathogenic fungus.

Entomopathogenic nematodes are endoparasites (lethal) of insects (Gaugler, 2002). Their trial has been successful in controlling insect pests of soil under field conditions (Kaya & Gaugler, 1993)). Though they have not studied in detail a greater range for storage pest control, they exhibit some characteristics that make them perfect biocontrol choices. They have low toxicity to vertebrates (Bathon, 1996) and some species are commercially available (Grewal, 2002). Other important characteristics of such nematodes include tolerance to a number of pesticides (Koppenhofer, et al., 2000), wide host range (Capinera & Epsky, 1992) and active host finding ability (Campbell & Lewis, 2002). They have been taken as effective biocontrol agents for a number of storage-grains insects. They are used to control storage insects belonging to Pyralidae (Shannag & Capinera, 2000) and Curculionidae (Shapiro & McCoy, 2000). (Morris, 1985) demonstrated the effectiveness of nematodes for controlling storage product insects like *Tenebrio molitor* L and *Ephestia kuehniella* Zeller.

C. cephalonica, along with other different insect pests such as thrips, aphids and mealybugs in cropping systems of Sub-Saharan Africa and the Mediterranean region, has been effectively controlled using Anthocorid bugs (Zhang et al., 2012); (Efe & Cakmak, 2013); (Wang et al., 2014). One of the important biological control agents used against stored-grain pests such as moths, mites and bruchids is a predatory bug, X. flavipes (Rahman et al., 2009). Eggs and larvae of lepidopteran pests, sucking pests

like mealy bugs, aphids, thrips, mites, and stored insect pests have been effectively controlled by using a biocontrol agent *Blaptostethus pallescens* (Kaur et al., 2019). The highest mortality (51.66%) of rice weevil (Sitophilus oryzae L.) was observed by the mixture of mix *B. bassiana* ARSEF 5500+ *M. anisopliae* ARSEF 2974 isolates (Bello et al., 2000).

Monitoring for The Stored-Grain Pests

Monitoring for the stored-grain pests helps to identify and isolate pest populations which prevent qualitative and quantitative loss of stored commodities. It also suggests the practitioner get to know the effectiveness of the particular Integrated Pest Management (IPM) technique for a particular storage-product pest (Campbell et al., 2002). The technique of pest monitoring depends upon the type and nature of the pest, commodity, and type of storage method. Bulk commodity storage, pheromone attractant, food attractant, white painted bins are some monitoring strategies and techniques. Besides, modern monitoring techniques involve near-infrared spectroscopy for parasitoid stored products and electronic nose technology for grain spoilage detection. The effectiveness of pheromone traps can be increased by using food attractants for Flour beetles (*Tribolium* spp.) as well as attraction to Attagenus, Trogoderma, and *Anthrenus larvae* (Burkholder & Ma, 1985). Near-Infrared Spectroscopy (NIRS) has been used for the application of agriculture and food technology (Panford, 1987). It has been used for the detection of infested and un-infested wheat kernels to identify internal insect pests of wheat (Dowell et al., 1988). Similarly, it has been used in wheat to distinguish unparasitized and parasitized weevil larvae by wasps (Burks et al., 2000). (Magan & Evans, 2000) suggested that electronic nose technology has been used in recent years for the rapid detection of grain quality by taking grain properties such as odor and volatility into consideration.

CONCLUSION

The use of chemicals for storage-product pests' control has resulted in a number of complications such as effects to non-target organisms, insecticide and fungicide resistance, acute and chronic health hazards, and so on. Biological pesticides can be alternative to chemical pesticides in a number of ways as they are environment friendly and applicable in the long run. Natural enemies, including predators and parasitoids, can be used for pest control; however, important considerations such as knowledge about lifecycle, behavior, mode of feeding, and so on are crucial before releasing any natural enemy. Botanicals or the plant-derived chemical compounds such as *Allium sativum*, *Curcuma longa, Melai azadirach, Azadirachta indica,* etc., can be used as a repellent deterrent for feeding and oviposition, disruption of the biochemistry, physiology, and behavior of insect pests. As biorational compounds, pheromones can act as an important controlling agent for a number of storage grain pests, particularly insects. Emphasis on the promotion, scaling up and commercialization of the bio rational methods should be given so that it will effectively control the pathogens without developing resistance on one hand and recovering the environment on the other.

ACKNOWLEDGEMENT

CONFLICT OF INTEREST

The authors claim there is no conflict of interest.

REFERENCES

Abd-El-Aziz, S.; Sherief, M. Insecticidal effects of modified diatomaceous earth (DE)with different hydroxides (MOH, M=Na, Ca, Al) against *Callosobruchus maculatus* (F.) beetles (Coleoptera: Bruchidae) on stored cowpea grains. J. Entomol.Res.2010, 34, 1-9.

Ahmad, H. Losses incurred in stored food grains by insect pests – a review. *Pakistan Journal of Agricultural Research*. 1983, 4, 198-207.

Ahmed, S.; Koppel, B. Use of neem and other botanical materials for pest control by farmers in India: summary of findings. In: Schmutterer, H.; Ascher, K. (Eds.), Natural Pesticides from the Neem Tree (*Azadirachta indica* A. Juss) and Other Tropical Plants. 1987, 623-626. Nairobi, Kenya: Deutsche Gesellschaft fur Technische Zusammenarbeit, Eschborn, Germany.

Arbogast, R. Population growth of *Xylocorisf luuipes* (Hemiptera: Anthocoridae): influence of temperature and humidity. *Environmental Entomology*. 1975, 4, 825-831.

Atreya, K. J. Health and Environment costs of pesticide use in vegetable farming in Nepal. *Environment Development and Sustainability*, 2012, 14(4):1-17.

Barak, A.; Burkholder, W. A. versatile and effective trap for detecting and monitoring stored product Coleoptera. *Agriculture, Ecosystems and Environment*, 1985, 12, 207-218.

Bathon, H. Impact of entomopathogenic nematodes on non-target hosts. *Biocontrol Science and Technology*, 1996, 6, 421-434.

Batta, Y.; Murdoch, G.; Mansfield, S. Investigations into the formulation and application of entomopathogenic fungi against larvae of yellow Downloaded by University of Cambridge. at 10:14 19 June 2016 15 mealworm (*Tenebrio molitor* L., Coleoptera: Tenebrionidae).

General and Applied Entomology, 2010, 39, 5-8.

Bello, G. D.; Padin, S.; Lopez Lastra, C.; Fabrizio, M. Laboratory evaluation of chemical-biological control of the rice weevil (*Sitophilus oryzae* L.) in stored grains. *Journal of Stored Products Research*, 2000, 37(2001), 77-84.

Benhalima, H.; Chaudhry, M.; Mills, K.; Price, N. Phosphine resistance in stored-product insects collected from various grain storage facilities in Morocco. *Journal of Stored Products Research*, 2004, 40, 241-249.

Brower, J.; Smith, L.; Vail, P.; Flinn, P. Biological control of *B. Subramanyam*. *In*: D. Hagstrum (Eds.), Integrated Management of Insects in Stored Products. 1995. 223-286 pp., New York: Marcel Dekker.

Burkholder, W.; Ma, M. Pheromones for monitoring and control of stored product insects. *Ann. Rev. Entomol*. 1985, 30, 257-272.

Burks, C.; Dowell, F.; Xie, F. Measuring fig quality using near-infrared spectroscopy. *J. Stored Prod. Res.* 2000, 36, 289-296.

Campbell, J.; Lewis, E. Entomopathogenic nematode host-search strategies. *In*: Lweis, E.; Campbell, J.; Sukhdeo, M. (Eds.). The Behavioural Ecology of Parasites, 2002, 13-38pp. Wallingford, UK: CABI Publishing.

Campbell, J.; Arthur, F.; Mullen, M. Insect management in food processing facilities. Advances in Food and Nutrition Research, 2004, 48, 240-295.

Campbell, J.; Mullen, M.; Dowdy, A. Monitoring Stored-product pests in food processing plants with pheromone trapping, contour mapping and mark-recapture. *J. Econ. Entomol,* 2002, 95, 1089-1101.

Capinera, J.; Epsky, N. Potential for biological control of soil insects in the Caribbean basin using entomopathogenic

nematodes. *Florida Entomologist*, 1992, 75, 525-532.

Dowell, F.; Throne, J.; Baker, J. Automated non-destructive detection of internal insect infestation of wheat kernels using near-infrared reflectance spectroscopy. *J. Ecol. Entomol.*, 1998, 91, 899-904.

Edde, P. A review of the biology and control of *Rhyzopertha dominica* (F.) the lesser grain borer. *Journal of Stored Products Research*, 2012, 48, 1-18.

Efe, D.; Cakmak, I. Life table parameters and predation of Oriusniger (Wolf) (Hemiptera: Anthocoridae) feeding on two different prey. *Turkish Journal of Entomology*, 2013, 37, 161-67.

EPA. Recognition and management of pesticide poisoning. In-Office of Pesticide Programs. Washington DC, USA, 1999, United States Environmental Protection Agency.

Fang, L.; Subramanyam, B.; Dolder, S. Persistence and efficacy of spinosad residues in farm stored wheat. *Journal of Economic Entomology*, 2002, 95, 1102-1109.

Fields, P.; Muir, W. Physical Control. *In*: Subramanyam, B.; Hagstrum, D. (Eds.), Integrated Management of Insects in Stored Products, 1996, 195-221 pp., New York: Marcel Dekker Inc.

Fleurat-Lessard, F. Grain mites, general characteristics and consequences of their presence in stocks. *In*: Multon, J. Preservation and Storage of Grains, Seeds and Their By-Products: Cereals, Oilseeds, Pulses and Animal Feed, 1988), 409-416 pp., New York: ell. Lavoisier.

Flinn, P. Temperature effects on the efficacy of *Choetospila elegans* (Hymenoptera: Pteromalidae) to suppress *Rhyzopertha dominica* (Coleoptera: Bostrichidae) in stored wheat. *Journal of Economic Entomology*, 1998, 91, 320-323.

Flinn, P.; Hagstrum, D. Augmentative releases of parasitoid wasps in stored wheat reduces insect fragments in flour. *Journal of Stored Products Research*, 2001, 37, 179-186.

Flinn, P.; Subramanyam, B.; Arthur, F. Comparison of aeration and Spinosad for suppressing insects in stored wheat. *Journal of Economic Entomology*, 2004, 97, 1465-1473.

GASGA (Group for Assistance on Systems Relating to Grains After Harvest). Larger Grain Borer, 1987, Kent: Technical Leaflet No. I, NRI.

Gaugler, R. Entomopathogenic Nematology. 2002, Wallingford, UK: CABI Publishing.

Grainge, M.; Ahmed, S. Handbook of Plants with Pest-control Properties, 1988, John Wiley and Sons, New York: Resource Systems Institute, East-West Center, Honolulu, Hawaii.

Grewal, P. Formulation and application technology. In: Gaugler, R. (Ed.), Entomopathogenic Nematology, 2002), 265-287pp, UK: CABI Publishing, Wallingford.

Gupta, P. Pesticide exposure- Indian scene. *Toxicology*, 2004, 83-90.

Hagstrum, D.; Flinn, P. Integrated Pest Management. *In*: Subramanyam, B.; Hagstrum, D.; Subramanyam, B.; Hagstrum, D. (Eds.), Integrated Management of Insects in Stored Products, 1995, 399-408pp., New York: Marcel Dekker.

Ho, S. Grain quality maintenance through the use of bioactive compounds from spices, 1995, Perak, Malaysia.

Jilani, G.; Su, H. Laboratory studies on several plant materials as insect repellents for protection of cereal grains. *Journal of the Entomological Society of America*, 1983, 76, 154-157.

Kaur, R.; Sharma, S.; Shera, P.; Sangha, K. Evaluation of anthocorid predator, *Blaptostethus pallescens* Poppius against spider mite, *Tetranychus*

urticae Koch on Okra under insect net cage condition. *Journal of Biological Control*, 2019, 33(3), 236-241. doi: DOI: 10.18311/jbc/2019/16283

Kaur, S.; Thakur, A.; Rajput, M. A laboratory assessment of the 349 potential of *Beauveria bassiana* (Balsamo) Vuillemin as a biocontrol agent of 350 *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae). *Journal of Stored Products Research*, 2014, 59, 185-189.

Kaya, H.; Gaugler, R. Entomopathogenic nematodes. *Annual Review of Entomology*, 1993, 38, 181-206.

Kent, Haines CPo. Insects and Arachnids of Tropical Stored Products: Their Biology and Identification, 1991, Natural Resources Institute.

Ketkar, C. Use of tree-derived non-edible oils as surface protectants for stored legumes against *Callosobruchus maculatus* and *C. chinensis*. Proceedings of the 3rd International Neem Conference, 1987, 535-542pp, Nairobi, Kenya: Deutsche Gesellschaft fur Technische Zusammenarbeit, Eschborn, Germany. Retrieved 10-15 July 1986

Kirubal, S.; Jeeva, S.; Kanagappan, M.; Stalin, S.; Das, S. Ethnic storage strategies adopted by farmers of Tirunelveli district of Tamil Nadu, Southern Peninsular India. *Journal of Agricultural Technology*, 2008, 4, 1-10.

Kleith, U.; Pike, V. Economic assessment of Psocid infestations in rice storage. *Trop Sci*. 1995, 35, 280-289.

Koirala, P.; Dhakal. S.; Tamrakar, A. S. Pesticide Application and Food Safety Issue in Nepal. *The Journal of Agriculture and Environment*, 2009, 111-114.

Koppenhofer, A.; Brown, I.; Gaugler, R.; Grewal, P.; Kaya, H.; Klein, M. Synergism of entomopathogenic nematodes and imidacloprid against

white grubs: greenhouse and field evaluation. *Biological Control*, 2000, 19, 245-251.

Lund, M. Rodents as commensal pests. *In*: Buckle, A.; Smith, R. Rodent Pests and Their Control, 1994, 23-43 pp., Wallingford: CAB International.

Magan, N.; Evans, P. Volatiles as an indicator of fungal activity and differentiation between species and the potential use of electronic nose technology for early detection of grain spoilage. *J. Stored Products Res*. 2000, 36, 319-340.

McGaughey, W.; Beeman, R. Resistance to Bacillus thuringiensis in colonies of Indianmeal moth and almond moth (Lepidoptera: Pyralidae). *Journal of Economic Entomology*, 1988, 81, 28-33.

Morallo-Rejesus, B.; Maini, H.; Ohsawa, K.; Yamamoto, I. Insecticidal actions of several plants to *Callosobruchus Chmensis* L., 1990. 99-100.

Morris, O. Susceptibility of 31 species of agricultural pests to entomogenous nematodes *Steinernema feltiae* and *Heterorhabditis bacteriophora*. *The Canadian Entomologist*, 1985, 122, 309-320.

Multon, J. Spoilage mechanisms of grains and seeds in the post-harvest ecosystem, the resulting losses and strategies for the defense of stocks. In Preservation and Storage of Grains, Seeds and Their By-Products: Cereals, Oilseeds, Pulses and Animal Feed, 1988, 3-63pp., New York: Lavoisier.

Nansen, C.; Philips, T.; Sanders, S. The effect of height and adjacent surfaces on captures of the Indian meal moth, *Plodia interpunctella* (Lepidoptera: Pyralidae), in pheromone-baited traps. *Journal of Economic Entomology*, 2004, 97, 1284-1290.

Padin, S.; Dal Bego, G.; Fabrizio, M. Grain loss caused by *Tribolium castaneum*, *Sitophilus oryzae* and *Acanthoscelides obtectus* in stored durum wheat and

beans treated with *Beauveria bassiana*. *Journal of Stored Products Research*, 2002, 38, 69-74.

Panford, J. Application of Near-infrared Reflectance Spectroscopy in North America. *In*: Williams, P.; Norris, K. (Eds.), Near-Infrared Technology in the Agricultural and Food Industries, 1987, Minnesota: ASCC, St.Paul, 201-211 pp.

Paranagama, P.; Abeysekera, T.; Nugaliyadde, L.; Abeywickrama, K. Effect of the essential oils of *Cymbopogon citratus*, *Cymbopogon nardus* and *Cinnomomum zeylanicum* on pest incidence and grain quality of rough rice (paddy) stored in an enclosed seedbox. *Journal of Food, Agriculture and Environment*, 2003, 1, 139.

Pérez, S.; Ramos-López, M.; Zavala-Sánchez, M.; Cárdenas-Ortega, N. Activity of essential oils as a biorational alternative to control coleopteran insects in stored grains. *Journal of Medicinal Plants Research*, 2010, 4, 2827-2835.

Philips, T.; Throne, J. Biorational approaches to managing stored-product insects. *Annual Review of Entomology*, 2010, 55, 375-397.

Philips, T.; Cogan, P.; Fadamiro, H. Pheromones. *In*: Subramanyam, B.; Hagstrum, D. (Eds.), Alternatives to Pesticides in Stored-product IPM, 2000, Boston: Kluwer Academic, 273-302 pp.

Poschko, M. Biologie und Wirtsspezihtat von *Teretriosoma nigrescens* Lewis (Coleoptera: Histeridae). [Biology and host specificity of *Teretriosoma nigrescens*], Ph.D. thesis, Technische Universitat. 1993, Berlin.

Press, J.; Cline, L.; Flaherty, B. A. comparison of two parasitoids, *Bracon hebetor* (Hymenoptera: Braconidae) and *Venturia canescens* (Hymenoptera: Ichneumonidae), and a predator *Xylocoris Jlavipes* (Hemiptera:

Anthocoridae) in suppressing residual populations of the almond moth. *Journal of The Kansas Entomological Society*, 1982, 55, 725-728.

Rahman, M.; Islam, W.; Ahmed, K. Functional response of the predator *Xylocoris flavipes* to three stored product insect pests. *International Journal of Agriculture and Biology*, 2009, 11, 316-320.

Rajendran, S.; Sriranjini, V. Plant products as fumigants for stored-product insect control. *J. Stored Prod. Res.*, 2008, 44, 126-135.

Rath, A. The Use of Entomopathogenic Fungi for Control of Termites. *Biocontrol Science and Technology*, 2000, 10, 563-581.

Rees, D. Life history of *Teretriosoma nigrescens* Lewis (Co].: Histeridae) and its ability to suppress populations of *Prostephanus truncatus* (Horn) (Co].: Bostrichidae). *Journal of Stored Products Research*, 1985, 21, 115-118.

Scholler, M.; Flinn, P. Parasitoids and Predators. *In*: Subramanyam, B.; Hagstrum, D. (Eds.), Alternatives to Pesticides in Stored-Product IPM, 2000, Massachusetts: Kluwer Academic Publishers, Norwell, 229-271 pp.

Sedehi, A.; Sedaghatfar, E.; Modarres-Najafabadi, S. Studies on the effect of the *Beauveria Bassiana* on eggs and larvae of Plodia interpunctella. *Canadian Journal of Basic and Applied Science*, 2014, 2, 40-45.

Shannag, H.; Capinera, J. Interference of *Steinernema carpocapsae* (Nematoda: Steinernematidae) with *Cardiochiles diaphaniae* (Hymenoptera: Braconidae), a parasitoid of melonworm and pickleworm (Lepidoptera: Pyralidae). *Environmental Entomology*, 2000, 29, 612-617.

Shapiro, D.; McCoy, C. Virulence of entomopathogenic nematodes to

Diaprepes abbreviatus (Coleoptera: Curculionidae) in the laboratory. *Journal of Economic Entomology*, 2000, 93, 1090-1095.

Shukla, A.; Toke, N. Plant products as a potential stored product insect management agent. *Indian Journal of Research*, 2013, 2, 4-6.

Shukla, R.; Srivastava, B.; Kumar, R.; Dubey, N. Potential of some botanical powders in reducing infestation of chickpea by *Callosobruchus chinensis* L. (Coleoptera: Bruchidae). *Journal of Agricultural Technology*, 2007, 3, 11-19.

Singal, S.; Chouhan, R. Effect of some plant products and other materials on the development of pulse beetle, *Callosobruchus chinensis* (L.) on stored pigeon pea, *Cajanus cajan* (L.) Millsp. *Journal of Insect Science*, 1997, 10, 196-197.

Smith, R. Rodents and birds as invaders of stored-grain ecosystems. *In*: Jayas, D.; White, N. and Muir, W. Stored-Grain Ecosystems, 1995, New York: Marcel Dekker, 289-323 pp.

Srinivasan, G. Efficacy of certain plant oils as seed protectant against pulse beetle, *Callosobruchus chinensis* L. on pigeonpea. *Pesticide Research Journal*, 2008, 20, 13-15.

Subramanyam, B.; Hagstrum, D. Resistance measurement, and management. *In*: Subramanyam, B. and Hagstrum, D. (Eds.), Integrated Management of Insects in Stored Products, 1995, New York: Marcel Dekker, 331-397pp.

Teotia, T.; Tewari, G. Dharek drupes and leaves as protectants against *Sitotroga cereclella* Oviver infesting wheat seeds. *Bulletin of Grain Technology*, 1971, 9, 7-12.

Vail, P. Novel virus composition to protect agricultural commodities from insects, 1991, US Patent no. 07/212,641.

Valizadegan, O.; Pourmirza, A.; Safaralizadeh, M. Combination of microwaves radiation and cold storage for control of *Oryzaephilus surinamensis* (L.) (Col. Silvanidae). *J. Biol. Sci.* 2009, 9, 230-236.

Wajnberg, E.; Hassan, S. Biological Control with Egg Parasitoids, 1994, Wallingford, U.K: CAB International.

Wang, S.; Michand, J.; Tan, X.; Zhang, F. Comparative suitability of aphids, thrips, and mites as prey for the flower bug Oriussauteri (Hemiptera: Anthocoridae). *European Journal of Entomology*, 2014, 111, 221-26. doi: https://doi.org/10.14411/eje.2014.031

Weaver, D.; Petroff, A. Pest Management for Grain Storage and Fumigation, 2004, Montana: Montana Department of Agriculture.

Yankanchi, S.; Jadav, A.; Patil, P. Insecticidal and repellent activities of *Clerodendrun serratum* L. leaf extract against rice weevil, *Sitophiluus oryzae* L. *Asian Journal of Biological and Life sciences*, 2014, 3, 35-39.

Yassin, M. S. Knowledge, attitude, practice, and toxicity symptoms associated with pesticide use among farmworkers in the Gaza Strip. *Occup. Environ. Med*., 2002, 387-394.

Zettler, J.; Arthur, F. Chemical control of stored product insects with fumigants and residual treatments. *Crop Protection*, 2000, 577-582.

Zhang, S.; Zhu, F.; Zheng, X.; Lei, C.; Zhou, X. Survival and developmental characteristics of predatory bug, Oriussimilis (Hemiptera: Anthocoridae) fed on *Teteranychus cinnabarinus* (Acari: Tetranychidae) at three constant temperatures. *European Journal of Entomology*, 2012, 109, 503-508. doi:https://doi.org/10.14411/eje.2012.063

Journal of Agriculture & Forestry Research (JAFR)

Journal of Agriculture & Forestry Research (JAFR) is an open access multidisciplinary journal that publishes original research articles, review articles and short-communication on all areas of Agriculture & Forestry. Submission of manuscript to this journal implies that the work is original. The work has not been published elsewhere and that is not consideration for publication to any other scientific journals. The researchers are invited to submit original research papers in English.

Scope of the journal

Agriculture: Crop Science, Land use, Rural development and biodiversity, Ecology and Environment, Irrigation and water management, Soil Science, Remote sensing, GIS, Horticulture, Medicinal Plants, Plant Biotechnology and Plant Breeding, Seed technology, Plant Protection, etc.

Forestry: Silviculture, Silvicultural genetics, Forest Botany, Forest Economics, Forest Inventory, Forest Protection, Mangrove Silviculture, Plantation, Minor Forest Products, Seed Science, Soil Science, Forest Chemistry, Pulp and Paper, Wood Seasoning & Timber Physics, Veneer & Composite Wood Products, Wood Preservation, Wood Working & Timber Engineering etc.

Guidelines to the authors:

Manuscripts should be prepared in MS word format and typewritten on an A4 sheet having '1.5' line-spacing throughout the text. The margins should be 2.54 cm (1inch) in all sides and page number should be consecutively on the bottom of the page. The manuscript should be written in Time new roman using '12' font size and not exceed 30 pages. Manuscripts must be written in English.

Title: The title of the manuscript should be specific and concise but sufficiently informative the full names of authors and affiliations of all authors (Department, Faculty, University, City, and Country) including a valid e-mail address for the corresponding author along with telephone and fax numbers should be mentioned after the title.

Abstract: The abstract should contain brief summary of findings and conclusion of the study. The abstract should not contain abbreviations references or diagrams. The abstract must not go to more than 300 words each for original and review papers or 150 words for short communications.

Key words: Author should provide no more than 6 key words. The Key words should arrange alphabetically. Acronyms should be avoided.

Introduction: The introduction should be arguing the case study, outlining essential background and the objectives of the work. Avoid a detailed literature survey or a summary of the results.

Materials and methods: The materials and methods section should be including sufficient technical information about the materials and the analytical and statistical procedures used. Describe new methods completely and give sources of useful chemicals and equipment.

Results: Result and discussion can be written separately or combined. The results obtained from the experiments including their statistical evaluation and any explanation should be presented graphically or in tables in this section. This section may be organized into subheadings. Extensive interpretation of the results should be reserved for the Discussion section.

Discussion: The Discussion section should provide an interpretation of the results in relation to previously published works. It should not contain extensive repetition of the Results section. The Discussion may be organized into subheadings.

Conclusion: In the conclusion section, author should state the most important outcome of the work by interpreting the findings at a higher level of abstraction than the Discussion and by relating these findings to the motivation stated in the Introduction. Do not simply summarize the points already made in the body. Conclusions must not contain references to the cited literature.

Acknowledgements: In this section author should give credit to people who have helped author with the research or with writing the paper. If the author work has been supported by a grant, author should also give credit for that in this section.

Tables and Figures: All illustrations (photographs, drawings, graphs, etc.), not including tables, must be labelled "Figure." Figures and table must be submitted at the end of the manuscript, after the references, not in the running text. All tables and figures must have a caption and/or legend and be numbered (e.g., Table 1, Figure 2), unless there is only one table or figure, in which case it should be labelled "Table" or "Figure" with no numbering. Captions must be written in sentence case (e.g., Microscopic view of *Trichoderma*). The font used in the figures should be Times New Roman.

Statistical analysis: Statistical analysis is to be done if necessary. Biological data without statistical analysis cannot be accepted.

References

The manuscript should be checked carefully to ensure that the spellings of the authors' names and the years are exactly the same in the text as given in the reference list.

A. Text citations:

- In-text citations appear in brackets, and consist of the author(s) last name, as well as the document's year of publication (e.g. Rahman, 2012). The end reference list appears in alphabetical order by author last name.
- If the author's name is clearly mentioned in the text, it can be directly followed by the year of publication, in parentheses: Zakaria (2020) isolated and identified 5 species of *Trichoderma* from the rhizosphere of rubber trees in Malaysia, namely…..
- If a document has two authors, include both surnames separated by "and". For works with three or more authors, include only the first author name, followed by "et al.": … (Rahman and Illias, 2012). … (Rahman et al., 2013). If the author cites several sources at once, list them in

chronological order, or alphabetically if two or more works were published in the same year, and separate each one with a semicolon: ... (Rahman, 1963; Rahman and Alam, 1975; Beagum, 1975; Alam et al. 1992). Citing two or more works written by the same author in the same year, add a designator (a, b, c...) to distinguish them. (Rahman, 2011a, 2011b).

B. Reference list:

Compile all references together in a list at the end of the manuscript text. Authors must reference all previous publications in which portions of the present work has appeared. Articles accepted for publication should be cited as "in press"; the DOI should be given if the paper is published online only.

References should be listed alphabetically. Abbreviated journals names must be written, not full name of journal.

The names of authors are written in reverse order. Include the initials for the first and middle names. When two or more authors work together on a source, write them in the order in which they appear on the source.

Example: Rahman, M. A.; Begum, M. F.; Rahman, M. M.; Bari, M. A.; Ilias, G. N. M.; Alam, M. F.

For journals

Structure: Author(s) last name, First initial. Middle initial. Article title. Abbreviated journal name in italic. Year, Volume (Issue), Pages.

Example: Rahman, M. A.; Begum, M. F.; Rahman, M. M.; Bari, M. A.; Ilias, G. N. M.; Alam, M. F. Isolation and identification of *Trichoderma* species from different habitats and their use for bioconversion of organic solid waste. *Turk. J. Biol*. 2009, 35(2), 183-194.
For journal articles published online ahead of print or online only, the DOI should be used:
Rahman, M. A.; Moni, Z. R.; Hussen, M. A.; Ansari, T. H. Prevalence of fungal diseases in medicinal
plants in northern region of Bangladesh. *SAARC J. Agric*. 2009, 17(2), 197-212. DOI: https://doi.org/10.3329/sja.v17i2.45306

For Books

Structure: Author(s). Book Title (In Italic), Edition,; Publisher: Place of Publication, Year; pages.

Example: Falero, E. M.; Fernandez, S. M.; Antonio, D.; Abril, G. *Quantitative techniques in participatory forest management*. 4th ed.; Bota, R., Ed.; Academic Press: New York, 2003; 1-39 pp.

Chapter in a book

Structure: Author(s). Book title (In italic). Edition.; Publisher: Place of Publication. Chapter #, Chapter title, Year; Pages of the chapter.

Example: Shmulsky, R.; Jones, D. P. *Forest product and wood science an introduction*. 6th ed.; John Wiley & Sons: Surrey (U.K). Chapter 6, Juvenile wood, reaction wood, and wood of branches; 107-139 pp.

Thesis or dissertation

Structure: Author. Title of the Thesis. Level of Thesis, Degree-Granting University, Location of University, Date of Completion.

Example:

Rahman, M. A. Screening of *Trichoderma* spp. and their efficacy as a bioconversion agent of municipal solid waste through appropriate technique of solid state fermentation. Ph.D. Dissertation, University of Rajshahi, Bangladesh, 2009.

Conference papers or proceedings

Structure: Author(s). Title of paper/presentation. Presented at conference title [Online], Place, Date; Paper Number. Title of the Site. URL (accessed Month Day, Year).

Example: Torreta, N. K.; Takeda, H.; Azuma, J. I. Presented at the 20th winter workshop on nuclear dynamics [Online], Trelawny Beach, Jamaica, March 15–20, 2004. University of Rochester, DSpace Web site. http://hdl.handle.net/1802/228 (accessed Oct 13, 2004).

Online source

For online articles provided as content in a subscription database, use the reference style for periodicals or nonscientific magazines as appropriate, and include the name of the database provider, the URL of the top page, and the date accessed.

Example: Hallet, V. Scanning the Globe for Organic Chemistry. *U.S. news and world report* [Online], April 19, 2004, p 59. Business Source Premier. http://www.epnet. com/academic/bussourceprem.asp (accessed April 24, 2005).

Articles published online

Structure: Authors. Title of Article. *Journal Abbreviation* [Online early access]. DOI or other identifying information. Published Online: Month Day, Year. URL (accessed Month Day, Year).

Example:
Rahman, M. A,; Begum, M. F.; Alam, M. F. Screening of *Trichoderma* Isolates as a biological control agent against *Ceratocystis paradoxa* causing pineapple disease of Sugarcane. Mycobiology. [Online early access]. DOI: 10.4489/MYCO.2009.37.4.277. Published Online: December 31, 2009. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3749418/. htm (accessed September 20, 2020).

Electronic book

Books published online generally correspond to printed versions, and the reference styles are similar. Online location and access date should always be included when citing online books. Reference works published online are often updated with new content, and the dates on which sections were posted or updated should also be included.

Structure: Author(s). *Book Title* [Online]; Series Information (if any); Publisher: Place of Publication, Year, Volume Number, Pagination. URL (accessed Month Day, Year).

Example: Grebner, D.; Bettinger, P.; Siry, J. *Introduction to Forestry and Natural Resources* [Online]; Academic Press, Amsterdam, 2013; 177-180 pp. https://www.sciencedirect.com/science/book/9780123869012 [accessed 2017 Dec 30].

Online encyclopaedias

Structure: Article Title. *Encyclopedia Title*, edition [Online]; Publisher, Posted Online Posting Date. URL (accessed Month Day, Year).

Example: Alkanolamines from Nitro Alcohols. *Kirk-Othmer Encyclopedia of Chemical Technology* [Online]; Wiley & Sons, Posted March 14, 2003. http://www.mrw. interscience.wiley.com/kirk/articles/alkaboll.a01/frame.html (accessed Nov 7, 2004).

Short Communications

These should be within four journal pages with graphs, tables and statistics. The manuscript must be without sub-heads, e.g., abstract, introduction, materials and methods etc. but with keywords and references.

Manuscript submission:

Submit the manuscript by using as an attachment to this e-mail: editor@sarpo.net or sarpopublications@gmail.com

Correspondence shall be made with:
The Editor
Journal of Agriculture & Forestry Research (JAFR)
South Asian Research and Publishing Organization (SARPO)
Email: editor@sarpo.net; sarpopublications@gmail.com
Website: www.sarpo.net