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Journal of Agriculture & Forestry Research (JAFR)

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Thank you for joining us in this exciting endeavor.

Sincerely,

Editor-in-Chief, Journal of Agriculture and Forestry Research

Journal of Agriculture & Forestry Research (JAFR)

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Research Article **Open access**

Agronomic Performance and Yield of *Celeosia argentea* and *Amaranthus caudatus* Treated With Organic Manure And Mineral Fertilizer

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ABSTRACT

Most Nigerian soils have low nitrogen status usually supplemented with nutrient sources, like chemical fertilizers. However, the problem with the usage of chemical fertilizer is that though enhances high crop yield, it can result in groundwater pollution, which is hazardous to human health. A field experiment was conducted to evaluate the effect of organic manure, organomineral fertilizer and inorganic (urea) fertilizer on two vegetable types namely; *Celosia argentea* and *Amaranthus caudatus*. The experiment was carried out at the Teaching and Research Farm, Faculty of Agricultural Science, Ekiti State University, Ado-Ekiti. The experimental design was a randomized complete block design with three replications. The treatments used in the experiment are; poultry manure applied at the rate of 15 tons/ ha, organomineral fertilizer (7.5 tons/ha of poultry manure + urea 50kg/ha), Urea (46%N) at 100kgN/ha and control (no fertilizer). The result showed that application of organomineral fertilizer (urea + poultry manure) to the *Amaranthus caudatus* gave the highest plant height, stem girth, number of leaves, number of branches of leaves of 45.5 cm, 18.0 cm and 69.7 cm respectively at 4weeks after sowing when compared with values obtained in plots treated with urea, poultry manure and control. In addition, the application of organometal on the vegetables produced the highest yield and was significantly different from the other sources of nutrients used in the experiment.

INTRODUCTION

Agricultural land loses fertility after a long period of cultivation as a result of degradation of soil due to natural phenomena, and improper land use management practices over many years. Also, soils naturally are no longer able to supply all the needed nutrients required by crops for proper growth and development. Thus, it becomes imperative to supplement the soil nutrient with additional nutrient sources. Fertilizer plays an important role in increasing the soil nutrients which helps to nourish the plants. Thus, fertilizer application is essential for enhancing soil fertility for proper crop production. Common types of fertilizers used in crop production are organic and fertilizers for good crop productivity. Organic and inorganic fertilizers are essential for plant growth. Both fertilizers supply plants with the nutrients needed for optimum performance (Erisman et al. 2008). Organic fertilizers have been used for many centuries whereas chemically synthesized inorganic fertilizers were only widely developed during the industrial revolution. Inorganic fertilizer has significantly supported global population growth, it

has been estimated that almost half the people on the earth are currently fed as a result of chemical fertilizer use (Erisman et al. 2008). Commercial and subsistence farming have been relying on the use of inorganic fertilizers for crop production (Masarirambi et al. 2010), because they are easy to use, quickly absorbed and utilized by crops. But the continued dependence on inorganic fertilizers has made the prices of agricultural products skyrocket (Makinde et al. 2010). Furthermore, the high price of inorganic fertilizers and the possible environmental hazard posed by overuse of same, are of great concern. Research has shown that organic fertilizers are less leached into groundwater and cheaper than chemical fertilizer (Sridhar and Adeoye, 2003). As a result of this fact, the use of organic fertilizer has found favor in boosting crop production in Nigeria. In addition, it improves soil fertility status as well as increases the income of farmers at a cheap cost of production.

Celosia argentea L. (Lagos spinach) is an edible species of the Amaranthaceae family, widely grown in home gardens in Nigeria and other parts of West Africa. It is cultivated during the rainy and dry seasons. This green vegetable is an essential component of people's diet in Nigeria. The leaves and young shoots are used in soups and stews. The leaves contain high levels of calcium, phosphorus and iron. The plant is an important source of vegetable proteins, calories, vitamins and minerals (Akinyemi and Tijani-Eniola, 1997) that enrich the diet of the people of West Africa. The crop is produced in Nigeria by poor farmers and in compound gardens where it is intercropped with other arable crops like maize and cassava to produce enough food and meet-up the dietary and cash requirements of these farmers (Akinyemi and Tijani-Eniola, 1997). *Amaranthus caudatus* is grown mainly for its leaves and is among the highest-priced leafy vegetables in Nigeria, one of the important vegetables of the family Amaranthaceae. Several amaranth species are useful as food crops and are grown both for their leaves and for their edible seeds. Amaranthus, like a number of other vegetables, requires soil with a high nitrogen content and adequate nutrient reserve for optimum yield. Many researchers have reported that the complementary use of organic fertilizers is able to give the desired higher sustainable crop yields than sole use of inorganic fertilizer (Ogunlade, et al. 2011; Akanbi, et al. 2010). In addition, most vegetable farmers in tropical Africa are smallholders who cannot afford the high cost of inorganic fertilizers. Fertilizer application rates for intensive agricultural systems have increased rapidly in recent years in Nigeria and farmers depend largely on locally and cheaply sourced organic fertilizers for enriching their soil (Makinde et al. 2010). In Nigeria, there are huge amounts of organic manure sources such as poultry waste, animal dung, sewage sludge, refuse soil and palm oil mills. The nutrients contained in manures are slowly released and can be stored for a longer period in the soil. This ensures longer residual effects that help in improving root development, and higher crop yields (Abou El Magd et al. 2005). Bayu et al. (2006) reported that the utilization of organic manure is necessary in order to reduce the cost of crop fertilization, thus improving the environmental conditions and reducing the cost of production. Organic manure not only helps in sustaining cropping system through improved nutrient recycling (El-Shakweer et al. 1998), it also provide all necessary macro- and micro-nutrients in available forms on the farm, thereby improving the physical, chemical and biological properties of the soil (Abou El-Magd et al. 2006.. Various studies have been done on how fertilizer use affect the yield of different plants. Several studies have centered on the effect of organic, inorganic fertilizer or in combination on soil properties, nutrients uptake, growth and yield of crops. However, there is scarce research information on the effect of organic and inorganic fertilizer on production of *Amaranthus caudatus* and *Celosia argentea*. Thus, to enhance the optimal production of the vegetables, appropriate use of fertilizers have to be employed. The aim of this study is to evaluate the effect of fertilizer types on the growth and yield performance of *Celosia argentea* and *Amaranthus cadautus*.

MATERIALS AND METHODS

Experimental site

This work was carried out March - June, 2022. The site is located at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti (Lat. 70 45' North and Long. 5º 38' E) and 432 meters above sea level. The texture of the soil is predominantly loamy sand with some traces of clay loam. The site is covered with large vegetation which shows that the site has a good nutrients to cultivate on it, located on a bearing of 7° 31N and 70 49S and covers an appropriate elevation of 730m above sea level. The area has a humid tropical climate with marked wet and dry seasons. It is characterized by high temperature and relative humidity. The average annual rainfall for the area is

309mm with an average number temperature is between 21° and 27°C. The site being part of southern Nigeria has a rainfall period of about 6 - 7 months and moderate temperature with relatively assistant sunshine intensity during the dry season. The humidity is relatively high during the wet season. The common weed found on the site is Elephant grass (*Pennisetum purpureum*), some wild sunflower (*Tithonia deversifolia*), and (*Chromolaena odorata*) siam weed. The vegetative cover showed that there are lots of macros and micronutrient in the soil.

Land preparation

After selecting the site, it was cleared and ploughed, it was harrowed and plots were assigned. The length and breadth of the site were measured and divided to three replication, and each replication made up of eight plots, measuring 2m by 2m, each with 1m in between, giving total number of twenty-four (24) plots. Each plot was tilled using a hoe to loosen the soil, thus providing a good seed bed to enhance the easy germination of the seeds.

Experimental Design and Treatment

The seeds of celosia argentia (Lagos spinach) and *Amaranthus caudatus* planted were obtained from previous planting at the Teaching and Research farm. The inorganic fertilizer used (urea) was purchased from the local market, while organic fertilizer was obtained from the poultry unit of the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Ekiti State. The experimental design used was a randomized complete block design (RCBD). The planting of amaranths and celosia was carried out on the 25th of March. The poultry manure was applied 2 weeks preceding the planting day, while the application of urea was done a day before planting. Planting was done using the broadcasting method. The treatments used in the experiment are; poultry manure (PM8) applied at the rate of 15 tons/ ha; organomineral fertilizer i.e split application of poultry manure at 7.5 ton/ha and urea (46 % N) at 50 kg/ha (PM4+U20); Urea (46%N) at 100 kg N/ha (U40) and control (no fertilizer).

Data collection

The data taken include plant height, stem girth, number of leaves per plant and fresh vegetable weight/yield. The plant height was measured using meter rule (ruler). Plant height was measured from base of the plant to its tip, from 14 DAS to 42 DAS. The number of leaves was measured by counting fully opened leaves. Stem girth was measured with Vernier caliper from 14 DAS to 42 DAS on weekly interval. The harvesting of vegetables leaves were done 6 weeks after planting. Yield parameter was measured on the plants from by selecting the mid rows plants and uprooted from the root, shaking the soil away gentle, while the whole plants were placed on a weighing balance to ascertain weight per plant (fresh vegetable weight).

Data analysis

The data was subjected to Analysis of variance (ANOVA) using SPSS 23 version (Version 23.0, 2015). The least significant difference (LSD) test or turkey ($\alpha = 0.05$) was used for means separation among the treatments used.

RESULTS

Growth parameters measured in the experiment

Table 1 shows the effects of urea fertilizer, poultry manure and organomineral on plant height of the two vegetables varieties used in the experiment. From the result obtained, it could be clearly seen that there were no significant differences in all values recorded for the growth parameters measured on varieties of vegetables used at different levels of nutrients applications. Although application of organomineral fertilizer (PM4+U20) on *Amaranthus caudatus* gave the highest plant height, number of leaves and stem girth, which are 45.5 cm, 69.7 and 18.0 cm respectively at four weeks after planting, while the control (no application) gave the lowest values recorded in almost all the weeks sampled.

Yield parameters measured in the experiment

Yield of the different nutrients sources

Figure1 showed the yield values obtained on the two vegetable varieties used in this experiment as a result of the effect of nutrient sources used. From the chart, it could be seen clearly that application of organomineral fertilizer (PM4+U20) on the vegetables varieties gave the highest yield and differ significantly from all the other treatments used in the experiment, followed significantly by application of poultry

manure (PM8) at the rate of 15 ton/ ha and the control gave the lowest yield.

Yield of the two vegetable varieties as affected by the nutrient sources

Figure 2 showed the yield values obtained on the two vegetable varieties used in this experiment as a result of the influence of nutrient sources used on them. From the chart, it could be seen clearly that application of organomineral fertilizer (PM4+U20) on the vegetables varieties gave the highest yield, followed by poultry manure PM8, while the control gave the lowest yield. In addition, *Amaranthus caudatus* produced higher yield under the influence of treatment PM4+U20 when compare with *Celosia argentea* in the experiment.

Table 1. Plant height (PH), number of leaves (NOL) and stem girth (SG) of the two vegetables under different nutrient sources.

		WAP (cm)								
Veg		2	3	4	2	3	4	2	3	4
	Nutrient		PH			NOL			SG	
Celosia	PM8	4.3	13.2	27.5	7.7	13.3	28.3	0.4	5.5	8.9
	PM4+U20	8.3	20.5	42.7	9.3	22.0	51.7	0.6	8.8	16.4
	U40	5.2	9.3	16.3	4.7	9.7	20.7	0.2	5.2	8.4
	Control	4.7	11.3	22.0	7.3	11.0	22.7	0.3	4.9	8.3
Caudatus	PM8	6.8	19.0	38.7	7.0	18.3	40.3	0.5	9.9	16.8
	PM4+U20	7.3	17.0	45.5	8.3	36.3	69.7	0.5	10.7	18.0
	U40	6.0	11.5	23.0	5.3	8.7	23.7	0.3	6.2	13.8
	Control	3.8	7.3	12.2	6.7	6.3	9.7	0.3	4.0	8.2
	SEM	1.01	2.75	5.68	0.66	3.01	5.11	0.07	1.57	2.68
	$p < 0.05$	0.300	0.260	0.284	0.604	0.190	0.539	0.355	0.234	0.277

Veg: vegetable; WAP: weeks after planting; PM8: poultry manure; PM+U20: poultry manure + Urea; U40: 40 g Urea. SEM: standard error of the mean $P < 0.05$ means a 5% level of probability with means separated by Tukey test.

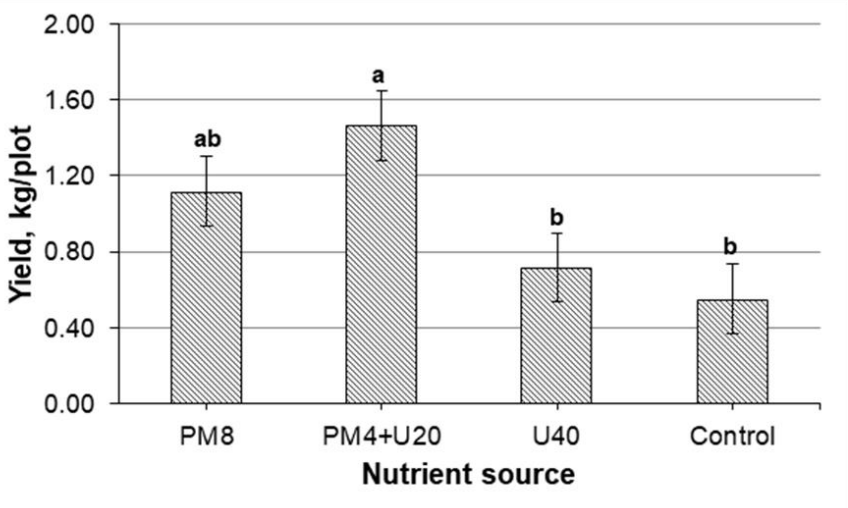

Figure 1. Yield of the different sources of nutrients. PM8: 8 kg poultry manure; PM4+U20: 4 kg poultry manure + 20 g Urea; U40: 40 g Urea. Bars with different letters differed significantly at 5% level of probability by Tukey test.

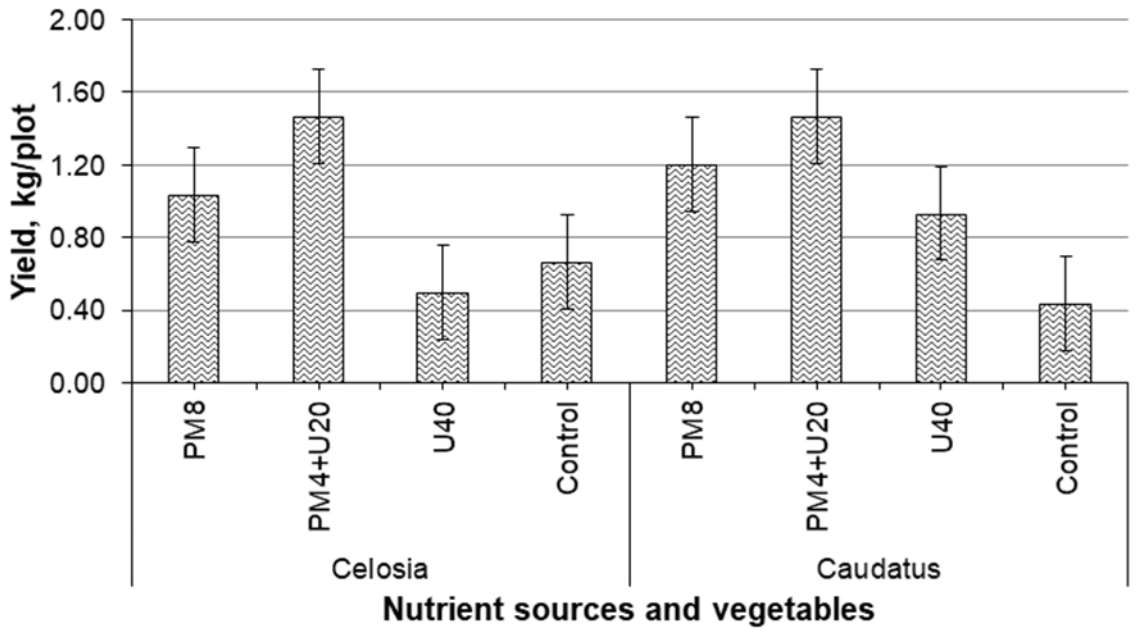

Figure 2. Yield of the two vegetable varieties as affected by the nutrient sources. PM8: 8 kg poultry manure; PM4+U20: 4 kg poultry manure + 20 g Urea; U40: 40 g Urea. Bars with different letters differed significantly at 5% level of probability by Tukey test.

DISCUSSION

Fertilizers play an important role in improving soil fertility by adding essential nutrients to soil which aid in adequate growth and yield of plants, hence the two varieties of amaranth grown under different level of urea fertilizer, and poultry manure (PM) had significantly showed increased in growth and yield rate when compared to the control plants. This effect could be associated to the vital nutrients contained in the mineral fertilizer as well as the poultry manure, which are deposited in the soil and thereby absorbed by the plants. Also, the two varieties of amaranths used in this experiment exhibited better response to organomineral fertilizer and poultry manure than urea fertilizer and control. This implies that minerals fertilizer quickly releases nutrients, which can easily be leached away from the soil than poultry manure. It could also be noted that increase in the dosage of the urea fertilizer and poultry manure had an increment effect on the plant height, an average number of leaves, stem girth and yield, which can be attributed to the increased amount of nutrient (nitrogen) supplied to the vegetables in the experiment. The highest plant height obtained from plants treated with organomineral (Pm4+U20) are 45.5 cm and 42.7 cm, for caudatus and celosia plants respectively, which might be due to favorable nutrient mineralization of this fertilizer as a result of the influence of the mineral component on its organic content (Sikora and Enkiri, 2000), while the control plants produced the shortest plants height (Fig 1), which could be due to the fact that they had to rely solely on the native soil fertility which might be deficient in nutrients. Figure 2 shows that organomineral (Pm4+U20) enhanced the production of leaves and maintained that trend in plant height and stem girth for both caudatus and celosia. An increase in the number of leaves over the weeks of samplings are bound to affect the overall performance of Amaranthus as the leaves serve as a photosynthetic organ of the plant (Law-Ogbomo and Ajayi, 2009). Although, there were no significant differences ($P < 0.05$) in the number of leaves, plant height and stem girth, obtained from the two vegetable types used in the experiment, among the treatments used, and all through the weeks samplings, all the same, the highest number of leaves, plant height and stem girth were obtained from plants (plots) treated with organomineral fertilizer, which are 69.7, 45.5 cm and 18 cm respectively. This could be due to continuous release of nutrients by the organomineral fertilizer (Ogunlade, et al. 2011). Thus, the increase in number of leaves under organomineral and urea fertilizers application, reconfirmed the role of fertilizer in promoting vegetative growth in leafy vegetables (Tijani-Eniola, et al. 2000).

The fresh yield of *Amaranthus caudatus* was significantly increased with application of organomeniral (PM4+U20). These results are in agreement with the findings of Bruce & Philip (2008) who reported a linear response of amaranth yield to N fertilization. The higher yield produced by the two vegetables varieties under organomineral treatment over other treatments used, could have been due to increased plant height, stem girth and the number of leaves obtained from the plants under this treatment, thus the higher performance of vegetables in PM4+U20 treatment over PM8 and U40 treatments are indicative of the ease dissolution of nutrients in the inorganic fertilizer at the initial stage of growth being a more soluble form, which could be enhanced by the poultry manure at the later growth stages. In addition, poultry manure also contains useful soil nutrients that are needed for the plant's growth, but their composition is in the crude form that is released slowly to the soil possibly accounting for the slow and steady growth of plants in both PM4+U20 and PM treated plots, when compared with urea treated plots and control. All the fertilizers applied were found to increase the plant height, stem girth, and yield of Amaranths caudatus and celosia when compared with the control. In Fig 2, it could be clearly seen that *Amarantus caudatus* produced the highest yield under the influence of treatment PM4+U20, followed by PM, then urea while the control plants produced the least. Furthermore, it can be noted that vegetable yield was the least in the control plots. This confirmed the findings of (Olowoake, 2014), who reported the application of organic, mineral and organomineral fertilizers for the enhancement of Amaranthus cruentus yield. There were significant differences ($P <$ 0.05) in the yield of two vegetables under the different treatments used. Fig 1 showed that organomineral (PM+U40) treated plots gave the highest yield compared to other treatments. This was similar to the works of Akanni et al. 2011.; Ayeni, 2008.; Ogunlade et al.; 2011, who reported that the combinations of organic and mineral fertilizers performed better on the yield of tomato, maize, and *Solanum macrocarpon* than when each of them is solely used.

Application of organic manures significantly increased levels of organic Carbon and Nitrogen, and the formation of water stable aggregates, when compared with application of chemical fertilizers (N'Dayegamiye, 2006). Makinde et al. (2011), also reported that Celosia and Corhorus treated with poultry manure had better yields, higher number of leaf, stem girth and higher moisture contents than vegetables fertilized with urea. The scarcity and high cost of obtaining mineral fertilizer calls for alternative nutrient sources (Akanbi et al. 2006), hence this research work. Also, Celosia as a productive leafy vegetable, yet its yields are lower when compare with the yield of *Amaranthus caudatus* (Denton, 2004).

CONCLUSIONS AND RECOMMENDATIONS

This study shows that *Amaranthus caudatus* and celosia exhibited a better response to split application of urea and poultry manure (organomineral) than sole urea, and poultry manure. Application of treatment PM4+U20 showed a significant increase in plant height, stem girth, number of leaves, and fresh weight (yield) for both celosia and caudatus than all the other treatments used in the experiment including control, though caudatus perform better for both growth and yield parameters. Therefore, it reveals the need for basal application of mineral fertilizer for the early proper growth and development of the vegetable plants. Organic manure and inorganic manure had a good influence on growth, development and yield of these vegetable varieties used. The results obtained revealed that both vegetables responded well to the application of organomineral fertilizer compared to other different nutrients sources used and control in the study. Therefore poultry manure could be used as the good organic nutrient source for increasing the productivity of the vegetables. The study concluded that leaf numbers increased with increase in poultry manure and urea fertilizer levels. This showed that increase in N level promoted the vegetative growth of the vegetable plants. This study showed that treatment PM4+U20 fertilizer gave the best performances in all growth and yield parameters measured. Given its superior responses, organomineral fertilizer could be a very attractive fertilizer alternative, particularly for annual crops with short growth cycles such as *Amaranthus caudatus* and celosia. It is therefore, reasonable to recommend the use of organomineral fertilizer in the cultivation of *Amaranthus caudatus* and *Celosia argentea*.

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Research Article

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Distribution of Birds in Communities around Kakum National Park (Knp), Ghana, Using Foraging Behaviors

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ABSTRACT

The study was undertaken in Kakum, National Park of Kakum Conservation Area Ghana in the wet season 2022 to identify birds and determine their distribution based on their foraging habits. Using both purposive and convenience sampling, transects and surveys, birds were counted by Point counts and opportunistic surveys All birds were observed at a fixed location using an Opticron Polarex 8×40 binocular and identification of bird species were confirmed by birds of Ghana and recorded vocal reply of birds. Birds coordinate and location was taken at all station using a Gramin GPS device. The results were documented and analyzed in Microsoft Excel 2016 and presented in graphs. A checklist of identified birds' species was produced with reference to Birds of Ghana. Arc Map (Arc GIS 10.3) was used to plot the locations of species and survey points on the map of the study area. Ten categories of feeding guilds were identified. An Anova test result from the study indicates a p-value of 0.976, showing that there are no significant differences among the birds' population in the various communities. Family Ploceidae an insectivorous birds dominates the population in the study area. Insects are known to be favored by moist conditions and dense foliage, which is characteristic of the Kakum Conservation Area, hence insects being a ready source of food for birds.

1.0 INTRODUCTION

Avian biodiversity is an essential component of our planet for providing various services to ecosystems like seed dispersal, aesthetic beauty, biological control and environmental cleaners. Their bright colors, distinct songs and calls, and showy displays add enjoyment to our lives and offer an easy opportunity to observe their diverse plumage and behaviors (Khan et al. 2012).

Birds are the only chordates in the Class Aves of the Phylum Chordata, with more than 10,000 species distributed around the world from the Artic to Antarctic areas (Bird Life International, 2012). Birds are important because they maintain the equilibrium of natural systems by pollinating plants, dispersing seeds, scavenging animal carcasses, and recycling nutrients back into the soil. Additionally, they nourish our souls and our existence on the earth. In some ways, man is dependent on the ecological services that birds provide, making us dependent on them. Globally, people are rapidly destroying ecosystems, particularly in the tropics, which is causing a sharp decline in biodiversity. (Laurance et al. 2002; Dirzo, & Raven, 2003; Lindenmayer, & Fischer, 2013).

The concept of nature conservation is sometimes viewed as something that occurs "out there" in protected areas rather than as an essential part of daily living. The idea that humans are separate from the natural world is reinforced by this viewpoint,

which contributes too many of the environmental problems we face today. However, safeguarding biodiversity and ecosystems should be prioritized in public policy, development strategies, and day-to-day activities because they are vital to human society (Hackett, 2015; Kareiva et al. 2011; Lovins, et al. 2001). It implies that we need to comprehend the importance of biodiversity to human society. Biodiversity is formally defined by the Convention on Biological Diversity (CBD) as "the variety of living organisms from all sources, including terrestrial, aquatic, and other habitats, and the ecological developments of which they are a part; this comprises diversity within species, between species, and between ecosystems." (UN 1992 Article 2).

An important part of the world's biodiversity is birds. Birds are the animal category with the most extensive time series of data because of the attention they draw to their behaviors, colors, and songs. Globally, biodiversity is fast vanishing. (Balmford et al. 2003). The majority of wild animal (Birds) ecology's economic components have been disregarded, which an issue is made worse by the drop in financing for the fall in instruction in natural history and organismal ecology. (Tewksbury et al. 2014).

For the past 300–400 years, there has been a significant loss in bird habitats, particularly for plants and animals (Decher et al. 2000). There are numerous explanations put out for this decline. Global observations show that habitat changes, particularly in the case of bird populations, are the most frequent cause of population decrease and species extinction. (Mace et al. 2000 According to estimates, habitat degradation was responsible for 36% of all animal extinctions worldwide (Jenkins, 1992). According to another estimate, over 100 species are thought to go extinct every day as a result of habitat degradation (Ehrlich et al. 1991). Hunting pressure brought on by growing human populations in nearby villages near forests (the fringe communities) and their need for food to survive is another factor contributing to extinction. (Brockington, & Igoe, 2006) concur that humans pose a threat to species. According to one definition, ecosystem services are "the set of ecosystem functions that are helpful to humans" (Kremen, 2005) There have been extensive investigations on the history of ecosystem services (Daily, 1997; Gomez-Baggethun et al. 2010). The last 20 years have seen a sharp increase in ecosystem services. Governments became aware of ecological services during the Millennium Ecosystem Assessment (MEA, 2005). (Gomez-Baggethun et al. 2013). The MEA (2005) identified four classifications of ecosystem services: provisioning services, cultural services, regulatory services, and sustaining services, with the goal of evaluating the potential effects of ecosystem change from a human well-being perspective and with an emphasis on ecosystem services. All four categories of ecosystem services are provided by birds. (Sekercioglu, 2006a; Whelan et al. 2008). Both domesticated (like poultry) and non-domesticated creatures offer provisioning services. Birds have always been a significant part of the human diet for sport, consumption, and subsistence. (Moss and Bowers, 2007), particularly waterfowl (Anatidae) and terrestrial fowl (Galliformes) (Peres, 2001; Peres and Palacios, 2007)). Bird feathers provide bedding, insulation, and ornamentation (Green and Elmberg, 2014). Birds provide a crucial focal point for research of cultural services within the ES paradigm because of their special relevance for humans; this is the topic of ethno-ornithology (Clayton, 2013; Podulka et al. 2004; Tidemann and Gosler, 2013). One of the most well-liked outdoor pastimes in both the United States and around the world is bird watching. (Kronenberg, 2014a; Ma et al. 2013; Sekercioglu, 2002; White et al. 2014 and has both direct and indirect economic benefits due to the many citizen science initiatives that involve birdwatchers (Greenwood et al., 2007). Through their foraging ecology, several bird species provide regulating and supporting functions. Scavenging carcasses, nitrogen cycling, seed distribution, pollination, and pest control are some of these services. (Sekercioglu. 2006a; Whelan et al. 2008). Here, we concentrate on regulating and assisting services because the advantages of these services are frequently passed on to people subtly. Many of the ecosystem services that birds provide are a result of their ecological roles. Thus, estimating their value requires thorough familiarity with the natural history of the species in question. (Sekercioglu, 2006 a, b; Wenny et al. 2011; Whelan et al. 2008). The majority of regulating and supporting services result from resource consumption's top-down impacts. Birds utilize a wide range of resources in terrestrial, aquatic, and aerial settings. There are over 10,000 species of birds on the planet. In certain cases, the resource being consumed is a nuisance to forests or agricultural products. In other instances, birds' use of resources aids in pollination or seed dissemination, encouraging the successful reproduction of thousands of commercially or culturally valuable plant species. Through the numerous Ecosystem Services (ES) that forests and other plants provide, these services

indirectly benefit humans. Birds have a significant, global impact on ecosystems through these services Forest fragmentation rate in the country is estimated at 22,000 square kilometers per annum (Hawthorne and Mussah, 1993). Despite the fact that a large portion of the resource is severely depleted, Ghana's forests and savanna land still host a diverse range of intriguing plant and animal species. However, it is estimated that more than 70 % of the initial 8.22 million hectares of closed forest in Ghana have been lost (IIED, 1992), and only about 10.9 % to 11.8 % (representing 15,800 to 17,200 square kilometers of forest cover) remain as intact forests. Data on the status of specific plant species are not readily available. Without sufficient action, the country won't have any intact forests left in a century if things continue at this rate.

The progressive conversion of some forests in Ghana's middle belts into savannah lands is a sign of the country's ongoing deforestation. As a result, Ghanaians' ability to produce goods and earn a living has decreased, and the severe environmental damage brought on by deforestation threatens their very survival (e.g. soil erosion, local climate changes, instability of hydrological regimes and loss of biological diversity). Although most of these are hastened by human activity, their impact on the reduction of the bird population in some sections of Ghana's middle transition zone cannot be overstated. As a result, several bird species are in danger. (Ives et al., 2017). There are currently eight (8) endangered birds and 14 nearly endangered bird species in Ghana i.e. species at risk and requiring monitoring. Bird species are the most significant mobile link (Lundberg and Moberg, 2003), top consumers and keystone species in some ecosystems (Raffaelli, 2004); It is impossible to overstate how important they are to ecosystems, and because birds are so widespread in most locations, we also monitor the effects they have on the environment. However, because of the numerous ways in which birds interact with the environment, people can financially benefit from them (Dirzo and Raven, 2003). Predation and food availability are likely to have an impact on birds (Chace and Walsh 2006). Additionally, seen as key influences on bird habitats, quantity, and dispersion include biological background, agriculture, forest degradation, habitat loss, forest resource use, and environmental contamination. (Borges et al., 2016).
The purpose of ecotourism is to integrate the market-driven consumption of goods and services with the mitigation of emissions, ecological destruction, wildlife persecution, and tourism-related effects on biodiversity. this includes observing animals and birding (Isaac et al., 2015).

The activity of identifying and observing birds in their natural habitat is known as bird watching. Both bird's call and appearance can be used to identify it. Given that they are the single largest category, ecotourism has one of the strongest financial foundations (Cordell and Hebert, 2002). Tourists can take part in these activities thanks to bird-watcher excitement. Birding is developing into the ecotourism sector with the highest growth and environmental consciousness, and it offers Bird watchers are interest in keeping an eye on the remaining species and learning how new bird species will be introduced to verify their status (Agyei-Ohemeng, 2014). There are over 760 different bird species in Ghana (Brown and Demey, 2010). Domestic birds and other animal species benefit from this, which increases biodiversity. Kakum National Park has roughly 360 different bird species (Dosset and Dosset, 2008). About 40% of Ghana's total bird population is represented by this. According to Bird Life International in 2005, the Kakum National Park was classified as one of the most significant bird areas in Ghana because of the park's abundance of bird species in numerous ornithological surveys and research that have been conducted there.

1.1 PROBLEM STATEMENT

Consumption of resources by birds promotes successful plant reproduction in hundreds of plant species by facilitating pollination or seed dispersal. Due to the role that birds play in a variety of natural and human-dominated ecosystems, it is anticipated that these crucial ecosystem processes—in particular, decomposition, pollination, and seed dispersal will experience a reduction (Whelan et al. 2015). An increase in the human population in the outlying areas surrounding the KNP has led to a rise in demand for natural resources, such as land for agriculture, building materials, and fuel wood. Logging and other human disturbances have made these issues worse, resulting in a loss of natural vegetation and the fragmentation of species habitats in KNP. (IUCN/PACO; Deikumah and Kudom, 2010).

Deforestation and forest fragmentation have a direct correlation with species decline in protected areas (Stuart et al., 2008), causing them to colonize new parts including green spaces in cities (Symes et al. 2018). Forest specialists are now being recorded in

rainforests, transitional zone savanna, and other dry areas (Agyei-Ohemeng et al. 2017). Most birds choose habitats that are ecologically suitable for foraging. (Agyei-Ohemeng et al. 2017). The monitoring of biodiversity is essential for the sustainable management of the conservation areas in Ghana. Birds as part of biodiversity can be monitored in several ways. One of the many ways in monitoring birds is the study of their feeding habits. Root (1967) defined a guild as a group of species that exploit the same class of environmental resources in a similar way. Thus, guilds point out a functional relationship between a group of species and an ecosystem (de Iongh and van Weerd, 2006).

However, for the majority of ecological biomes, including Kakum National Park, information on the ecological state of birds, their feeding habits, and the diversity of species in their new settings is scarce. (Allport, 1991).

In order to properly manage the avian biodiversity in Kakum National Park (KNP), which is a crucial component of the KNP management plan that is being considered, the study is an effort to document the diversity, feeding habits, and ecological state of birds around the park.

1.2 JUSTIFICATION

This project will provide information that can be utilized to lessen human activities that have harmed bird habitats and to enhance bird viewing in Kakum National Park in some particular settlements. The study's findings will improve our knowledge of birds and their eating behavior in the ecosystem, promote tourism, improve rural livelihoods, boost park revenue, and contribute to the improvement of biodiversity conservation. It might also serve as a starting point for future bird-related scholars. It will also be a useful resource for anybody interested in learning more about the birds of Kakum National Park, the tourism sector, the Ghana Tourism Authority, and researchers.

1.3 AIMS AND OBJECTIVES

The main objective of this project is to do a checklist of birds in some selected communities around Kakum National Park (KNP and relate them to their foraging behavior habits in order to establish their ecological importance and status.

1.4. SPECIFIC OBJECTIVES

The study will be used to:

- Identify bird species in some selected communities around Kakum National Park.
- Relate identified birds to their foraging habits.
- Determine birds' distribution in selected communities
- Determine the ecological status of the identified birds in the selected communities.

2.0. METHODOLOGY

2.1. Study Area Description

Kakum Conservation Area is made up of two blocks of forests lying adjacent to each other that is Kakum National Park and Assin Attandanso Resource Reserve. They lie in the Upper Guinea forest zone of southern Ghana (Eggert and Woodruff, 2003). The conservation area covers 360 km2 of moist evergreen forest and also seasonal dry semi-deciduous forest, it receives an annual rainfall of 1,380mm (Csontos and Winkler, 2011). Kakum National Park is located in the Twifo-Hemang-Lower Denkyira District in the Central Region of Ghana. It is located just 33 kilometers from Coast in the Central Region of Ghana.

It lies within longitude 1̊ 5‟ East and 1̊ 2‟ West and on latitude 5̊ 39‟ North and 5̊ 20‟ South. (Fig 1). A study by Wellington (1998) revealed that Kakum Conservation Area has more than five rivers and the main river is called the Kakum River which supplies fresh water to Cape Coast Metropolis and 133 other towns, communities and villages. The river was named after the calling of a Mona monkey (Cercopithicos mona) "Kiakum". The Kakum Forest, named after Kakum River whose headwaters lie within the park's boundaries, was originally set aside as a forest reserve in 1925. Although there is a disagreement as to the exact date of their demarcation, they have been 'reserved' since the 1930s (Eggert et al. 2003).

Logging, which began in the 1930s, was intensified in the 1950s and continued until 1989 when the Central Region Administration suspended all logging. These two forest reserves are now managed as Kakum Conservation Area by the Wildlife Division of the Forestry Commission. The Kakum Conservation Area was legally gazette as a National Park and Resource Reserve in 1992 under the Wildlife Reserves

Regulations (LI 1525) under the administrative Jurisdiction of the Wildlife Department.

The Park was legitimately opened to the general public in 1994 (Twerefo, et al. 2012). The Park is surrounded by fifty-two (52) fringe communities, over 400 hamlets, and over 4500 people. Recreational activities that can be undertaken in the park include; nature walks, bird watching, campsite and tree house, canopy walkway and butterfly watching.

It is inhabited by diverse plant and animal species. It serves as a home for more than five different kinds of globally endangered species of mammals which include forest Elephants, (*Loxodonta africana*), Bongo (*Tragelaphus eurycerus*), Diana Monkey (*Cercopithecus diana*), Black and White Colobus Monkey (*Colobus guereza*) and Yellow Buck Duiker (*Cephalophus silvicultor*) (Eagles et al. 2002). It serves as a habitat for over 300 different species of birds and over 100 species of mammals, reptiles, amphibians and 600 different species of butterflies. One of the butterfly species found in Kakum is (Diopeteskakumi) which was originally discovered in the conservation area.

The uniqueness of this park lies in the fact that it was established at the initiative of the local people and not by the State Department of Wildlife who are responsible for wildlife preservation in Ghana (Wellington, 1998). It is also the only park in Africa with a canopy walkway, which is 350 meters (1,150 ft.) long and connects seven tree tops that provide access to the forest. The canopy walkway was designed by Dr. Illar Muul a Canadian ecologist and was constructed by two Canadians; Tom Ainsworth and John Keelson and was assisted by six Ghanaians who were also experts in tree climbing. The construction took place in the year 1994 and took six months before its completion. The maximum weight the walkway can take is eight tons (8 tons), which is equivalent to eight thousand kilograms (8000kg), this weight is said to be the weight of two forest elephants.

2.2. Experimental procedure

The research was conducted between May/June and September/October, 2021 using Point Count Method (Ralph et al. 1993, 1995a, 1995b). Transects were laid from one community to the other covering four fringe communities in searching and identifying birds using birds of Ghana (Borrow and Demey, 2010).

All birds observed at a fixed location were tallied at repeated observation periods. The fieldwork was carried out in the morning between 6:00 am to 9:00 am, for five (3) stations at regular intervals of thirty (30) minutes each and ten (10) minutes rest to a different station for a total distance of 5 km each, in a compass direction determined on each count day for each week in a month.

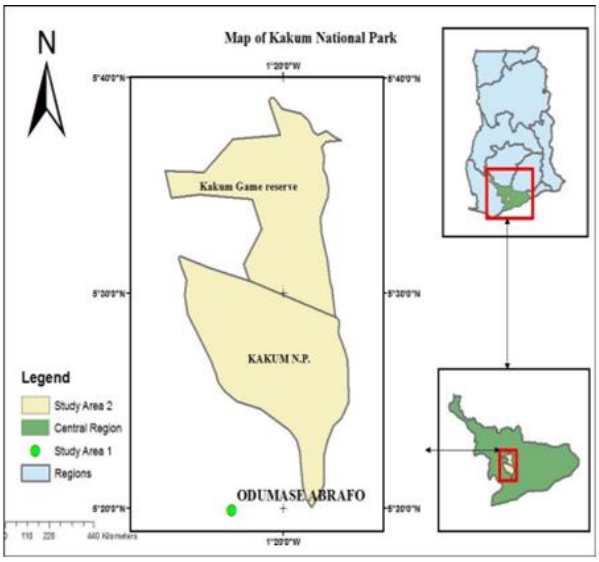

Figure 1: Map of Study Area

All counts were done on every Wednesday, Thursday and Friday on the first and third week of the counting months. In all 24 count days were spent counting and identifying birds.

An Opticron Polarex 8×40 field binocular was used to assist in the observation and identification of the bird species. The Gamin GPS device was used to take the coordinate and location of the stations. Nomenclatures of birds were referenced in the field book of birds; 'Birds of Ghana' by Borrow and Demey (2010) and vocal replay of birds was used where necessary, especially in the forest where visibility was a challenge for identification. Global Information System (Arc GIS) was used to plot the coordinates of where birds were located on the map of the Kakum National Park (KNP). Every GIS operation was carried out using ArcGIS version 10.3.

2.3. Analysis of Results/Data

All records were documented in a tabular form in an Excel data sheet and the data were analyzed using histogram and statistical methods to determine the diversity of families. We also entered the available data on the conservation, distribution, ecology, and

life history of all bird species of the world from 248 sources into a database with >600,000 entries. This provided us with guidance in classifying the foraging behavior of birds and identifying their families and determining their conservation status. An ANOVA test for significance was used to analyze the variations of birds in the various communities.

3.0. RESULTS

3.1. Species list and feeding guild categorization

A feeding guild is a group of species that exploits similar food resources in a habitat, and its characterization is usually based on the type of food being consumed, which in turn determines the feeding behavior of the availability of food resources. Foraging guilds can be a useful way to compare changes between species-rich communities because their functional organization can be investigated even if no species are shared. The foraging behavior of birds species based on the Point count method was grouped into various trophic structures to determine the feeding behaviors of different bird species and the food resources of the areas.

A total of one thousand one hundred and sixty-nine (1169) individual birds which were representing one hundred and one (101) species and thirty-two (32) families were observed and identified in the Study Area of Kakum National Park. With the aid of Birds of Ghana (Borrow and Demey, 2010) birds were categorized into insectivores, fruigivores, carnivores, omnivores, nectarivores and granivores. Birds that have a combination of two source of food were grouped into fruigivores- granivores, insectivore-carnivores, insectivores-fruigivores, carnivores-omnivores, and insectivore-nectarivores. And those who feed on more than two food sources were grouped considered and omnivore (Munira et. al, 2012). Table:1, shows the various categories of feeding guilds, families and numbers of individual sightings of the bird species.

The insectivore feeders recorded the highest number of birds with a total of 401 birds species followed by omnivores with 292 total number of birds. granivores recorded the third highest of bird with a total number of 208 and granivore-frugivore recorded the least number of birds with a total of 4 individual bird species. Figure 3 shows the highest and the least number of birds recorded in the various foraging type.

3.2. Mapping Avifauna Distribution

The GPS data collected from the survey were entered into MS Excel sheet and converted to comma-separated values (csvCSV) file format to be read by ArcGIS for the generation of a distribution map, Figure 2 below.

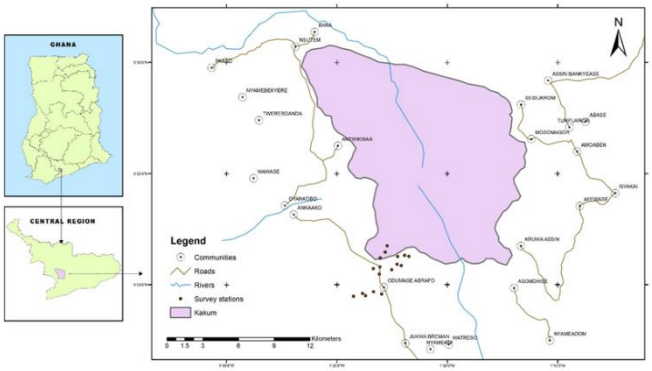

Figure 2: Distribution map of birds in the survey area.

Using Table 2 above, an ANOVA test was run to test significant differences among the bird population within the communities.

Table 3 below, indicates that the p-value =0.976, shows that there are no significant differences among the birds' population in the various communities around Kakum National Park, p-value>0.05.

3.2. RALATIVE ABUNDANCE OF BIDS FAMILIES

The family Ploceldae were abundance in the study area with relative frequency of 27.203, Pycnonotidae recorded the second highest with relative frequency of 11.121 followed by Estrildidae and Columbidae of 9.581 and 8.554 relative frequency respectively. Picidae, Hyliidae and Turdidae recorded the least relative frequency of 0.0855. The table 4 below, shows the families of birds and their relatively abundance in the study area.

4.0. DISCUSSION

Kakum Conservation area lies in the Upper Guinea forest zone of southern Ghana which serves as a habitat for over 300 different species of birds (Eggert and Woodruff, 2003). A total of 1169 individual birds which represent 102 species and 32 families were observed and identified in the Study Area, Table 1.

Table 1: Categories of feeding guilds, families and numbers of individual sightings of the bird species

CATEGORIES	FAMILY	SPECIES	NUMBER
Granivore	***Ploceidae***	*Yellow mantled widow bird*	*11*
		weaver Village	*94*
	Estrildidae	*Bare-breasted fire finch*	*2*
		Chesnut breasted nigrita	*5*
		Black-bellied seed cracker	*1*
		Black and white mannikins	*45*
	Passeridae	*Passeridae*	*19*
	Columbidae	*Red eyed-dove*	*10*
		River ramped dove	*1*
Subtotal	***4***	***9***	***188***
Insectivores	***Cuculidae***	*African emerald cuckoo*	*1*
		Klass cuckoo	*7*
		Dedric cuckoo	*3*
		Senegal coucal	*14*
	Cisticolidae	*Tawny frank prinia*	*17*
		Grey-backed camoroptera	*13*
		Yellow-browed camoroptera	*1*
		Red-faced cisticola	*7*
	Muscicapidae	*Dusky blue flycatcher*	*1*
		Blue-shoulders robin-chatt	*1*
		Grey-throated tit-flycatcher	*5*
	Monarchidae	*Blue-headed crested flycatcher*	*7*
		Red-bellied paradise flycatcher	*2*
		Paradise flycatcher	*6*
	Picidae	*Buff-spotted woodpecker*	*1*
	Meropidae	*Black bee-eater*	*3*
	Apodidae	*Little swift*	*34*
	Hyliidae	*Green hylia*	*1*
	Macrosphenidae	*Kemps long bill*	*1*
		Green crombec	*2*
	Turdidae	*African thrush bird*	*1*
	Platysteiridae	*Chestnut wattle-eye*	*4*
	Ardeidae	*Cattle egret*	*9*
		Little egret	*1*
	Nicatoridae	*Barn swallow*	*4*
	Hirundinidae	*Press swift swallow*	*19*
		Common house matin	*16*
		Western nicator	*22*
	Ploceidae	*Black-necked weaver*	*23*
		Maxwell black weaver	*68*
		Violet black weaver	*90*
		Red-vinted malimbe	*5*
		Red-headed malimbe	*1*
	Pycnonodidae	*Little greenbul*	*5*
		Yellow wipsked greenbul	*1*
	Alcedinidae	*African dwarf kingfisher*	*2*

	Malacanotidae	*Black crown tchagra*	*1*
		Brown crown tchagra	*2*
Subtotal	***17***	***38***	***401***
Frugivores	***Musophagidae***	*Western grey plantain eater*	*2*
	Bucerotidae	*Pipping hornbill*	*2*
		African pied hornbil	*19*
		African grey hornbill	*1*
	Pycnonodidae	*Swamp palm bulbul*	*17*
		Honeyguide greenbul	*1*
		White-throated greenbul	*8*
	Columbidae	*African green pigeon*	*57*
	Nicatoridae	*Western nicator*	*4*
	Lybiidae	*Nacked-faced barbet*	*2*
		Yellow-spotted tinkerbird	*1*
		yellow-fronted tinkerbird	*8*
		Red-ramped tinker bird	*1*
		Vieillot's barbet	*1*
Subtotal	***6***	***14***	***124***
Omnivores	***Pycnonotidae***	*Common garden bulbul*	84
		Slenderbill greenbul	*5*
		Simple leaflove	*2*
		Camaroon sombrine greenbul	*1*
	Sturnidae	*Splendid glossy starling*	*17*
	Corvidae	*Pied crow*	*67*
	Psittacidae	*Red-fronted parrot*	*8*
	Estrildidae	*Bronze mannikins*	*35*
		Western bluebill	*1*
	Motacillidae	*Pied wagtail*	*5*
	Musophagidae	*Green turaco*	*5*
	Columbidae	*Blue-headed wood dove*	*9*
		Tambourin dove	*4*
		Blue-spotted wood dove	*8*
	Nectriniididae	*Tiny sunbird*	*7*
		Buff-throated sunbird	*4*
		Superb sunbird	*7*
		Olive bellied sunbird	*22*
		Copper sunbird	*7*
		Yellow-billed barbet	*1*
Subtotal	***9***	***20***	***292***
Carnivores	***Accipitridae***	*Yellow-billed kite*	*4*
		Lizard buzzard	*2*
		African haired hawk	*5*
Subtotal	***1***	***3***	***11***
Carnivores-Insectivores	***Alcedinidae***	*Malachite kingfisher*	*6*
		Shining blue kingfisher	*1*
		Blue-breasted kingfisher	*1*
	Laniidae	*Common fiscal*	*12*
Frugivores-Granivores	***Columbidae***	*Grey-headed wood dove*	*4*

Subtotal	***1***	***1***	***4***
Nectarivores	***Nectriniididae***	*Callard sunbird*	*8*
		Little green sunbird	*1*
		Splendid sunbird	*9*
		Green-headed sunbird	*24*
Subtotal	***1***	***4***	***42***
Insectivores, Frugivores	***Lybiidae***	*Speckled tinkerbird*	*3*
	Estrildidea	*Grey headed nigrita*	*1*
		Chesnut breasted nigrita	*5*
Subtotal	***2***	***3***	***9***
Granivore, Insectivore	***Ploceidae***	*Black winged bishop*	*24*
	Estrildidae	*Oranged-checked waxbill*	*22*
		Red-fronted antpecker	*4*
	Viduidae	*Pintail whydah*	*22*
	Columbidae	*Loughing dove*	*6*
Subtotal	***4***	***5***	***78***

Table 2: Summary of number of birds in each community

Community	Total No. of Species	Total No. of Birds
Bekawopa	26	308
Kobeda	20	206
Abrafo Odumase	34	357
Gyae Aware	21	298

Table 3: ANOVA test of significance of birds within the communities.

ANOVA						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	7024.5	3	2341.5	0.06346	0.97645	6.591382
Within Groups	147589	4	36897.25			
Total	154613.5	7				

The study indicated that the p-value of 0.976 from ANOVA test of significance, using Table 2, shows that there are no significant differences among the birds' population in the study communities around Kakum National Park. (p-value>0.05).

Birds were categorized into several groups according to their foraging behavior. village weaver (Ploceus cucullatus) was abundance 94 followed by the violet black weaver (Ploceus nigerrimus) 90 and maxwell black weaver (Ploceus albinucha) 64 in that order being seed eater (granivores). They are common in the study area because of the common traditional practice in the farming of corn and cereals such as rice maize etc. around the study area Kakum National Park. By germinating the seeds of trees, birds can contribute to the reforesting of deforested lands, diminishing the costs of restoration, Wunderle, 1997. The fields create habitats that are used for foraging by other birds, as they dive down to where the layer of left-over harvested corn rests on the ground, they tear, shred, and churn up the pieces of straw looking for grain (Agyei-Ohemeng et al. 2017).

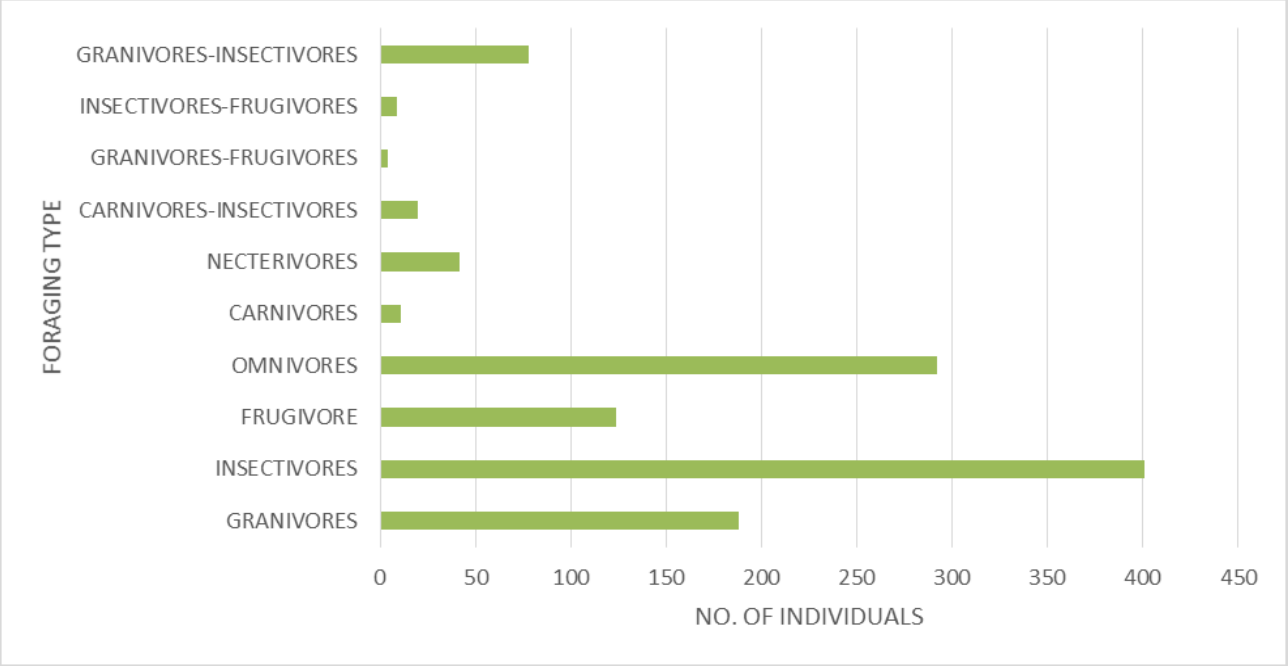

Figure 3: Foraging Mode and Number of Bird Species

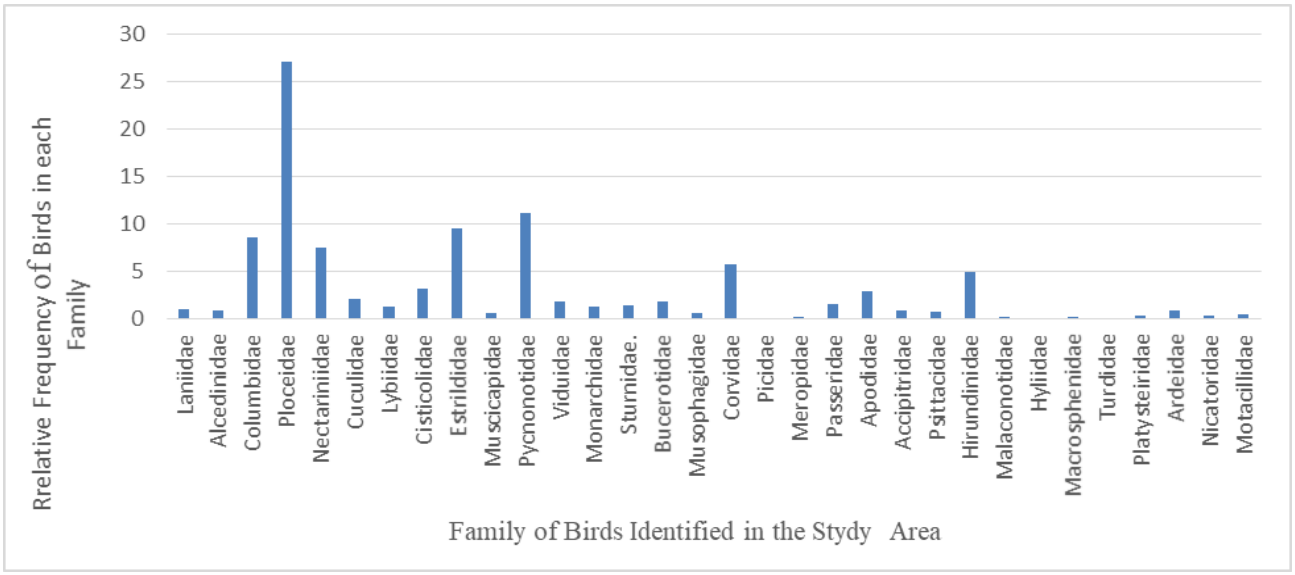

Figure 4: Family of Bird Species Identified

The three most often observed species throughout the study were granivores, omnivores, and insectivores, in that order (Fig. 4). According to Erwin et al (2002), the study location, The Kakum Conservation Area, is a lush, wet, evergreen rain forest with dense foliage; insects and seeds (grains) prefer moist environments and dense foliage. Insectivore, omnivore and granivore birds were therefore observed in large numbers in and around Kakum National Park due to the existence of a significant food source. According to Chettri et al. (2005), a habitat with dense vegetation, such as increased tree density and basal regions, influences the high existence of insects and seed; as a result, birds that feed on both insects and grains (Omnivores) were also abundant. Most birds get at least some of their nutrition from seed. Once more, studies by the Academy of Natural Sciences at Drexel University show that insectivorous birds get the majority of the water they require from their prey. Species from the family Pycnonotidae were recorded in four different feeding categories. These species include Swamp Palm Bulbul being insectivores, *Anropadus virens* (Little Greenbul) a frugivore, and *Calyptocichlaseri nanicatorchloris* (Western Nicator) an omnivore. The Nicatorchloris (Western Nicator), according to Borrow and Demey

(2010), has been proposed to be in a separate family (Nicatoridae) from the family Pycnocotidae.

Insectivores were identified to be the most diverse and numerous species in the research area, supporting Rajashekara and Venkatesha's findings (2014). The occurrence and abundance of insectivorous species depend on the availability of a variety of food sources for adults and young as well as safe habitat for nesting and roosting in and near forest environment. On the one hand, insectivores in agricultural areas aid farms by reducing the number of insect pests in agricultural and habitation habitats, which raises the farms' conservation value for birds and other animals. (Johnson et al. 2010).

The location of the study had one of the lowest densities of nectarines, therefore the timing of flowering and the presence of more nectarivores in the forest edge community may be to blame. According to Fleming & Sosa (1994), the structure and makeup of birds alter throughout time and space depending on the availability of food supplies. Variation is particularly obvious in bird species that eat patchy and transient food sources like nectar and fruit. As the level of land modification rose, Walterz et al. (2005) discovered fewer species of nectarivore in disturbed landscapes (farmland/settlement). According to Cotton (2007), an increase in nectar availability is associated with an increase in the diversity and abundance of nectarivores. Because of their small size, nectarivores are challenging to monitor and are probably underappreciated in comparison to other guilds, according to Loiselle (1988). In addition, more bird species were discovered in the forest than in the disturbed region, according to Li et al. (2013).

The capture rate of frugivores in forests is typically higher during times when fruits are abundant, and the presence of some species belonging to the family Stunidae, Pycnonotidae is a perfect indicator of forest regeneration in semi-degraded/disturbed habitat such as a forest. Moegenburg and Levey (2003) note that the availability, abundance, and richness of fruiting plants are significant and associated with the diversity of frugivorous bird species and foraging. In the early stages of tropical forest succession and restoration, the tolerance of frugivore species to disturbed environments is crucial (Corlett, 2017). According to Vallejo et al. (2006), existing green spaces must be preserved, and fruit trees must be added, to boost bird biodiversity. The Kakum environment will have a distinctive food web. A food web is a collection of organisms connected by interactions between consumers and resources, as well as predators and prey, and it represents all of the connected food chains in an ecological community. With the presence of hawks, who eat tiny birds, flycatchers, and swifts, which eat flying insects, no food source will go to waste when taking into account the many foraging guild groups. The International Union for Conservation of Nature and Natural Resources (IUCN) Red List 2015-4 lists three of the species identified as being of global concern and vulnerable, which adds to the interest of the observations. Species that are considered vulnerable are those that are most likely to go extinct unless certain conditions are changed.

Numerous bird species' distribution and abundance are influenced by the type of flora that makes up the majority of their habitats. Bird species abundance was highly correlated with vegetation traits, suggesting that areas with abundant plant life supported more birds. Because less resources are offered by this vegetation type within the sites, the relative low bird abundance in the highly disturbed areas compared to the other sites may be the result. A certain bird species may arise, increase or decline in population, and disappear when the habitat changes as vegetation changes along a long, complex geographic land environmental gradient. (Lee and Rotenberry, 2005)

The families ploceidae were recoded the higher number of individual species with the relative abundance of 27.203 and pycnonodidae recorded the second highers number of species in the study area, probably because the conditions needed by their members were available in the study area. Example, Village Weaver (*Ploceus cucullatus*) belonging to Ploceidae is the most abundant species in the study area due to the abundance of their food (Seed-eating birds). The Common Bulbul (*Pycnonotus barbatus*) belonging to Pycnonotidae are also among the abundant species and are mostly found on farmlands due to the availability of food (Seeds) (Aziz et al. 2015). They were commonly observed on the ground and in grassy habitat where they would pick grains from plant sources such as maize and grasses. This shows

that these two families are the most diverse in the study area. Most plants completed their reproductive processes between the early months of the year. Also, harvesting of crops on farmlands started in January and there were much left-over foods on farmlands for birds to feed on (Agyei-Ohemeng et al. 2017). Granivores are considered as pests by local farmers in the area (Kennedy, 2000). Moorcroft et al., (2002) concluded that fields left fallow after harvest support high densities of many species of granivorous birds, and they emphasized that variation in the abundance and availability of 41 weeds affects the diversity of granivorous species. Furthermore, the presence of a high diversity of granivores in a habitat indicated habitat disturbances (Gray et al. 2007).

5.0. CONCLUSION

The study gathered data on the structure and diversity of bird communities in and around Kakum National Park, and the findings imply that resource availability in a particular area or habitat determines the diversity, abundance, and distribution of birds. Nevertheless, birds can be divided into different groups based on their feeding habits. The study clearly shows that the majority of the bird species were found in places with dense vegetation and closed canopies. Since factors like fruits, seeds, flowers, and grains are present on healthy vegetation or habitat, this type of habitat promotes the growth of insects.

There are various bird species from various bird families that belong to various guilds of feeders. The Kakum National Park and Kakum Conservation Area have an extremely broad range of bird species, which is a sign of excellent ecological stability. The study also adopted an ecological perspective by concentrating on the ways that birds assist humans by interacting with the environment through their foraging behaviors. It should be mentioned, however, that birds' feeding habits often improve the ecosystem in ways that are ecologically beneficial. Nevertheless, if man made activities take hold, the diversity of bird species may fall.

Again, it may be said that viewing birds in local communities near protected areas has the greatest potential to inform residents and raise their knowledge of the value of bird ecology to local, national, and global biodiversity.

5.1. RECOMMENDATION

Promotion of and education in bird watching in communities around Kakum National park (KNP) has a considerable potential to produce money through the protection, conservation, and promotion of natural areas. This can boost the contribution of bird watching in rural communities.

The lack of understanding among the populace regarding the significance of birds in the ecosystem as pollinators, pest controllers, and environmental health indicators, must be promoted so that the municipality's department of natural resources, land, and environment will educate the populace about conservation issues. This can help in the education on the importance of birds to the ecosystem.

To capture both nocturnal and diurnal bird species throughout various seasons of the year, an intense investigation and a survey of a comparable nature should be conducted. This could aid in identifying the number of birds of international importance that are lacking from the research

In order to find the best period for bird viewing, similar research comparing bird species populations during the rainy and dry seasons should be conducted.

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APPENDIX

Categorization of birds and their ecological status in Kakum National Park

Granivore	**Scientific name**	**Family**	**Ecological status**
Yellow-Mantled Widow Bird	*Euplectes macroura*	Ploceidae	Lc
Village Weaver	*Ploceus cucullatus*	Ploceidae	Lc
Bar-Breasted Fire Finch	*Lagonosticta rufopicta*	Estrildidae	Lc
Chesnut Breasted	*Nigrita bicolor*	Estrildidae	Lc
Black-Bellied Seed Cracker	*Pyrenestes ostrinus*	Estrildidae	Lc
Black and White Mannikins	*Spermestes bicolor*	Estrildidae	Lc
Northern Grey-Headed Sparrow	*Passer griseus*	Passeridae	Lc
Red Eyed-Dove	*Streptopelia semitorquata*	Columbidae	Lc
River Ramped Dove	*Spilopelia chinensis*	Columbidae	Lc
Insectivores	**Scientific name**	**Family**	**Ecological status**
African Emerald Cuckoo	*Chrysococ cyxcupreus*	Cuculidae	Lc
Klass Cuckoo	*Chrysococ cyxklaas*	Cuculidae	Lc
Diedric Cuckoo	*Chrysococ cyxcaprius*	Cuculidae	Lc
Senegal Coucal	*Centropus senegalensis*	Cuculidae	Lc
Tawny-Franked Prinia	*Prinia subflava*	Cisticolidae	Lc
Grey-Backed Camoroptera	*Camaroptera brevicaudata*	Cisticolidae	Lc
Yellow-Browed Camoroptera	*Camaroptera superciliaris*	Cisticolidae	Lc
Red-Faced Cisticola	*Cisticola erythrops*	Cisticolidae	Lc
Dusky Blue Flycatcher	*Muscica pacomitata*	Muscicapidae	Lc
Blue-Shoulders robin-Chatt	*Cossypha cyanocampter*	Muscicapidae	Lc
Grey-Throated Tit-Flycatcher	*Myioparus griseigularis*	Monarchidae	Lc
Blue-Headed Crested Flycatcher	*Trochocer cusnitens*	Monarchidae	Lc
Red-Bellied Paradise Flycatcher	*Terpsiphone rufiventer*	Monarchidae	Lc
Paradise Flycatcher	*Terpsiphone*	Monarchidae	Lc
Buff-Spotted Woodpecker	*Campethera nivosa*	Pecidae	Lc
Black Bee-Eater	*Merop sgularis*	Meropidae	Lc
Little Swift	*Apus affinis*	Apodidae	Lc
Green Hylia	*Hylia prasina*	Hyliidae	Lc
Kemps Long Bill	*Macrosphenus kempi*	Macrosphenidae	Lc
Green Crombec	*Sylvietta virens*	Macrosphenidae	Lc
African Thrush Bird	*Turdus pelios*	Turdidae	Lc
Chest nut wattle-Eye	*Platysteira castanea*	Platysteiridae	Lc
Cattle Egret	*Bubulcus ibis*	Ardeidae	Lc
Little Egret	*Egretta garzetta*	Ardeidae	Lc
Western Nicator	*Nicator chloris*	Nicatoridae	Lc
Barn Swallow	*Hirundo rustica*	Hirundinidae	Lc
Press Swift Swallow		Hirundinidae	Lc
Common House Matin	*Delichon urbicum*	Hirundinidae	Lc
Black-Necked Weaver	*Ploceus nigricollis*	Ploceidae	Lc
Maxwell Black Weaver	Ploceus albinucha	Ploceidae	Lc
Violet Black Weaver	Ploceus nigerrimus	Ploceidae	Lc
Red-Vinted Malimbe	Malimbus scutatus	Ploceidae	Lc
Red-Headed Malimbe	Malimbus rubricollis	Ploceidae	Lc

Little Greenbul	*Eurillas virens*	Pycnonodidae	Lc
Yellow Wipsked Greenbul	*Eurillas latirostris*	Pycnonodidae	Lc
African Dwarf Kingfisher	*Ispidina lecontei*	Alcedinidae	Lc
Black Crown Tchagra	*Tchagra senegalus*	Malacanotidae	Lc
Brown Crown Tchagra	*Tchagra australis*	Malacanotidae	Lc
Frugivores	**Scientific name**	**Family**	**Ecological status**
Western Grey Plantain Eater	*Crinifer piscato*	Musophagidae	Lc
Pipping Hornbill	*Bycanistes fistulator*	Bucerotidae	Lc
African Pied Hornbill	*Lophoceros fasciatus*	Bucerotidae	Lc
African Grey Hornbill	*Lophoceros nasutus*	Bucerotidae	Lc
Swamp Palm Bulbul	*Thescelocichla leucopleura*	Pycnonotidae	Lc
Honeyguide Greenbul	*Baeopogon indicator*	Pycnonotidae	Lc
White-Throated Greenbul	*Phyllastrephus albigularis*	Pycnonotidae	Lc
African Green Pigeon	*Treron calvus*	Culumbidae	Lc
Western Nicator	*Nicator chloris*	Nicatoridae	Lc
Nacked-Faced Barbet	*Gymnobucco calvus*	Lybiidae	Lc
Yellow-Spotted Tinkerbird	*Pogoniulus chrysoconus*	Lybiidae	Lc
Yellow-Fronted Tinkerbird	*Pogoniulus chrysoconus*	Lybiidae	Lc
Red-Ramped Tinker Bird	*Pogoniulus atroflavus*	Lybiidae	Lc
Vieillot's Barbet	*Lybius vieilloti*	Lybiidae	Lc
Omnivores	**Scientific name**	**Family**	**Ecological status**
Common Garden Bulbul	*Pycnonotus barbatus*	Pycnonodidae	Lc
Slenderbill Greenbul	*Stelgidillas gracilirostris*	Pycnonodidae	Lc
Simple Leaflove	*Chlorocichla simplex*	Pycnonodidae	Lc
Cameroon Sombrine Greenbul	*Andropadus importunus*	Pycnonodidae	Lc
Splendid Glossy Starling	*Lamprotornis splendidus*	Sturnidae	Lc
Pied Crow	*Corvus albus*	Corvidae	Lc
Red-Fronted Parrot	*Poicephalus gulielmi*	Psittacidae	Lc
Bronze Mannikins	*Spermestes cucullata*	Estrildidae	Lc
Western Bluebill	*Spermophaga haematina*	Estrildidae	Lc
Pied Wagtail	*Motacilla alba*	Motacillidae	Lc
Green Turaco	*Tauraco persa*	Musophagidae	Lc
Blue-Headed Wood Dove	*Turtur brehmeri*	Columbidae	Lc
Tambourin Dove	*Turtur tympanistria*	Columbidae	Lc
Blue-Spotted Wood Dove	*Turtur afer*	Columbidae	Lc
Tiny Sunbird	*Cinnyris minullus*	Nectriniididae	Lc
Buff-Throated Sunbird	*Chalcomitra adelberti*	Nectriniididae	Lc
Superb Sunbird	*Cinnyris superbus*	Nectriniididae	Lc
Olive Bellied Sunbird	*Cinnyris chloropygius*	Nectriniididae	Lc
Copper Sunbird	*Cinnyris cupreus*	Nectriniididae	Lc
Yellow-Billed Barbet	*Trachyphonus purpuratus*	Lybiidae	Lc
Carnivores	**Scientific name**	**Family**	**Ecological status**
Yellow-Billed Kite	*Milvus aegyptius*	Accipitridae	Lc
Lizard Buzzard	*Kaupifalco monogrammicus*	Accipitridae	Lc
African Haired Hawk	*Polyboroides typus*	Accipitridae	Lc
Nectarivores	**Scientific name**	**Family**	**Ecological status**
Callerd Sunbird	*Hedydipna collaris*	Nectriniididae	Lc
Little Green Sunbird	*Anthreptes seimundi*	Nectriniididae	Lc
Splendid Sunbird	*Cinnyriscoccini gastrus*	Nectriniididae	Lc
Green-Headed Sunbird	*Cyanomitra verticalis*	Nectriniididae	Lc
Insect-Frugivore	**Scientific name**	**Family**	**Ecological status**

Speckled Tinkerbird	*Pogoniulus scolopaceus*	Lybiidae	Lc
Grey Headed Nigrita	*Nigrita canicapillus*	Estrildidae	Lc
Chesnut Breasted Nigrita	*Nigrita bicolor*	Estrildidae	Lc
Insect-Granivores	**Scientific name**	**Family**	**Ecological status**
Black Winged Bishop	*Euplectes hordeaceus*	Ploceidae	Lc
Oranged-Checked Waxbill	*Estrilda melpoda*	Estrildidae	Lc
Red-Fronted Antpecker	*Parmoptila rubrifrons*	Estrildidae	NT
Pintail Whydah	*Vidua macroura*	Viduidae	Lc
Laughing Dove	*Spilopelia senegalensis*	Columbidae	Lc
Insect-carnivores	**Scientific name**	**Family**	**Ecological status**
Malachite Kingfisher	*Corythornis cristatus*	Alcedinidae	Lc
Shining Blue Kingfisher	*Alcedoqua dribrachys*	Alcedinidae	Lc
Blue-Breasted Kingfisher	*Halcyon malimbica*	Alcedinidae	Lc
Common Fiscal	*Lanius collaris*	Laniidae	Lc
Gran-Frugivores	***Scientific name***	***Family***	***Ecological status***
Grey-Headed Wood Dove	*Leptotila plumbeiceps*	Columbidae	Lc

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Cheek List of Ethnobotanical Plants of Tehsil Colony, Samarbagh, District Dir Lower, Khyber Pakhtunkhwa Pakistan

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ABSTRACT

An ethnobotanical survey was carried out on the flora of Smarbagh Colony from August 2021 to September 2022. Smarbagh Colony situated in District Dir Lower, in regards to exploring the ethnobotanical potentiality of plants in the area. A total of 75 species belong to fifty-five families. Out of fifty-five families fifty-one families belong to angiosperm and one family belongs to gymnosperm and three families belong to Pteridophytes. Out of 39 families of angiosperms 4 families belong to Monocot and 47 families belong to Dicot. Rosaceae family has the largest number of species 7, followed by Poaceae and Lamiaceae have 5, 5 species, Asteraceae and Rutaceae have 4 species and Polygonaceae, Rhamnaceae and Urticaceae have 3 species. Amaranthaceae, Brassicaceae, Ebenacaeae, Euphorbiaceae, Fabaceae, Fagaceae, Moraceae and Solanaceae have 2 species, while the remaining families show the lowest number of species. Ethnobotanical study of plants clearly showed that all the 90 plant species reported from Tehsil Colony, Samarbagh had some kind of traditional or vernacular uses in the district. The largest ethnobotanical class was of 31 species which were used as Medicinal, followed by 25 Fodder and Forage species, 14 fuel wood species, plant species that were used for more than three purposes (miscellaneous), 11 species were used as a vegetable, while 9 species are ornamental plants. The results indicate that the area is climatically and ecologically dry temperate i.e., high species richness and low abundance and this is supported by the majority of species used as fodder and forage.

1. INTRODUCTION

District Dir Lower is situated in the north-western part of the Khyber Pakhtunkhwa province at 34°, 37° to 35°, 07'N Latitude and 71°, 31°to 72°, 14'E longitude. It is surrounded by Dir Upper from the north, Malakand in the southwest, Swat from the east and in the west by the tribal district Bajaur. It lies at 2700 feet (823 m) from the sea level. River Panjkora are flow in the middle of the two-sister district, Dir Upper and Dir Lower. Snow -covered mountains peak is the source of feed for this River. The total area of the Dir lower is 1582 km2 and the total population is 1,435,917 (2017 census report). The natural flora of the Valley is consisting of some coniferous forest. The vegetation of the valley is degrading by various anthropogenic

activities and intensive deforestation for agriculture practices. The commonly found plants in the area are Melia, Morus, Ficus, and Pyrus and Pinus. Samarbagh is a lush green valley that provides a good habitat for many birds like sparrows, pigeons and other animals (Anonymous, 1998). The ground floor has rich humus and moisture and the humidity is also supporting the rich distribution of ferns in the moist shady condition (Saleem et al., 2000). Further, due to the availability of favorable climatic conditions and suitable habitats for growth and development, the Pteridophytes are widely distributed in the valley. Forests are the most valuable and vagarious declining natural resource of Pakistan. Most of the forest management studies depict that forests owned by the farmers are comparatively well managed than the state forests. Liverworts and Hornworts collectively constitute a non-vascular group of plants called Bryophyte (Crandall and Stotler, 1980). The Plant body is gametophyte which is relatively small, ranging from 2 cm to 20 cm long. Bryophytes play an important, though inconspicuous role in the cycles of nature. Some of them provide food for herbivorous mammals, birds and other animals.11 fungal species are isolated from rhizosphere and non-rhizosphere regions of Pteris vittata (Yasmin and Saxena, 1990). Comparing to bryophytes they are somehow resistant to drought and even some ferns are serious weeds and their control is a problem as Salvinia molesta (Jayanth, 1987). A study was conducted in a greenhouse to investigate the effect of defoliation and injury on dormant buds and apices of Schizoid fern (Punetha, 1987). Some of the members of this group are economically important e.g. Christella parasitica, Marsilea minuta, Pteris vittata and Salvinia molesta are used to fix green plant tissues (Devi et al. 1994), others are toxic and can cause diseases. The term‟ Ethnobotany‟ coined by an American Botanist J William Hershberger in 1896 (Cotton, 1996). Ethnobotany is a branch of biological science that show medicinal relationship exist between people and plants. German physician Leopold Glueck was the first person to work on the traditional uses of medicinal plants in Sarajevo (Bosnia). In the 19th century he reported the uses of plants. Their published work is considered to be the first ethnobotanical work (Chaudhary, et al 2008). In last century ethnobotany is developed to a more practical field from a documentation field of science, and play vital role in survival of plants resources and protection (Khan 2011). From evidence it is demonstrated that people living an area for long period of time have knowledge about local flora and ecology (Khan 2011). Ethnobotany play a vital role and become essential part of our world, new ethnobotanical research prove that people used traditional drugs for treatment of various diseases since time immemorial and plants are very important element of tribal life (Amrit 2007, Bourdy 2008).

2. Material and Methods

2.1 Study Area

An extensive study was carried out on the flora of Smarbagh Colony from August 2021 to September 2022. The area was frequently visited for the collection of data belonging to the plant diversity of the flora. The data for the research project was obtained in two phases.

2.2 Fieldwork (Phase-1)

In this phase all the vascular plants of the hill were thoroughly collected. The plant specimens were identified with the help of available literature, herbarium specimens and Flora of Pakistan. The sampled plants were processed according to the international standard. The ethnobotanical information regarding all aspects of plant use of the flora of Sheen Ghar was obtained. This information's was collected through a questionnaire, observations, interviews and guided field walks.

2.3 Observations

The local community has a very rich knowledge of plant use, to know the practices of indigenous knowledge, repeated surveys including transect walks, discussions and informal talks with hakims and local people were made. Field observations include local methods of plant collection, harvesting time, drying, processing, storage and utilization. This information enabled me to develop a broader envision of the interactions of local people with plant resources. A formal questionnaire was developed keeping in view the experiences of observations for the development of more systematic data and field surveys. A pre-test for the application of the questionnaire was applied at the same time all the plants were collected during flowering or fruiting stage and refine the same for the large-scale application in the field. At the same time all the plants were collected during the flowering or fruiting stage and consequently were poisoned, pressed and preserved.

2.4 Interviews

A field diary was used to record the data during interviews with the plant collectors, local people and hakims. The interviews and group discussions were held with villagers that provided valuable information including all sorts of plant use. The structured and semi-structured questionnaires were adopted in interviews to get participatory, qualitative as well as Quantitative data about the plant resources and their utilization by the local people during the survey.

2.4 Survey of vascular plants

The research area was extensively visited during flowering and fruiting seasons of the year. Vascular plant diversity information that includes Pteridophytes, Gymnosperms, and Angiosperms was obtained throughout the year at appropriate seasons. The relevant data pertaining to the locality, habitat, habit, family, scientific, local names, part used, and other valuable information were recorded through a questionnaire. The plant specimens were pressed in newspaper and dried. The collected plant specimens were identified. High-resolution pictures were selected from the photographs of the plants taken in the research area. The specimens were deposited in the herbarium of Ghazi Umara Khan Degree College Samarbagh Dir Lower.

2.6 Ethnobotanical Survey

The plant specimens collected from the area were classified on the basis of their overall utility in the valley. The ethnobotanical information was collected through interviews of the inhabitants, herd men, hakims, and plant collectors on the basis of age and gender group of the area. The information includes plant usage is medicinal, fuel, timbers, fodder, fruits, plants, vegetables, condiments, spices, plants used as ornamental, fences, dyes, and poisonous.

2.7 Documentation and analysis of the obtained data (Phase-2)

Analysis and Documentation of Research Data:

The information collected during the survey of the area was analyzed and documented according to the set procedures. The data obtained regarding plant use from the area was checked and compared with the available literature and hence reconfirmed. This information's was arranged according to their indigenous uses and is presented in tabulated form. The dependence of the local population on plant resources, their ethnomedicinal and cultural aspects as well as their conservation status was also documented. The inventory for various uses includes voucher numbers, scientific names, local names, family, habitat, habit, part used and flowering season.

3. RESULT

3.1 Floristic Inventory

The floristic inventory is the complete checklist of species of a defined geographical area and it gives an outlook of the vegetation type of the area. Plant resources are severely affected by anthropogenic activities, tillage practices, natural calamities and other biotic and abiotic influences. The present research is first-hand information on the flora of the area. A total of 57 species belong to 43 families. Out of 59 families the 39 families belong to angiosperm and one family belongs to gymnosperm and three families belong to Pteridophytes. Out of 59 families of angiosperms the 4 families belong to Monocot and 47 families belong to dicot. Rosaceae family have largest species in the study area which contain 7 species followed by Poaceae and Lamiaceae have 5 species. Asteraceae and Rutaceae have 4 species and Polygonaceae, Rhamnaceae and Urticaceae have 3 species. Amaranthaceae, Brassicaceae, Ebenacaeae, Euphorbiaceae, Fabaceae, Fagaceae, Moraceae and Solanaceae have 2 species, while the remaining families show the lowest number of species.

PTERIDOPHYTES

Plants No: 1
Family name: Adiantaceae
Botanical name: *Adiantum capillus veneris* L.
Local name: Bibi Aisha sanra
Part used: Fronds
Local uses: Fronds juice used in cough and sore throat.

Plants No: 2
Family name: Dryopteridaceae
Botanical name: *Dryopteris serrato-dentata* (Bedd.) Hay
Local name: Kwanjay
Part used: Rhizome
Local uses: Rhizome is anthelminthic.

Plants No: 3
Family name: Equisetaceae
Botanical name: Equisetum arvense L.
Local name: Bandakay
Part used: Shoots
Local uses: The extracts of shoots are mixed with mustard oil and used as a hair tonic and against lice. It is used for cleaning and washing utensils.
GYMNOSPERMS

Plants No: 4
Family: Pinaceae
Botanical name: *Cedrus deodara* (Roxb. ex D. Don) G. Don
Local name: Diyar
Parts used: Oil, Bark, gum and wood
Local uses: The wood is durable and resistant to white ants, fungal attacks, and water. It yields the strongest timber and is employed extensively in buildings, for making railway sleepers, carriages, and for making bridges.

Plants No: 5
Family name: Pinaceae
Botanical name: *Pinus roxburghii* Sargent
Local name: Nakhtar
Part used: The whole tree
Local uses: The resin locally known, as "Jaula" is a stimulant used for ulcers, snakebites, scorpion stings, and skin diseases. It is a blood purifier. Wood is an aromatic, antiseptic, deodorant, diaphoretic, and stimulant, and is used in the burning of the body, cough, fainting, and ulceration. Wood is used as timber in construction, making a good fuel.

ANGIOSPERMS (Monocots)

Plants No: 6
Family name: Acoraceae
Botanical name: Acorus calamus L.
Local name: Khawaja
Part used: Rhizome
Local uses: Rhizomes are emetic and a good remedy for flatulence, colic and diarrhea. It is also used against snake bites.

Plants No: 7
Family name: Araceae
Botanical name: Colocacia esculenta (L.) Schott
Local name: Kachalo
Part used: Corn
Local uses: Corn is used as vegetable.

Plants No: 8
Family name: Cyperaceae
Botanical name: Cyperus rotundus L.
Local name: Shamookha
Part used: Tuber and rhizome
Local uses: Used for the treatment of diarrhea, diabetes, malaria.

Plants No: 9
Family name: Poaceae
Botanical name: *Avena sativa* L.
Local name: Jawdar
Part used: Seeds
Local uses: use as energy booster. Correct sleeping disorder.

Plants No: 10
Family name: Poaceae (Gramineae)
Botanical name: *Cynodon dactylon* (Linn.) Pres.
Local name: Kabal/drab
Part used: Whole plant
Local uses: It is used along with rose flower in jaundice. It is also used for piles and dysentery.
Plants No: 11
Family name: Poaceae (Gramineae)
Botanical name: *Saccharum bengalensis* Retz.
Local name: Nal
Part used: Whole plant
Local uses: It is used as hedge, soil binder and for various utensils.

Plants No: 12
Family name: Poaceae (Gramineae)
Botanical name: Sorghum helepense (L.) Pers.
Local name: Dadam
Part used: Whole plant
Local uses: It is used as fodder and hey fodder.

Plants No: 13
Family name: Poaceae
Botanical name: Zea mays L.
Local name: Jawar
Part used: Seeds
Local uses: used for diabetes, high blood pressure, fatigue and high cholesterol level. Seeds as used as a major source of food.

ANGIOSPERMS (Dicots)

Plants No: 14
Family name: Anacardiaceae
Botanical name: *Pistacia chinensis Bunge* spp. *integerrima* (J.L.S) Rech. f.

Local Name: Kikar
Part used: Insect-infected galls
Local Uses: Fruits and gall extract is given in jaundice. Leaves are used as fodder for cattle. Wood yields timber, and is used for making furniture. Branches serve the purpose of fuel wood.

Plants No: 15
Family name: Amaranthaceae
Botanical name: Amaranthus viridis L.
Local name: Chalwayi
Part used: The whole plant
Local uses: Cooked as pot-herb, used as an emollient.

Plants No: 16
Family name: Amaranthaceae
Botanical name: *Chenopodium ambrosioides* L.
Local name: Sakha boty
Part used: shoot
Local uses: The young shoots are used as laxative and against malaria.
Plants No: 17
Family name: Apiaceae
Botanical name: *Foenicullum vulgare* Mill.
Local name: Kagainali
Part used: Fruit, leaves, seeds
Local uses: Seed oil is used as vermicide and stomachache. Seed is the source of volatile oil. Leaves are used as diuretic and digestive. Fruit juice is used to improve eyesight.

Plants No: 18
Family name: Araliaceae
Botanical name: *Hedera nepalensis* K. Koch.
Local Name: Perwati
Part used: Whole plant
Local uses: Leaves and berries are stimulant, cathartic, and diaphoretic. Dry leaves are used to stimulate sores. Berries are purgative and are used in febrile disorders. Aphrodisiac, Nerve tonic, General tonic, and Depurative.

Plants No: 19
Family name: Asclepiadaceae
Botanical name: *Calotropis procera* (Ait.) Ait.f.
Local name: Spulmai
Part used: Latex of leaves, leaves and roots
Local uses: latex is used as purgative. In small amount its seeds along with red chili and opium are also used for cholera. Milky latex of stem is used in eczema and ring worm.

Plants No: 20
Family name: Asteraceae
Botanical name: *Artimisia absinthium* L.
Part used: leaves
Local uses: used for dyspepsia, and nephrothy

Plants No: 21
Family name: Asteraceae (Compositae)
Botanical name: Artemisia vulgaris L.
Local name: Tarkha
Part used: Leaves
Local uses: Leaves are anthelminthic and useful for curing skin diseases.

Plants No: 22
Family name: Asteraceae
Botanical name: Helianthus annuus L.
Local name: Nwar parast
Part used: Whole plant
Local uses: Oil is used for cooking. Plant is ornamental.

Plants No: 23
Family name: Asteraceae
Botanical name: Verbesina encelioides (Cav.) Benth. & Hook.f. ex A. Gray
Local name:
Part used: Whole plant
Local use: Used in the treatment of gum sores, hemorrhoids, cancer, and skin problems. Also used as an ornamental plant.

Plants No: 24
Family name: Begnoniaceae
Botanical name: *Pyrostegia venusta* (Ker Gawl.) Miers
Local name: Khaista boty
Part used: The whole plant
Local uses: Used as infusion or decoction, also used as a general tonic. Also used as a treatment for diarrhea, cough etc. Also used as an ornamental plant.

Plants No: 25
Family name: Berberidaceae
Botanical name: *Berberis lycium Royle*
Local name: Kowary
Part used: Root, Fruits and Stem
Local uses: The roots are grinded into powder and the powders is placed on wounds for early recovery.

Plants No: 26
Family name: Brassicaceae
Botanical name: Lepidium pinnatifidum Ledeb.
Part used: leaves, seed

Local uses: Seeds are used for painful menstruation in Women. Leaves are cooked as vegetables. Whole plant is effect in constipation and pile.

Plants No: 27
Family name: Brassicaceae
Botanical name: Nasturtium officinale R.Br.
Local name: Talmeera,
Part used: Vegetative portion
Local uses: A vegetable, salad and pot-herb. It is antiscorbic, appetizer, diuretic and used in chest infections and stomachache.

Plants No: 28
Family name: Buxaceae
Botanical name: *Sarcococca saligna* (D. Don) Muell. Arg.
Local name: Shenaoly
Part used: Leaves,
Local uses: Used as a laxative and a blood purifier and for relieving muscular pain. Used as a useful soil binder. Leaves are laxative and blood purifier and good remedy for muscular pains.

Plants No: 29
Family name: Cactaceae
Botanical name: Opuntia dillenii Haw.
Local name: Zaqqum
Part Used: Phylloclade's, fruits
Local uses: The poultice made from the phylloclade is used for extracting guinea worms. The fruits are edible, demulcent and expectorant. The ripe fruit juice is a remedy for asthma and whooping cough. The plant is grown as hedge plant in some places.

Plants No: 30
Family name: Cannabaceae
Botanical name: *Cannabis sativa* L.
Local name: Bung
Part used: Leaves, Bark and seeds
Local uses: Warmed leaves are tied over the affected parts of the body for the treatment of spasm. Juice added with milk and nuts to make "Tandai" a cold drink which produces a pleasant excitement. It is sedative, tonic, narcotic, anodyne, refrigerant, and antispasmodic.

Plants No: 31
Family name: Capparaceae
Botanical name: *Capparis spinosa* L.
Local name: Wakha
Part used: Roots & Leaves
Local uses: Used as folk medicine to treat diabetes, hepatitis, and arthritis.

Plants No: 32
Family name: Cucurbitaceae
Botanical name: *Cucurbita pepo* L**.**
Local name: Kadoo
Part used: Leaves & Fruit
Local uses; used as an anti-inflammatory, analgesic, anti-diabetic. Used as a source of food**.**

Plants No: 33
Family name: Ebenacaeae
Botanical name: Diospyrus kaki L.
Local name: Farsi man/Ziar Amlok
Part used: Fruits, wood
Local uses: It is a very common commercial fruit tree. It is used in dry and fresh form and is very delicious. It is a laxative. Fruit stimulates gastric activities, treat diarrhea, piles, and has laxative properties.

Plants No: 34
Family name: Ebenacaeae
Botanical name*: Diospyrus lotus* L.
Local name: Tor Amlok
Part used: Fruit, wood, leaves
Local uses: The fruits are edible, carminative, purgative and beneficial in blood diseases, gonorrhea, and leprosy. Infusion of the fruit is used as gargle in aphthae or stomatitis and sore throat.

Plants No: 35
Family name: Euphorbiaceae
Botanical name: Euphorbia helioscopia L.
Local name: Mandarro
Part used: Shoots, Seeds and latex
Local Uses: Cathartic and anthelmintic.
The juice is applied to eruptions. Latex is poisonous and causes swelling on skin. It also causes irritation. It is used as a fish poison. The seeds grinded squeezed and extract its oil and used as purgative.

Plants No: 36
Family name: Euphorbiaceae
Botanical name: *Ricinus communis* L.
Local name: Kharkhanda
Part used: Leaves, seeds, oil
Local uses: The leaves are emetic, narcotic, poisonous and purgative. A poultice made from the leaves is applied to swellings. Castor oil is purgative; oil is given for constipation and to mothers before and after childbirth.

Plants No: 37
Family name: Fabaceae
Botanical name: *Amphicarpea bracteata* (L.) Fernald
Local name: Moot
Part used: Roots
Local uses: used for the treatment of diarrhea.
Plants No: 38
Family name: Fabaceae
Botanical name: Robinia pseudo acacia L.
Local Names: Toor Kikar
Part used: The whole plant
Local uses: The wood is heavy, hard, strong, and durable. It is used for general construction and as a fuel. The plant is poisonous, acting as a purgative and emetic. The flowers are a good source of honey.

Plants No: 39
Family name: Fagaceae
Botanical name: *Quercus baloot* Griffth.
Local Name: Ghuara Serai
Part used: Wood, nuts (acorns)
Local uses: The seeds are edible, astringent and diuretic, Also Used in asthma, diarrhea, indigestion and gonorrhea. Prevent excessive dejection in case of heaviness in the stomach.

Plants No: 40
Family name: Fagaceae
Botanical name: *Quercus brantii* Lindl.
Local name: Khar boty
Part used: The whole plant
Local uses: Used as fuel wood, charcoal, and timber hardwood.

Plants No: 41
Family name: Fumariaceae
Botanical name: *Fumaria indica* (Hausskn.) Pugsley
Local name: Papra/shatara
Part used: Shoot
Local uses: The plant is used as a pot herb. Medicinally used as a blood purifier; diaphoretic and antipyretic.

Plants No: 42
Family name: Juglandaceae
Botanical name: *Juglans regia* L.
Local name: Ghooz
Part used: Nuts, bark, leaves, and wood.
Local uses: The bark is used for cleaning teeth and sore throat. The leaves are also used as lipsticks. It is also used as a dye. A decoction obtained from the leaves or fruit is used as antispasmodic.

Plants No: 43
Family name: Lamiaceae
Botanical name: *Ajugba bracteosa* Wall. ex Benth.
Local name: Gooti
Part used: Whole plant
Local uses: The plant is used in internal colic, angina, and for the treatment of aches.

Plants No: 44
Family name: Lamiaceae
Botanical name: Mentha arvensis
Local name: Pudina
Part used: The whole plant
Local uses: The green and dried leaves are used as antispasmodic, refrigerant, stimulant, diuretic, and aromatic. The decoction of the leaves and lemon grass is prepared and used as a febrifuge in fever. It is a honey-bee species.

Plants No: 45
Family name: Lamiaceae
Botanical name: *Mentha longifolia* (L.) L.
Local name: Villanay
Part used: The whole plant
Local uses: A powder made from the dried leaves is used in chutney, as a stimulant, an anti-rheumatic, aromatic, flavoring agent, stomachache, and carminative.

Plants No: 46
Family name: Lamiaceae
Botanical name: *Osmium bacilicum* L.
Local name: Kashmalae
Part used: Vegetative portions
Local uses: It is used for toothache, earache and diuretic. Plant is also used as ornamental and for incense /perfume.

Plants No: 47
Family name: Lamiaceae
Botanical name: *Thymus linearis* Benth.
Local name: Spairkay
Part used: Fruits
Local uses: The fruits are used for colds, coughs and bronchial troubles. It can also use for the treatment of fever, pain, and inflammation.

Plants No: 48
Family name: Malvaceae
Botanical name: *Hibiscus esculentus* (L.) Moench
Local name: Bandai
Part used: whole plant

Local uses: used for wounds and boils. Leaves are diuretic, emollient. Fruit is edible.

Plants No: 49
Family name: Meliaceae
Botanical name: *Melia azedarach* L.
Local name: Tora shandai.
Part used: Bark, leaves
Local Uses: The decoction of the leaves is employed in hysteria and for skin diseases. The leaves and flowers are effective for relieving nervous headache.

Plants No: 50
Family name: Mimosaceae
Botanical name: *Acacia modesta* Wall.
Local name: Palousa
Part used: Gum, sticks
Local uses: The gum obtained from the bark is used as a tonic and stimulant. Usually, the natives mix the gum with wheat flour, sugar is added and roasted in desi ghee, especially given to women, who give birth to new babies. Ash is used in snuff preparation.

Plants No: 51
Family name: Moraceae
Botanical name: *Ficus carica* L.
Local name: Inzar
Part used: Fruits, latex
Local uses: Fruits, both in dry or fresh form, are edible. It is laxative and demulcent, used in constipation, piles and urinary bladder problems. The latex is used against warts and to remove spines and thorns easy.

Plants No: 52
Family name: Moraceae
Botanical name: *Morus alba* L.
Local name: Spin Toot
Part used: Fruits, leaves, branches, trunk
Local uses: The fruits are eaten both fresh and dry. They are a laxative and purgative. The leaves are emollient and used for cleaning the throat and as cooling agent. Main source of fuel wood.

Plants No: 53
Family name: Myrtaceae
Botanical name: *Eucalyptus camaldulensis* Dehnh.
Local name: Laachi
Part used: leaves, seed
Local uses: Used as cough remedy and expectorant. Also used as tonic, astringent, antiseptic.

Plants No: 54
Family name: Oleaceae
Botanical name: *Olea ferruginea* Royle
Local name: Khona
Part used: Fruits, leaves and trunk
Local uses: The fruit is antidiabetic. The leaves are used for toothache and throats soar. The leaves and bark are bitter and used as a astringent, antiseptic, antiperiodic, diuretic and tonic.

Plants No: 55
Family name: Oxalidaceae
Botanical name: *Oxalis corniculata* L.
Local name: Grady tarookay
Part used: Leaves
Local uses: Used for stomach problems, fever, and dysentery. It is refrigerant, vermifuge and flavoring agent.

Plants No: 56
Family name: Papilionaceae
Botanical name: *Indigofera heterantha* Wall. ex Brand.
Local name: Ghoraja
Part used: Whole plant
Local uses: The leaves, shoots and flowers used as demulcent, refrigerant and anti-cancerous. The roots used as diuretic, carminative and the root-bark in urinary diseases.

Plants No: 57
Family name: Plantaginaceae
Botanical name: *Plantago lanceolata* L.
Local name: Ghawajabai
Part used: Leaves, fruits, seeds
Local uses: Extract of leaves is applied to sores, wounds and inflamed surfaces. The seeds are laxative and are used for dysentery and mouth diseases. The leaves slightly rubbed and used as antifungal in athlete's foot disease.

Plants No: 58
Family name: Plantanaceae
Botanical name: Platanus oriantalis L.
Local Name: Chinar
Part used: Bark
Local uses: The bark is given for toothache and diarrhea. Bark is used in rheumatism. Bark boiled with vinegar is used in dysentery and diarrhea. Powdered leaves are used in ophthalmic.

Plants No: 59
Family name: Polygonaceae
Botanical name: *Persicaria hydropiper* (L.) Delabre
Local name: Palpolak

Part used: Whole plant
Local uses: used as astringent, analgesic and hemostatic. Also used for the treatment of kidney stones, edema and asthma.

Plants No: 60
Family name: Polygonaceae
Botanical name: *Rumex dentatus* L.
Local name: Shalkhy
Part used: Leaves, roots
Local uses: Plant is used as pot-herb. It is diuretic, astringent and demulcent. It soothes the irritation caused by Urtica dioca, which often grows in association with it. Roots are astringent.

Plants No: 61
Family name: Polygonaceae
Botanical name: *Rumex hastatus* D. Don
Local name: Tarookay
Part used: Leaves, young shoots
Local uses: Fresh leaves are crushed and used to stop bleeding from wounds. It is used in chutneys and as a flavoring agent. The plant is used as antiemetic, carminative, purgative, astringent and diuretic.

Plants No: 62
Family name: Portulaceae
Botanical name: *Portulaca oleracea* L.
Local name: Warkhari
Part used: the whole plant
Local uses: Used as febrifuge, antiseptic, vermifuge. Also used as an antibacterial, antioxidant. Used as a source of food.

Plants No: 63
Family name: Myrsinaceae
Botanical name: *Myrsine africana* L.
Local name: Maru rang
Part used: Leaves, fruits
Local uses: The fruits are edible and anthelmintic. Leaves are used for fragrance in tea, as spices, carminative, appetizer, flavoring agent, and digestive.

Plants No: 64
Family name: Punicaceae
Botanical name: *Punica granatum* L.
Local name: Ananghorai
Part used: Fruits, bark, leaves
Local uses: Fresh leaves are crushed and the extract is used in dysentery, skin diseases, checking of bleeding from nose, and useful as eyewash. The fruit pericarp is used for whooping cough.

Plants No: 65
Family name: Ranunculaceae
Botanical name: *Ranunculus laetus* wall. Ex Hook.f & J. W. Thomson
Local name: Ziar goly
Part used: Leaves
Local uses: plant juice are antifungal and antimalarial, used in intermittent fevers, gout, and as thma. Paste made from leaves used for gas trouble and joints pain.

Plants No: 66
Family name: Rhamnaceae
Botanical name: *Sageretia thea* (Osbeck) M.C. Jhonston
Local name: Mamanra
Part used: Leaves, bark, fruits, roots
Local uses: Decoction of leaves is used as stimulant and blood purifier. Root decoction is very effective in jaundice. Leaves are used as fodder for cattle.

Plants No: 67
Family name: Rhamnaceae
Botanical name: *Zizyphus oxyphylla* Edgew.
Local name: Elanai
Part used: Roots, fruits
Local uses: The roots are used for curing jaundice. The fruits are edible and used for gas troubles. Also grown as hedge plant.

Plants No: 68
Family name: Rhamnaceae
Botanical name: *Zizyphus sativa* Gaertn.
Local name: Markhani
Part used: Fruit
Local uses: use in treatment of Jaundice, diarrhea, Ulcer and fever.

Plants No: 69
Family name: Rosaceae
Botanical name: *Cydonia oblonga* Mill.
Local Names: Boye
Part used: Fruits, Leaves, bark
Local uses: Leaves, buds and bark are considered as astringent. Seed is demulcent, used in dysentery, diarrhea, sore throat and fever.

Plants No: 70
Family name: Rosaceae
Botanical name: *Eriobotrya japonica* (Thunb.) Lindley.
Local names: Lokat
Part used: Fruits
Local uses: The fruit is edible; the tree is cultivated as an ornamental tree and for its fruit.

Plants No: 71
Family name: Rosaceae
Botanical name: *Malus pumila* Mill.
Local name: Manra
Part used: Fruits, flowers, wood
Local uses: Valuable commercial fruit, purgative, source of iron, expectorant, used in jams, jellies, marmalades and good for the heart.

Plants No: 72
Family name: Rosaceae
Botanical name: *Prunus armeniaca* L.
Local name: Khubani/asharay
Part used: Fruits, wood, leaves, seeds
Local uses: The fruits and seeds are eaten both fresh and dry. Dried fruit is refrigerant and laxative. It is used for fever.

Plants No: 73
Family name: Rosaceae
Botanical name: *Prunus domestica* L.
Local name: Alocha
Part used: Fruit
Local uses: The fruit is febrifuge, laxative and soma chic. Dried fruit can easily relieve constipation.

Plants No: 75
Family name: Rosaceae
Botanical name: *Rosa brunonii* Lindl.
Local name: Kuruch
Part used: Flowers, branches
Local uses: It is aphrodisiac and beneficial in bilious affections and burning of the skin. The root is beneficial in eye diseases. Used in skin and eye diseases.

Table no 1: Floristic list of the ethnomedicinal collected plant of the study area.

SL. No	Botanical Name	Local name	Study area	Species%	Family Name
1.	*Adiantum capillus-veneris* L.	Bibi Aisha sanra	Asharodheri	1.81	Adiantaceae
2.	*Dryopteris serrato-dentata*(Brdd.) Hay.	Kwanjay	Asharodheri	1.81	Dryopteridaceae
3.	*Equisetum arvense L.*	Bandakay	Garband	1.81	Equisetaceae
4.	*Cedrus deodara*(Roxb.exD.Don)	Diyar	Shenghar	3.63	Pinaceae
5.	*Pinus roxburghii* Sargent	Nakhtar	Shenghar	3.63	Pinaceae
6.	*Acorus calamus L.*	Khawaja	Asharodheri	1.81	Acoraceae
7.	*Colocacia esculenta(L.) Schott*	Kachalo	Asharodheri	1.81	Acoraceae
8.	*Cyperus rotundus*L.	Della	Lajbouk	1.81	Cyperaceae
9.	*Avena sativa L.*	Jaodar	Garband	9.09	Poaceae
10.	*Cynodon dactylon* (L.) Pers.	Kabal	Lajbouk	9.09	Poaceae
11.	*Saccharum bengalense Retz*	Nal	Lajbouk	9.09	Poaceae
12.	*Sorghum halepense*(L.) Pers.	Dadam	Garband	9.09	Poaceae
13.	*Zea mays L.*	Jawar	Shenghar	9.09	Poaceae
14.	*Pistacia chinensis* Bunge ssp.	Kikar	Asharodheri	1.81	Anacardiaceae
15.	*Amaranthus viridis* L.	Chalwayi	Asharodheri	3.63	Amaranthaceae
16.	*Foenicullum vulgare* Mill	Kagainali	Ghwargai	1.81	Apiaceae
17.	*Fumaria indica*	Sha tara	Asharodheri	1.81	Fumariaceae
18.	*Hedera nepalensis K. Koch.*	Perwati	Asharodheri	1.81	Araliaceae
19.	*Calotropis procera* (Ait.) Ait.f	Spulmai	Morani	1.81	Asclepiadaceae
20.	*Artemisia absinthium L.*		Asharodheri	7.27	Asteraceae
21.	*Artemisia vulgaris L.*	Tarkha	Garband	7.27	Asteraceae
22.	*Helianthus annuus L.*	Nwar parast	Asharodheri	7.27	Asteraceae
23.	*Pyrostegia venusta (Ker Gawl.)*	Khaista boty	Dermal	1.81	Begnoniaceae
24.	*Berberis lycium Royle*	Kowary	Ondesa	1.81	Berberidaceae
25.	*Lepidium pinnatifidum Ledeb.*	Alam	Asharodheri	3.63	Brassicaceae

26.	*Nasturtium officinale* R. Br.	Tarmira	Lajbouk	3.63	Brassicaceae
27.	*Sarcococca saligna (D. Don)*	Shenaoly	Asharodheri	1.81	Buxaceae
28.	*Opuntia dillenii* Haw.	Zoqam	Ghwargay	1.81	Cactaceae
29.	*Cannabis sativa* L.	Bung	Darmal	1.81	Cannabaceae
30.	*Capparis spinosa L.*	Wakha	Lajbouk k	1.81	Cyperaceae
31.	*Curcurbita pepo L.*	Kado	Lajbouk	3.63	Cucurbitaceae
32.	*Diospyrus Kaki*.	Ziar Amlok	Asharodheri	3.63	Ebenacaeae
33.	*Ricinus communis* L.	Kharkhanda	Biyari	3.63	Euphorbiaceae
34.	*Euphorbia helioscopia* L.	Mandaroo	Asharodheri	3.63	Euphorbiaceae
35.	*Amphicarpaea bracteata (L)*	Moot	Lajbouk k	3.63	Fabaceae
36.	*Robinia pseudo acacia* L.	Tor kikar	Asharodheri	3.63	Fabaceae
37.	*Quercus baloot* Griffth.	Ghuara Sera	Shen ghar	3.63	Fagaceae
38.	*Quercus barntiiLindl*	Khar boty	Darmal	3.63	Fagaceae
39.	*Juglans regia* L	Ghuz	Garband	3.63	Juglandaceae
40.	*Ajuga bracteosa* Wall. ex Benth.	Guti	Garband	9.09	Lamiaceae
41.	*Mentha arvensis L.*	Pondina	Lajbouk	9.09	Lamiaceae
42.	*Mentha longifolia(L.)*	Villanay	Lajbouk	9.09	Lamiaceae
43.	*Osmium bacilicum L.*	*Kashmalae*	Asharodheri	9.09	Lamiaceae
44.	*Ajuga bracteosa* Wall. ex Benth.	Guti	Garband	9.09	Lamiaceae
45.	*Mentha arvensis L.*	Pondina	Lajbouk	9.09	Lamiaceae
46.	*Hibiscus esculentus(L.)Moench*	Bandi	Lajbouk	1.81	Malvaceae
47.	*Melia azedarach* L.	Torashandai.	Asharodheri	1.81	Meliaceae
48.	*Acacia modesta*Wall.	Palosa	Morani	1.81	Mimosaceous
49.	*Ficus carica* L.	Inzar	Shen ghar	3.63	Moraceae
50.	*Morus alba L.*	Spin toot	Garband	3.63	Moraceae
51.	*Persicaria hydropiper (L.)*	palpolak	Lajbouk	5.45	Polygonaceae
52.	*Rumex hastatus* D. Don	Tarookay	Asharodheri	5.45	Polygonaceae
53.	*Sageretia thea* (Osbeck) M.C.	Mamanra	Garband	5.45	Rhamnaceae
54.	*Zizyphus oxyphylla* Edgew.	Eanley	Morani	5.45	Rhamnaceae
55.	*Zizyphus sativa Gaertn.*	Markhani	Shen ghar	5.45	Rhamnaceae

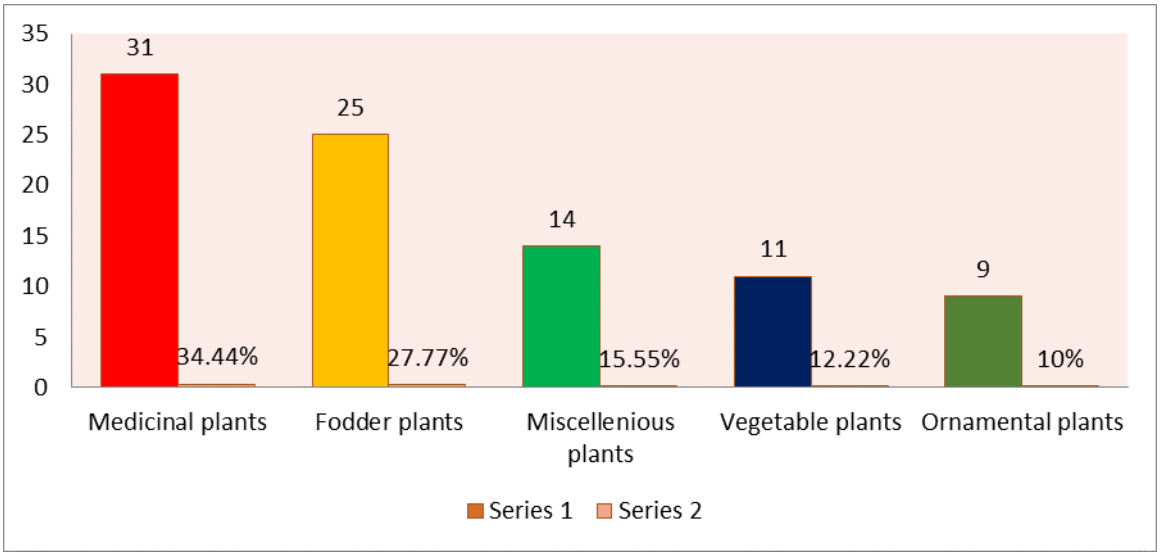

Fig: 1. Above graph showing the percentage value of the medicinal plant of the study area

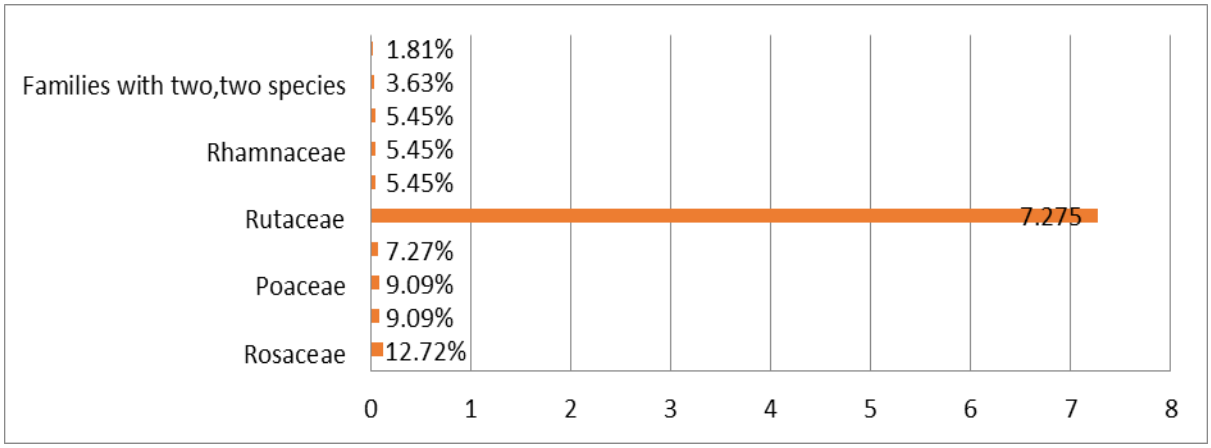

Fig: 2. Show the family composition of the study flied

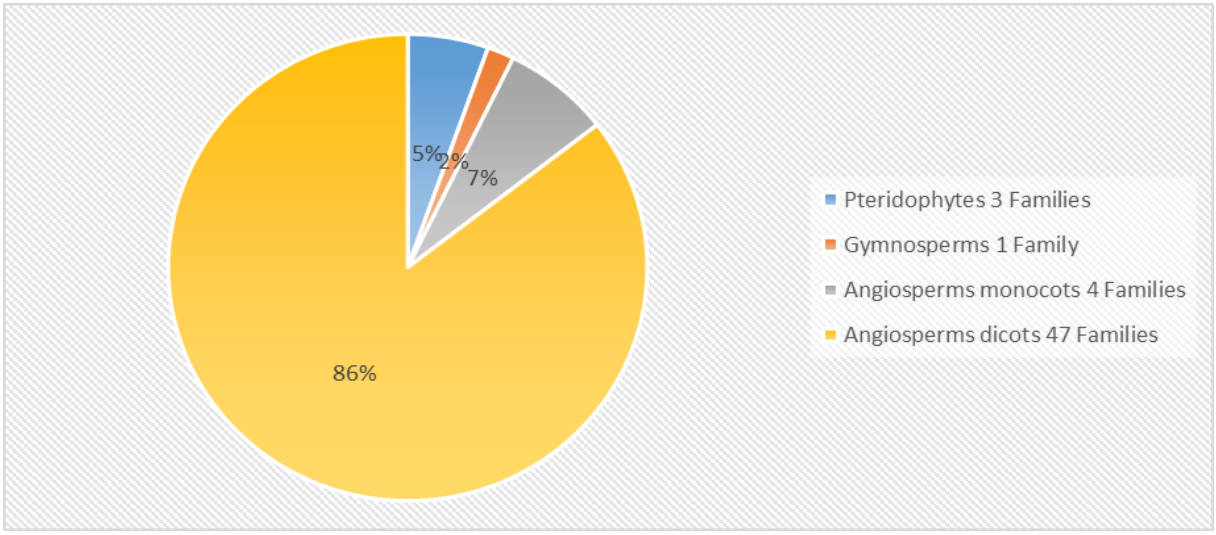

Fig: 3. Show the distribution of plant Families

3. Discussion

Pakistan has natural resources that have been gifted by nature with use and advantage of living organisms. The flora of Pakistan is very rich and diverse because of its various climatic and soil conditions and multiple ecological regions. About 6,000 species of wild plants reported from Pakistan out of which about 400 to 600 species are used for medicinal purposes, 23 species of gymnosperms and 128 species of Pteridophytes, about 4492 dicots species of flowering plants and round about 1508 monocots species are considered to be medicinally important (Jan et al., 2012). It is clear that dominant plants species are decrease day by day due to overpopulation, lack of awareness about the use of the plants by the local inhabitants. The people of the area used plants as limber and timber and cattle fodder. The majority of plants used for these purposes are *Mentha arvensis*, *Platanus orientalis*, *Dodonaea viscosa*, *Cedrus deodara*, *Pinus ruxburgii*, *Berberis lyceum*, *Olea ferruginea*, *Ricinus communis* etc. These plants have been studied and recorded for their medicinal uses like fever, asthma, dysentery etc. The results showed a similar relationship with our study due to the reason such as *Mentha arvensis* used for dysentery which is a similar to our finding. The people of the study area widely used medicinal plants for various human ailments. The current study showed that consistent indigenous knowledge on ethnomedicinal plants used in the treatment of basic human healthcare systems existed here. Most of the people live in the rural communities in the remote areas and away from the modern healthcare facilities. In the study area, the local residents are heavily dependent on medicinal plants for health issues and so the demand of ethnomedicinal plants increases day by day (Hassan, 2017). The importance of biodiversity conservation is therefore fundamental and strategies of sustainable use should be considered for long-term

availability of medicinal plants here and even in the whole country. The possible solutions for the conservation of biodiversity and ethnomedicinal flora of the study area, to strengthen national, regional, and local networking activities regarding conservation and sustainable utilization. There must be cooperation among the government, non-government organizations, and local community to help conservation of medicinal plants in the area. Furthermore, the fast populations of the study area are often unaware about the importance of biodiversity conservation; they also show poor selection of fuel wood species. There is need to re-introduce the indigenous knowledge about the conservation and management of medicinal plants resources. Even though there is no available database to deposit the documented traditional knowledge in the study area, elderly people were always pleased when we asked them about medicinal plants and their therapeutic uses. Unfortunately, the present generations lack of interest in the flied of medicinal plants. We suggest that the traditional knowledge from the elder people should be documented along with quality photography. In school, college and universities various awareness sessions (in the form conference and seminars) should be arranged for the current generation. The area heavy destruction of plants species should be conserved carefully. Future investigations should be carried out in order to ensure safe therapy concerning medicinal plants.

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Comparative Study of *Apis cerena* and *Apis mellifera*

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ABSTRACT

This paper presents a comparative analysis of the two most important honeybees found worldwide, namely, *Apis cerana* (Asian honeybee) and *Apis mellifera* (European honeybee). Both species are popular for their high-quality honey production and as effective pollinators. A. cerana is known for its hardiness, disease resistance, and ability to tolerate a wide range of temperatures. Additionally, *A. cerana* is smaller in size than *A. mellifera* and exhibits a shyer nature. Both species have similar life cycles, but *A. cerana* demonstrates greater hygiene awareness and is more capable of defending itself against potential threats or disturbances. This paper highlights the importance of understanding the unique characteristics of these two species, which can help inform management practices for beekeepers and aid in conservation efforts for these vital pollinators.

INTRODUCTION

Honeybees (Hymenoptera: Apidae), which belong to the genus Apis, are among the most well-known flying insects found in terrestrial habitats (Koetz, 2013). There are nine currently recognized Apis honeybee species worldwide, eight of which are native to Asia. *Apis mellifera* is the only Apis honeybee species outside of Asia (Koetz, 2013). Of the nine species of Apis, only A. mellifera (the European or Western honeybee) and *A. cerana* (the Asian or Eastern honeybee) have been domesticated for a long time, and are of major commercial importance. Most of these species are limited within tropical and montane zones in Southeast and South Asia, but the two species have far broader ranges. *A. cerana* occurs as far north as Japan and into the Middle East. European honeybee *A. mellifera*, the most representative and well-known honey bee, is native to Europe, Africa, and most of Asia, but it has been introduced into the Americas and Oceania, where feral populations can be found (Breed, 2010).

Due to their different ecological environment, they have different behavioral and physiological characteristics. Compared to *A. mellifera*, *A. cerana* has several distinguishing behavioral traits. It can easily adapt to extreme weather conditions and has long flight duration, effective grooming and hygienic behaviors, and cooperative group-level defenses. A well-known behavior of *A. cerana* is aggregation when a colony is exposed to dangers like predators or intruders. In such situations, guard bees produce alarm pheromones to communicate with other bees about the danger. In addition, *A. cerana* provides considerable economic benefits to the apicultural industry through its high-quality bi-products, perhaps more than *A. mellifera* (Park et al. 2015). *A. mellifera* has been subdivided into at least 20 recognized subspecies or races (Koetz, 2013). Similar to *A.*

mellifera, there are eight recognized subspecies of *A. cerana*. These subspecies tolerate a good range of temperatures from cold, temperate, to tropical ecosystems.

Even though *A. mellifera* produces a large amount of honey per colony, the indigenous *A. cerana* is profitable over *A. mellifera* because *A. mellifera* requires intensive management, standardized equipment, and larger foraging areas. *A. cerana* exhibits high tolerance to seasonal low temperatures as compared to *A. mellifera* and as a result, it is the first active honeybee on cool mornings in the northern tropics (Corlett, 2010).

MATERIALS AND METHODS

A review of the published literature in national and foreign journals, proceedings, reports, newsletters, and books has been made in an effort to compare the *A. cerana* and *A. mellifera*.

LITERATURE REVIEW

Comparison of morphological characteristics of A. melifera and A. cerana

In general, *A. cerana* is smaller than *A. mellifera*. Apart from a few conspicuous qualitative characteristics which are mainly used to discriminate between the very similar species *A. cerana* and *A. mellifera*, e.g., the radial vein of the hind wing, the tomentum on the sixth tergite or the absence of chitinous plates on the endo phallus, others are found which are also specific for *A. cerana*. *A. cerana* have more prominent and consistent striping on their abdomen with even black bands across the abdomen, whereas *A. mellifera* tend to have uneven black stripes with thinner stripes at the front and thicker black stripes towards the rear which makes it more yellow at the front and darker at the back of the abdomen. The most reliable morphological characteristic of *A. cerana* is the extension of the radial vein on the hind wing, which is absent in *A. mellifera*. The differences between *A. cerana* and *A. melifera* are most striking in the male genitalia, while they are easily overlooked in the female castes (Ruttner, 1988). The abdominal stripes (tomenta) of *A. cerana* are more pronounced than those of *A. mellifera*, and *A. cerana* workers have four abdominal stripes, whereas *A. mellifera* workers have three abdominal stripes.

Ecology and behavior

Foraging behavior

Bees gather nectar and pollen from blossoms and facilitate pollination at the same time. Nectar is later turned into honey by the bees in a nest, to provide energy in the form of carbohydrates for the colony. Foraging is one of the distinctive behaviors of honey bees which is the link between the honey bee colony and the ambient environment.

Table 1. Comparison of several specific characters between *A. cerana* and *A. melifera*.

Characters	*A. cerena*	*A. melifera*
Labrum - pigmentation	All yellow or brown	All dark or dark with yellow mark
Tibia of hind leg - drone	Grove (longitudinal)	Round
Cubital index (mean value)	4.40	2.30
Hooks on hind wing (mean value)	18.28	21.30
Endophallus Chitinous plates Upper cornua Fimbirate lobe	 Absent Three pairs Rosette-like	 Present Rudimentary Feather-like

Source: (Ruttner, 1988)

On a single foraging trip, *A. cerana* foragers tend to collect either pollen or nectar (not both) from a single species of plant, continuing to collect pollen or nectar from that plant throughout the day (Corlett, 2010). Foraging ranges of *A. cerana* vary between different studies, but maximum foraging ranges of 1,500 m to 2,500 m have generally been observed. In comparison, *A. mellifera* tends to forage across much larger distances, with maximum distances of over 10 km (Beekman and Ratnieks, 2000). Honeybees start and finish foraging often depending on ambient temperature, humidity and/or light levels of the day, as well as the availability of floral resources. In general, *A. cerana* tend to start foraging earlier than *A. mellifera*, as it requires slightly lower temperatures, light intensity and solar radiation levels to commence flight activity than *A. mellifera*. However, *A. mellifera*

start foraging later than *A. cerana* because of its larger body size that requires a higher thoracic temperature, and *A. cerana* are thus more adaptable to extreme fluctuations in ambient temperature and long periods of rainfall (Tan et al. 2012). *A. cerana* is more industrious in collecting nectar from scattered flowers, while *A. mellifera* worker has a stronger foraging capacity of large flower patches (Feng et al. 2014).

Fanning behavior

Honeybee colonies are able to maintain brood nest temperature within the range of 33–36˚C, even when the ambient temperature ranges from well below freezing to above 45˚C (Fahrenholz et al. 1989). Fanning bees stand on the landing platform at the doorway to their hive and produce a current of air by beating their wings, which serves as air-condition to the hive. Since they remain for up to five minutes in the same spot by gripping the floor with their claws, their regular wing movements present a state of 'flight' suitable for studying without fixing the animal (Junge, 2006).

One of the recognizable differences between *A. cerana* and *A. mellifera* is the fanning position of workers at the hive entrance in which *A. cerana* workers ventilate the hive by fanning away from the entrance with their head, whereas *A. mellifera* fan with their heads turning facing the entrance. The entrances of hived bees are generally at the bottom of the nest/hive. So, *A. cerana* workers face upwards, whereas *A. mellifera* workers face downwards (Ruttner, 1988).

Nest characteristics

Combs

A. cerana build multiple comb nests in dark cavities, although open nests (e.g., built underneath building eaves) have also been observed. Combs are built parallel with a uniform distance between the bee spaces. Honey is stored in the upper and outer combs adjacent to the cavity walls and the remaining comb space is taken up by brood of various ages. The number of combs in *A. cerana* nests varied from three to fourteen combs. *A. cerana* cells are of two sizes: generally smaller worker cells and larger drone cells (Phiancharoen, et al. 2010). In comparison, the A. mellifera worker cell is larger than that of *A. cerana*. *A. cerana* drone cells have a raised cap with a distinctive pore at their apex. The size difference between worker cells and drone cells is less noticeable in *A. cerana* than in *A. mellifera*. Large conical queen cells are built on the lower edge of the combs. However, just like body size, worker cell size also varies geographically and is larger in colder regions.

The wax of *A. cerana* has a melting point of 65°C which is about 2°C higher than that of *A. mellifera* (Ruttner, 1988). The drone cell is capped by the worker bees with a wax cover and the drone larva spins the cocoon. However, 1-3 days after completion of the cover, bees start to remove the wax and then a yellowish, hard, silky plate appears. Wherever the behavior of *A. cerana* has been studied, no use of propolis was found and the cracks in the hive are not sealed. However, a brittle and light greyish mass is present on hive walls and frames, which is not pure wax.

Colony Defense

A. cerana is generally docile, gentle, mild, tolerant and timid in defense behavior. *A. cerana* shows a number of behavioral changes which prove to be very effective against traditional enemies. Finally, *A. cerana* has several unique responses to disturbances including fast and sudden lateral body shaking of workers, the production of a hissing sound, and heat balling.

Hissing sound

When the beehive is disturbed or a certain enemy attacks, it induces a sharp hissing sound that lasts about 0.5 s. The sound is produced by a collective quick closing of the wings over the body and the abdomen jerks upward. The reaction is transmitted to bees, besides immediate contact with the stimulating agent, by body contact; it migrates over the comb or the bee cluster with a velocity of 3 cm per second (Koeniger and Fuchs, 1973).

Group defense

Similarly, if it is attacked by powerful enemies such as hornets, *A. cerana* bees do not counter-attack, as most races of *A. mellifera* do. But, *A. cerana* forms groups of 30 with the tip of the abdomen raised near the entrance. The shy *A. cerana* stops flight activities on a hornet's arrival. The hissing sound is repeatedly emitted in the hive. After this rapid retreat with no solitary counter-attack the hornet usually relinquishes

its attempt and leaves. If hornets persist in the attack, they do not dare to capture bees out of the group. But, if the hornet approaches too closely, it is seized simultaneously at the legs and wings by several bees and drowned in the mass of bees and killed. In most of the observations, virtually no bees died during the defense. The hornet attacks are stopped at the very beginning.

Heat balling

Heat balling is a unique defense of *A. cerana* to kill predatory hornets like Vespa simillima xanthoptera. Several hundred bees surround the hornet in a tight ball and vibrate their thoracic muscles to produce heat. The *A. cerana* workers are able to raise the temperature inside the ball to an average of 46°C for approximately 20 minutes. This temperature is high enough to kill the hornet inside, but not high enough to kill the bees, who can tolerate temperatures up to 48 and 50°C. *A. mellifera* workers also will surround a hornet, but they are not able to raise the temperature as high as can *A. cerana*. Instead, *A. mellifera* workers primarily sting the hornet and are less effective at eliminating the hornet. So, the attacks on *A. mellifera* colonies by Vespa develop quite differently as it waits for the attacking bees, seizes and kills them with its strong mandibles and transports the corpses back to the nest. When the number of hunting wasps increases with the decrease in the defense reactions of the bee colony, the wasps kill one bee after the other without carrying the corpses to their nest, until the resistance ceases and they succeed in occupying the beehive and eating or transporting pupae and larvae. At the entrance of the occupied hive, the territorial defense behavior of the wasps is observed (Matsuura and Sakagami, 1973). *A. cerana* is the only potential prey of *V. mandarinia* which has developed an effective defense tactic. Group defense behavior evidently represents a higher level of cooperation than individual counter-attacks.

Stinging behavior

A. cerana is in general less prone to sting than *A. mellifera*. *A. cerana* has a reduced frequency of sting apparatus autotomy. This is due to a change in behavior by revolving movements after stinging instead of straight runs and by strong muscles anchoring the sting apparatus to the spiracle plates. *A. cerana* uses its mandibles instead of the sting when attacking an enemy which resulted in the reduction of the sting-protracting muscles. Of all Apis species, *A. cerana* has the least developed barbs on the lancets of the sting (Koeniger et al. 1979). The venom of *A. cerana* is identical to that of *A. mellifera* in the amino acid sequence of the melittin, its main component. Isopentyl acetate, an alarm substance was found in worker bees in much lower quantities than in mellifera.

Robbing and direct fighting

When species come to overlap geographically and compete for the same limited resources, either a competitive exclusion or niche partitioning will occur. It is possible that the ecological and behavioral differences between A. mellifera and A. cerana will result in sufficient niche partitioning so that both species can co-occur successfully (Sharma, 2000). Both species can also coexist if resources are not limited. Floral resources and nest cavities are the two most important resources for cavity-nesting honeybees. Competition for pollen and nectar may occur on flowers, or they can attempt to rob honey from other nests that can be of the same a different species.

Robbing bees enter another colony's nest, kill bees and take their honey store. The smaller the colony the more susceptible it is to robbing (Partap, 2011). Robbing occurs when floral resources are low, nectar flow is interrupted, or a colony is weak or diseased. Interestingly, *A. mellifera* showed a much stronger defense response than any of the Asian honeybees (Breed et al. 2007). Studies on robbing behavior between managed hives of two species kept at the same apiary showed that *A. mellifera* usually won by killing *A. cerana* colony and taking over the foraging area although *A. cerana* initiated robbing during lean times. No effective defense reactions are developed in *A. cerana* to robbing attempts by *A. mellifera*. There are no guard bees at the entrance so, intruders can pass easily without being inspected and also sometimes robbed *A. cerana* bees were observed to feed the robber bees (Ruttner, 1988). During the hot season *A. cerana* colony attacked by *A. mellifera* bees usually loses all its stores and then absconds or dies. Overall, evidence suggests that *A. cerana* is a weak nest defender and competitor as compared to *A. mellifera*. Compared with *A. cerana*, *A. mellifera* has a

larger body size, longer flight range and stronger defensiveness. *A. mellifera* thus shows advantages in nectar robbing, nuptial flights and mating and disease-transmitting (Tan et al. 2012).

Brood development

The development of *A. cerana* is similar to that of Apis species in general, and that of *A. mellifera* in particular. *A. cerana* brood development is slightly faster than that of *A. mellifera*, except for *A. cerana* queens (Table 2) (Koeniger et al. 2010). However, it seems doubtful that this slight difference will affect competition or invasiveness. Like in other cavity-nesting species, the larva's brood cell is capped by the worker bees just before the last of the five larval instars.

Table 2. Duration of the life cycle (days) of different castes of *A. cerana* and *A. mellifera*

Stage	Worker		Drone		Queen	
	A. cerana	*A. mellifera*	*A. cerana*	*A. mellifera*	*A. cerana*	*A. mellifera*
Egg to larva	3	3	3	3	3	3
Larva to pupa	5	6	6	7	4-5.5	5
Pupa to adult	11	12	14	14	6-7.5	5
Total	19	21	23	24	13-16	13

Source: Koeniger et al. 2010

Swarming and absconding

Reproductive swarming and absconding are the two types of swarming in honeybees. Reproductive swarming involves the splitting of a colony and movement of the old queen with more than 70 % of the colony to a new nest site, while the new queen stays with the remaining colony and all its resources in the old nest site. It generally occurs when conditions are favorable and floral resources are abundant (Chinh et al. 2005). There are two types of absconding
i. Seasonal absconding/migration: movement of the whole colony due to resource depletion, declining nest site quality
ii. Disturbance-absconding: acute disturbance through natural causes like fire, flooding, or anthropogenic like intervention by beekeepers.

Migration is a resource-related and is a seasonal movement of tropical honeybee colonies without any reproduction. It maximizes the colonization of new areas and provides a spatial refueling cycle clearly driven by reselection. To migrate/abscond, bees must have sufficient flight fuel and energy reserves so that, they can construct new combs at a new site. Absconding colonies typically expand honey, accelerate wax production, reduce oviposition and consume eggs and young larvae so conserving protein. Absconding/migration may be beneficial to the survival, dispersal and propagation of honeybees, but imposes serious difficulties for beekeeping in the tropics (Hepburn and Radloff, 2011) Honeybees prepare for the move (lasting days to weeks) prior to moving, when foraging, reduce honey and brood levels during seasonal absconding but no such preparation occurs before disturbance absconding. In general, tropical honeybees including African strains of *A. mellifera*, are more prone to absconding than temperate species due to the change in temperature, humidity, and resource levels. This means tropical honeybees are able to move throughout the year in response to change or disturbance, and to follow the honey flow, both of which increase fitness and survival (Ruttner, 1988).

Seasonal absconding

Seasonal absconding is directly related to resource depletion and adverse environmental conditions of the current location. *A. cerana* don't store large amounts of honey so they have no sufficient stores to last for long. So, they move continuously to find better conditions elsewhere during periods of high temperatures and dry seasons, after the abatement of prolonged heavy rains (Hepburn and Radloff, 2011). Absconding has also been found highest in areas with high environmental uncertainty like drought, and when nest cavities are too small for the growing colony. However, studies on *A. cerana* have also observed absconding regardless of colony size, congestion, or food supply (Hepburn, 2011) or without an apparent external cause.

A. cerana prepare for migration by decreasing the numbers of pollen-carrying workers, reducing brood

feeding and rearing, and reduced predator and parasite defense, decreasing honey and pollen stores, eggs which leads to large changes in colony demography (Pokhrel et al. 2006). *A. cerana* abscond less often than open-nesting Asian honeybee species but more often than temperate *A. mellifera*. Temperate *A. mellifera*, especially wild colonies, may abscond for to the same reasons as tropical honeybees due to depleting resources and starvation, predation, disturbance, adverse environmental conditions, and disease/parasitism (Ruttner, 1988).

Predation (Disturbance absconding)

Tropical honeybee species are under more severe predation pressure than temperate honeybees. Predation is an important and powerful force in the evolution of Asian honeybees, shaping choice of nest site, nest architecture, population size, worker morphology, and behavior. Natural predators of A. cerana include wasps, ants, vertebrates (tiger, human, birds etc.), and hornets, which tend to prey on foragers but also at times attack colonies. In cavity-nesting Apis species, the main defense against predators is living in a protected cavity with a small entrance that can be easily guarded. Colony defense behaviors include abdomen shaking, hissing (through wing vibrations), group defense (including grasping, pulling, and biting, killing by overheating and/or asphyxiation), and stinging (Ruttner, 1988).

Reproductive swarming

Reproductive swarming in *A. mellifera* occurs when floral resources are abundant and a colony is performing well (Chinh et al. 2005). Soon after a swarm has left the old nest, *A. mellifera* settles tens of meters away and scouts will start searching for suitable nest sites. Similarly, *A. cerana* also settles 20 ± 30 m away from the old nest for several days and then moves to the new nest site. *A. mellifera* colonies are prevented from swarming by good colony management, removing new queen cells, re-queening and using queen excluders. Wild, temperate *A. mellifera*, however, swarm nearly every year and sometimes up to three times per seasonal cycle when resources are highest. Swarming of *A. cerana* is highly variable and depends on the geographic location and climate. *A. cerana* can swarm several times a year (Ruttner, 1988). According to Koeniger et al. (2010), swarming will start when a colony reaches 20,000 bees, with an average of eight swarms per colony. The timing of swarming has been found to vary from no seasonal rhythm, biphasic, to distinct times of the year (Hepburn, 2011).

When foraging conditions are good over a long time, swarming will occur more frequently resulting in the asynchronous production of queens and drones (Chinh et al. 2005). When foraging conditions are good only at certain times of the year (e.g., spring and summer in temperate zones), swarming will occur during those specific times, and swarming and the production of queens and drones will be synchronous as seen in temperate *A. mellifera* (Hepburn, 2011).

Diseases and Hygiene

Where honeybee species coexist, they are bound to interact in some way like robbing due to which parasites and pathogens can be transmitted between species. Diseases and parasites have been introduced from *A. mellifera* to *A. cerana* like the tracheal mites as well as Israeli acute paralysis virus and Varroa destructor from *A. cerana* to *A. mellifera*. *A. cerana* diseases include bacterial infections such as American and European foulbrood, protozoan and fungal infections like *Nosema ceranae* and *N. apis* and chalkbrood, and virus infections like Apis Iridescent virus, Deformed wing virus, Thai sacbrood virus, black queen cell virus etc. *A. cerana* parasites include Varroa (*V. destructor*, *V. jacobsoni*, and *V. underwoodi*) and tracheal mites (*Acarapis woodi*), as well as non-parasitic mites (Kojima et al. 2011). *Varroa jacobsoni* Oudemans is widespread throughout the cerana area. However, no severe damage is caused to *A. mellifera* due to absence of a particular host-parasite relation (Ruttner, 1988). *A. cerana* workers were found to clean themselves more thoroughly than *A. mellifera*. In addition, infected brood is either removed before capping (e.g., larvae infected with American foulbrood or worker brood with Varroa), or is entombed (e.g., drone larvae infected with Varroa) (Rath, 1999). Experiments showed that immediate cleaning behavior in *A. cerana* is due to the presence of Varroa semiochemical compounds. *A. cerana* are regarded as hardy and disease-resistant than *A. mellifera*, making it a better species in many poorer areas of Asia as *A. cerana* requires less management and treatment for diseases (Russo et al. 2020).

CONCLUSION

Hence, *Apis cerana*, an Asian honeybee and *Apis mellifera*, European honeybee are the two most important bee hives found in the wide range of the world. Both the species are cavity-nesting bee hives and are popular for their high-quality honey production and a good pollinator. *A. cerana* can tolerate a wide range of temperatures and are of shy nature, hardy and disease resistant as compared to *A. mellifera*. *A. cerana* is smaller than *A. mellifera* in average and have a similar life cycle. *A. cerana* are capable of defending themselves against enemies or disturbance and are conscious about their hygiene in comparison to *A. mellifera*.

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Perceptions and Practices on Postharvest Management Investment for Resilient Livelihoods in Uporoto Highlands of Tanzania

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ABSTRACT

Sub-Saharan Africa experiences seasonal loss of millions of tons of food and produces due to low postharvest infrastructure investment. Postharvest loss impedes the achievement of SDG 2 of Zero Hunger, which aims to end hunger, achieve food security and nutrition, and promote sustainable agriculture by 2030. This study employed a survey method to assess postharvest management for reducing food loss and waste among smallholder farmers, using questionnaire surveys, key informant interviews, and field observations. The data collected were analyzed thematically, and trend analysis for qualitative data and SPSS and Microsoft Excel for quantitative data. Results revealed that a lack of investment in postharvest management is responsible for about 90% of crop loss, food shortage, and loss of income. Challenges highlighted during the study included poor storage, production systems, processing knowledge, cultural aspects, storage infrastructure, seasonal markets, and a need for more supportive environments. Packing in bags (71%) and the roof of the house (ceiling board) 97% were common postharvest preservation and storage methods, with negative repercussions on postharvest management. The study recommends promoting investment in postharvest management, improving knowledge, infrastructure, production, processing, storage, and distribution systems to reduce food loss and waste.

1. INTRODUCTION

Strengthening postharvest management is crucial to address smallholder farmers' challenges and modernize agricultural production. Postharvest losses in developing countries exacerbate food insecurity and result in significant welfare loss for farming households (Tesfaye and Tirivayi, 2018). Cereal grains are particularly vulnerable to postharvest losses, with losses as high as 30 to 50 percent reported in the literature (Befikadu, 2018). These losses can affect the quality and quantity of the produced crops, leading to lost income and value. Therefore, reducing postharvest losses has become a primary concern for achieving food security and increasing productivity through modern agricultural production (Ridolfi et al. 2018).

Postharvest losses include food losses along the supply chain and food wastage at the consumer level (Parmar et al. 2018; Braun et al., 2019). Several factors responsible for postharvest losses include climate change and variability, incidents of insect, pest, and fungal infestation, inadequate storage strategies and poor infrastructures. Santeramo (2021) and Yimer (2022) indicated that cereal crops are more affected by postharvest loss from insect, pest, and fungal infestation and inadequate storage and crop management systems. Braun et al. (2019) identified

the underlying factors and consumers' food waste behavior resulting from conflicting goals, such as convenience, taste, and saving. It was noted that food waste highlights the inequity of the food system at the household level.

While postharvest losses are primarily initiated at the farm level in developing countries, the problem can persist across the value chain (Ridolfi et al. 2018; Befikadu, 2018). Contributing factors to postharvest losses include outdated harvest techniques, limited postharvest handling and infrastructure, and a lack of suitable agro-climates for generating technology that minimizes losses (Befikadu, 2018). In addition, postharvest infrastructure, particularly food storage and marketing, contributes to crop production challenges (Bendinelli et al. 2020). The challenges were increased by outdated harvest techniques, limited postharvest handling and storage, and marketing infrastructure. To address these issues, multiple suitable agro-climates with a great effort on generating technology that minimizes loss need to focus on cost-effective options and increase investment in storage technologies.

Reducing postharvest losses is critical for improving food security and safety, reducing unnecessary resource use, and increasing food supply chain actors' profits (Bendinelli et al. 2020). It is especially crucial in sub-Saharan Africa, where low investment in postharvest infrastructure has resulted in a seasonal loss of millions of tons of food and produce. Moreover, postharvest loss reduction is essential to achieve the Sustainable Development Goal (SDG) 2 of Zero Hunger, which targets ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture by 2030. In addition, the availability of cost-effective storage options has increased farmers' willingness to invest in safe storage technologies, such as various hermetic technologies (Njoroge et al. 2019).

Building awareness of improved storage technologies, finding solutions for pest infestations in the field and after harvest, and investing in postharvest infrastructure is vital for reducing postharvest losses. Postharvest losses do not include food waste in retail markets or after reaching consumers, which is generally related to retailers' and consumers' behaviour (Bendinelli et al. 2020). Despite the importance of postharvest management investment, perceptions, practices, and knowledge, less investment is animated, especially in low-income countries. Therefore, this work aims to study postharvest management practices to identify practical measures to address the challenges and increase resilience among smallholder farmers.

2.0 Materials and Methods

2.1 Study area

The study was conducted in the Isongole ward in Uporoto Highlands, Southern Highland of Tanzania. The Highlands extend into three districts Mbeya Rural and Rungwe (Mbeya Region), and Makete (Njombe Region). The area is characterized by high volcanic mountains (Sokoni and Tilumanywa, 2021) with steeply dissected escarpments ranging from Tembela ward in the Mbeya rural district and covering about 10% of the total area of the Rungwe district with an altitude ranging between 2000 – 2865 masl meters above the sea level. The climate is usually relatively cool (5^0c - 18^0c), with reliable rainfall ranging from 1500 mm to 2700 mm (Gwambene, 2020) that favour the production of maize, round potatoes, cabbages, peas, fruits pyrethrum, and wheat in the northern part. Farmers in the area primarily produce to meet their basic food requirements, with the booming round potato production as a cash crop. The area was selected due to its economic importance. It is strategically located in the highland region and interconnected with a good tarmac road network from Mbeya City to Rungwe, Kyela, and Malawi (Gwambene, 2022). It has many natural resources, including natural forests and fertile volcanic soils with a booming round potato production (Sokoni and Tilumanywa, 2021). However, the area is also constrained by heavy rainfall, fog, frost, crop pests, and diseases, essential in the postharvest loss.

2.2 Data Source and Methods

The study employed desk review and a survey method to investigate postharvest losses among smallholder farmers. It assesses postharvest management for reducing food loss and waste among smallholder farmers. The techniques used included a questionnaire survey (QS), Key informant interview (KII), and Field Observation (FO) data collection techniques.

Household questionnaire

Data were collected from randomly selected households using a structured questionnaire. The information was gathered through interviews with the head of households. Where the head of the household was unavailable for any reason, a close relative familiar with household activities, income, and expenditure was interviewed instead. The questionnaire gathered information on socio-economic, general household characteristics, post-harvesting management practices, challenges faced, and opine on sustainability and improving food security.

Focus group discussions: Focus group discussions comprise village Government, men and women: youth, elderly, preeminent farmers, and participants with different social and economic characteristics. The FGD was arranged to involve all other groups based on socio-economic factors (age, gender, education, socio-economic status, and spatial representation) in the selected area. The objective was to have their expressed needs and the constraints they face and gather their perception on postharvest management, challenges, and options for sustainability.

Key informant interviews

The guiding checklist was prepared for gathering information on postharvest management and coordination issues. The targeted respondent groups included expertise from the agricultural sector, Natural resources, land, environment sectors, local government at districts, wards, and village levels, and knowledgeable elders in the community. The interviews were conducted with key respondents guided by a checklist administered to target groups at their places or area of convenience.

Field observations: the technique includes visiting the different locations and households in the study to verify some of the infrastructure and methods used. It involved taking photos and jotting notes and other information in the study area. The technique used to validate and complement the information gathered through other methods.

2.3 Data Organisation and Analysis

Thematic and trend analysis was used for the qualitative data analysis, and SPSS Version 20 and Microsoft Excel software was used for the quantitative data. The analyzed data through SPSS and Microsoft Excel soft wares were presented in percentages, Tables, Figures, and inferential forms. Besides, the qualitative data were presented in narrative text, tables, and conceptual statements. The study assessed the postharvest management challenges ranging from pre and post-harvesting activities, management practices, and coordination to sustain and improve food security and income of farming households.

3.0 Results

3.1 The production system and postharvest practices

The production system differs among the farms depending on the available resources and constraints, geographical location and climatic conditions, government policy, socio-economic and political pressures, and the farmer's philosophy. The socio-economic factors are affected by household priorities and resource endowments. The study indicates that most crops are affected by harvesting operations, on-farm storage, transport operation, preliminary processing, packaging, sorting, and bagging. Such factors pose tremendous losses on adversity and reduce crop production profitability. Smallholder farmers, over time, develop methods to reduce pre and postharvest loss. Figure 1 indicates the past used postharvest methods; some are still in use.

The past postharvest preservation methods include the roof of the house (ceiling), warehouse, pesticides, use of herbs and spices, and smoking. The cause of postharvest loss is poor production, poor harvesting techniques, limited access to inputs, poor linkage to traders and brokers, and incorrect harvesting. In addition, low-cost and cost-effective postharvest technology adoption is affected by a lack of knowledge and information about such technologies, financial constraints, and farmers' prioritization of consumption over future income.

3.2 Food storage and storage facilities

The results indicate poor food storage and storage facility in the area. The situation resulted from the inferior technology and management strategies of the producers. Postharvest preservation methods include packing in bags 71% and storing on the house roofs (Ceiling) 97% (especially for maize). Figure 2 indicates the postharvest methods used for main food crops.

Figure 2 indicates the most used post-harvesting method among smallholder farmers in the southern

highlands. Depending on the nature of the crops produced, smallholder farmers apply methods that include storing on the roof of the house (especially for maize and regimes), on-farm consumption (some crops utilized directly from the farm), packing in bags, drying and packaging, and local processing. The most used post-harvesting preservation and storage methods for maize are packing in bags and roof of the house. Round potatoes are primarily packed in bags for business purposes. The preservation and storage methods used have repercussions on postharvest management. Among the challenges of postharvest management are the seasonal market and the need for access to appropriate processing equipment. The seasonal market depends on the harvesting season, which usually has its peak. Changes in timing, weather, and sociocultural and political situation can increase seasonal demands, processing, and storage challenges.

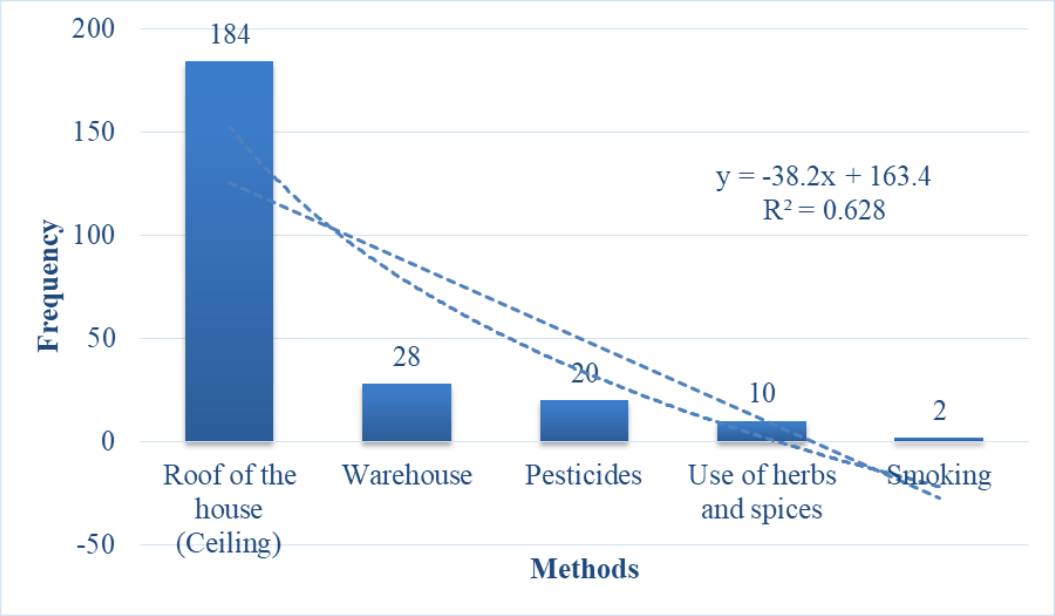

Figure 1 Past used postharvest preservation methods

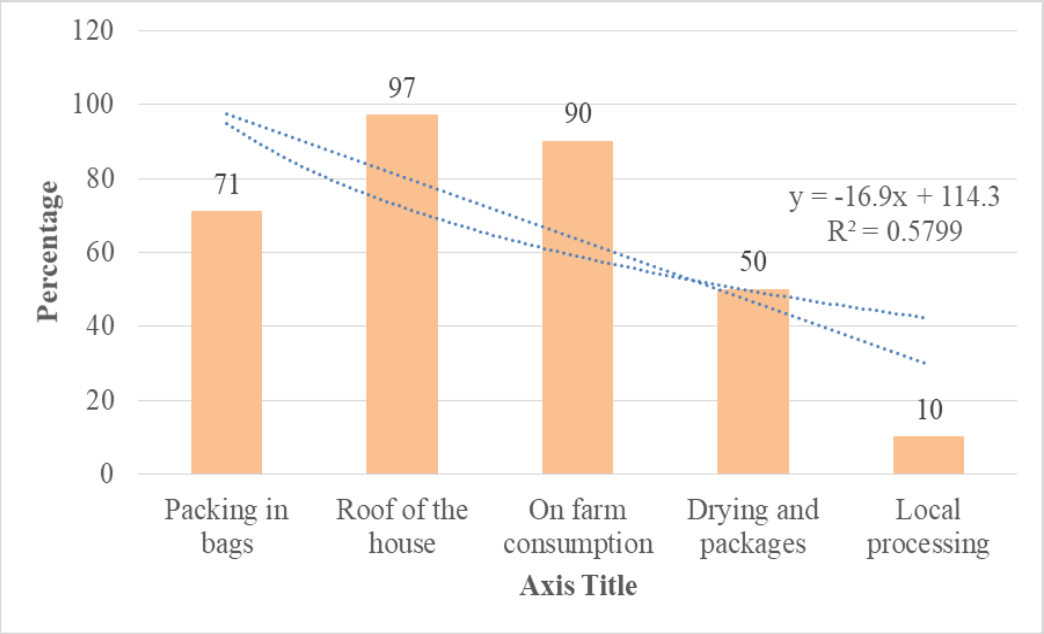

Figure 2 The commonly used post-harvesting method

3.3 Postharvest handling practices and management challenges

The practices of handling harvest from farms and commodities from the purchasing point up to their marketplace increased challenges in postharvest management. The study noted the practices which promote and that reduce postharvest losses. The results indicate that a lack of investment in postharvest management causes about 90% of crop loss, food shortage, and loss of income among smallholder farmers. The situation is augmented by poor handling practices, limited access to on-farm storage, and inadequate transportation. The persisting and pressing postharvest management challenges highlighted during the study included poor storage, production system, lack of processing knowledge and packaging facilities, cultural aspects, poor storage infrastructure, seasonal market, supportive environment, and institutional support (Figure 3). The seasonal market is conducted during harvesting, and the cultural aspects involve community consumption and preferences. The study by Chebanga et al. (2018) noted changes in food consumption habits that affect the postharvest chain. Thus, promoting postharvest management investment is needed by improving knowledge, infrastructure, production process, processing, and storage and distribution systems.

The revealed challenges in postharvest management are instigated by harvesting operations, on-farm storage, transport operation, preliminary processing, packaging, sorting, and bagging. Poor production, harvesting techniques, linkage to traders and brokers, limited access to inputs, and incorrect harvesting increased management challenges. In addition, poor handling practice, weather condition, inadequate transportation, and lack of access to appropriate processing equipment affects the pre and post-harvesting processes (Table 1). Ridolfi et al. (2018) noted similar results indicating challenges in adopting low-cost and cost-effective postharvest technology. The adoption is affected by a need for knowledge and information about such technologies, financial constraints, and farmers' prioritization of consumption over future income.

The postharvest losses in poor storage, transportation, and poor packaging significantly affect farmers' production benefits. For example, Chebanga et al. (2018) indicated poor transportation methods, a considerable distance from the market, and outdated storage facilities lead to higher postharvest harvest losses. Therefore, farmers are encouraged to improve their production by improving product quality and reducing harvesting, processing, packaging, transportation, marketing, and storage challenges.

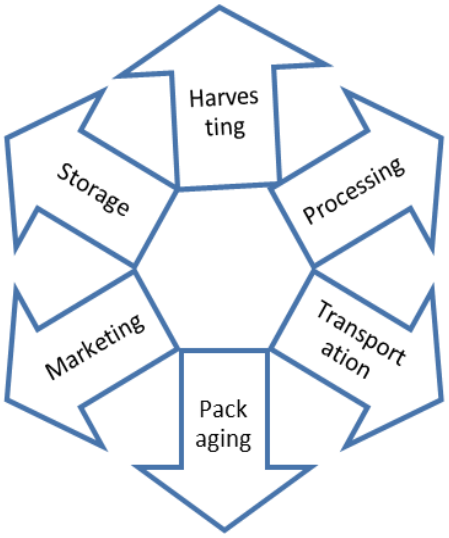

Figure 3. The postharvest management challenges among smallholders farmers

Table 1. The description of challenges across the supply chains

Supply chain	*Description*
Production and harvesting conditions	Water quality, insufficient or too much pesticide use, and lack of information on market quality standards
Transportation	Access to adequate transportation in which farmers are forced to harvest at a later stage and sell to nearby consumers, and poor road condition impacts the crops.
Handling and packaging	Through handseling by field workers, improper stacking and packaging, mechanical damage
Storage	lack of storage and preservation facility
Marketing	Poor marker sanitary conditions, the inability of smallholder producers to meet global standards and market requirements

3.4 Cause of postharvest losses

The causes of the postharvest losses experienced across the value chain have multiple and complex forms. Some of the reasons that have resulted in postharvest losses include poor storage, transportation, processing and packaging, and insect pests' damages (Table 2). The loss experienced at the farm level to the traders at the marketplace. Losses were also experienced during handling harvests, poor packaging, and transportation, including harvesting immature crops and inadequate carriage facilities. Chebanga et al. (2018) noted similar results from the experience of informal and formal traders. The climatic condition also contributed to the pre, during, and postharvest.

Table 2 Cause of postharvest loss across the process

On-farm	Transport	Processing and storage
Poor handling of items during harvesting	Poor transportation	Poor method of food preservation
Harvesting of immature crops	Poor carrying containers	Poor storage
Sorting and cleaning	Weather condition	Poor packaging
Insect pests	Poor infrastructure	Poor processing
Disease attack		

In the postharvest value chain, loss occurs from production to consumption, whereby, at the production point, part of the crop is lost due to rodents, pests, and diseases. Similarly, a lack of effective harvesting, transport, and storage facilities leads to losses at the farm level. Mndeme (2016) noted that food losses result in lost income for smallholder farmers and higher prices for poor consumers during harvest and storage. Thus, it recommended undertaking a research programme on building resilience through postharvest processing and value addition (FANRPAN, 2016).

3.5 Measures to minimize postharvest loss

Postharvest loss challenges are observed through the value chain at different stages; thus, such challenges are better addressed along the value chain (Table 3). The technique, innovations, and technologies to reduce postharvest losses include developing varieties with longer shelf-lives while maintaining nutritional properties, taste, and texture, capacity development, and training on specific value chains among farmers and key actors in the value chain. During harvesting, carefully handling harvests and harvesting during a proper time to reduce losses. Crop losses occur before, during, and after harvesting due to inadequate drying, inefficient storage facilities, and lack of appropriate technologies. First, drying in the field and at home, then stored near the house using different containers and technologies.

Table 3. Reducing postharvest loss along the value chain

s/n	Stages of management	Suggested measures, techniques
1	Harvesting	Careful handling of harvests and harvesting during a proper time to reduce losses
2	Handling	Protect crops from injury
3	Sorting and cleaning	increase shelf-life by separating higher and lower-quality products
4	Packaging	Proper packaging maintains freshness, prevents quality deterioration, and protects from physical damage
5	Transportation	care on time, during loading and unloading, is essential in reducing postharvest loss
6	Storage	crops that meet specific standards should be stored
7	Processing	The producer needs to stabilize the product to reduce postharvest loss and increase value.

The smallness of the operational activities and harvests among smallholder farmers affects the postharvest chain and its management. The study noted that aggregating produce from smallholder farmers is critical in improving postharvest management by allowing farmers to access

technologies (storage, packaging) and transportation facilities. In addition, smallholders need to have the ability to meet specific quantity, quality, and safety standards to access high market value and preserve of quality of produce (Omotilewa, 2018; Sibanda and Workneh, 2020). Meeting quantity, quality, and product safety standards are critical in accessing high-value markets for smallholder farmers. Thus, linking smallholder producers in the value chain through increasing awareness, access to technology, and coordination is crucial for improving postharvest management, food security, and household income. In addition, capacity building, learning, and applying practical methods to reduce losses across the postharvest value chain are equally important in improving food security and livelihood income.

4.0 Discussions

The study indicates that most crops are affected by postharvest practices such as harvesting operations, on-farm storage, transport operation, preliminary processing, packaging, sorting, and bagging. Such factors pose tremendous losses on adversity and reduce crop production profitability. Storage facilities in the study area could be better, primarily resulting from the producers' inferior technology and management strategies. Postharvest preservation methods commonly used among smallholder farmers include packing in bags and storing on the house's roof (Ceiling) for maize. Round potatoes are primarily packed in bags for business purposes. Outdated harvesting techniques, limited postharvest handling and storage, and marketing infrastructure have contributed to the problem (Bendinelli et al., 2020). The lack of suitable agro-climates for generating technology that minimizes losses also exacerbates the situation (Befikadu, 2018).

The highlighted significant impact of postharvest practices affects crop production and profitability. Various stages of the postharvest process, including harvesting operations, on-farm storage, transport, preliminary processing, packaging, sorting, and bagging, contribute to substantial losses and reduced crop production profitability. The results align with Santeramo (2021), who noted that inappropriate collection, transport, storage, and pest control systems account for approximately 30 to 50 percent of postharvest losses. In addition, postharvest losses encompass food losses along the supply chain, including food wastage at the consumer level (Braun et al. 2019). Several factors contribute to postharvest losses, including climate change and variability, insect, pest, and fungal infestation incidents, inadequate storage strategies, and poor infrastructure. Cereal crops, in particular, are more susceptible to postharvest losses due to insect, pest, and fungal infestation and inadequate storage and crop management systems (Santeramo, 2021; Yimer, 2022).

Reducing postharvest losses is crucial for achieving food security, ensuring food safety, optimizing resource utilization, and increasing profitability within the food supply chain (Bendinelli et al. 2020). Smallholder farmers have developed methods to mitigate pre and postharvest losses, such as utilizing the roof of their houses, warehouses, pesticides, herbs, and spices, and smoking for preservation. These findings are consistent with previous studies emphasizing critical technologies and services for reducing food loss (Díaz-Valderrama et al. 2020; Balana et al. 2021). However, adopting low-cost and cost-effective postharvest technologies faces challenges due to limited knowledge and information, financial constraints, and farmers prioritizing immediate consumption over future income. These findings align with a study by Parmar et al. (2018) and Braun et al. (2019) that identified factors influencing the adoption of postharvest technologies and consumers' food waste behavior resulting from conflicting goals, convenience, taste, and saving. The issue of food waste further highlights the inequity in the food system at the household level.

According to the literature, a sustainable food system improves food availability and income within the supply chain and reduces food waste (Braun et al. 2019; Balana et al. 2021; Afzal et al. 2019). Enhancing the value chain improves the storability and transportability of produce, ensures product quality, reduces postharvest losses, and enhances food access and price stabilization. Additionally, it improves food utilization by promoting diversification, reducing environmental impact, and implementing postharvest innovations. Reducing postharvest losses also minimizes food contamination and spoilage, significantly contributing to high postharvest losses.

Applying appropriate techniques, utilizing improved inputs such as high-quality seeds or planting materials, and ensuring efficient logistics and marketing improved agricultural production (Yimer, 2022; Balana et al. 2021; Abdullahi and Dandago,

2021). Investing in improved technology leads to increased production yield in smallholder farms and contributes to the overall food supply, job creation, and enhanced livelihoods. However, for an adequate food supply system, equal attention should be given to production and the postharvest supply chain, as they are interconnected elements (Yimer, 2022; Balana et al. 2021; Abdullahi and Dandago, 2021). It noted the increased application of the proper techniques, improved inputs (like seeds), and appropriate logistics levels and marketing. Investing in improved technology leads to higher production yields in smallholder farms (Yimer, 2022; Balana et al. 2021; Abdullahi and Dandago, 2021). A higher food supply system improves the total available food volume, creates jobs, and improves livelihoods. Nevertheless, to realize an adequate food supply system, the focus should be on production and the postharvest supply chain as an indissoluble link that creates effective food supply systems (Yimer, 2022; Balana et al. 2021; Abdullahi and Dandago, 2021).

Reducing postharvest losses is vital to achieving food security, safety, and sustainable agriculture. Therefore, investment in storage technologies, building awareness of improved storage technologies, finding solutions for pest infestations in the field and after harvest, and investing in postharvest infrastructure are essential. Braun et al. (2019) discussed the interventions to reduce food waste across supply chains and households. Postharvest management is vital to achieving the Sustainable Development Goal (SDG) 2 of Zero Hunger, which targets ending hunger, achieving food security, and promoting sustainable agriculture by 2030. Thus, interventions that focus on generating technology that minimizes losses and increases investment in storage technologies are needed. Besides, smallholder farmers should adopt low-cost and cost-effective postharvest technologies, access knowledge and information on technologies, and address production challenges.

5.0 Conclusion and Recommendation

Understanding and improving farmers' pre and postharvest management practices are crucial for enhancing farming households' food security and income. Adequate measures must be implemented to identify the most cost-effective and efficient ways to address postharvest loss among smallholder farmers. Aggregating produce from smallholder farmers can allow farmers to access technologies for processing, packaging, preserving, and storing their products, as well as transportation facilities and reliable markets.

Postharvest losses occur mainly during harvesting, transportation, storage, and marketing, and the mode of transport and transport distance can significantly influence the magnitude of these losses. Therefore, it is essential to create an enabling environment for all key stakeholders, including the private sector, non-profit organizations, and the public sector, to invest in postharvest management to address postharvest loss. Public and non-profit actors should coordinate across value chains where the private sector needs more capacity or incentives for investment in postharvest loss reduction. The activities may involve training and capacity building for smallholder farmers and linking them in the value chain through increased awareness and access to grading, sorting, storage, proper packing, and coordination technology. By implementing these measures, we can reduce postharvest losses and improve the livelihoods of smallholder farmers.

Declaration of competing interest

The Author declares that the manuscript adheres to the competing interest policy and discloses that all relevant sources, including financial and non-financial interests and relationships, have been acknowledged.

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Bioefficacy of insecticides against fall armyworm *Spodoptera fergpirda* on maize crop under field condition of Tandojam, Sindh

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ABSTRACT

Fall armyworm (*Spodoptera fergpirda*) is one of the destructive insect pests of agricultural crops, particularly maize in the field condition. It has severely damaged the maize in the early stage of crops. The efficacy of different insecticides such as Emamectin Benzoate 019EC, Chlorantraniliprole + Thiamethoxome 14% WDG, Lufeneron 05EC, Chlorantraniliprole + Thiamethoxome 17.5%SC, Chlorantraniliprole 20SC and control were used in the study. In the first spray maximum population reduction of S. fergpirda (90.377 %) was recorded for Chlorantraniliprole 20SC followed by Chlorantraniliprole+Thiamethoxome 14%WDG (68.287%), Chlorantraniliprole + Thiamethoxome 17.5%SC (58.283 %), Emamectin Benzoate 019EC (53.117%), and Lufeneron 05EC (37.800%), whereas minimum population reduction of S. fergpirda was observed from control treatment. Similarly in the second spray highest population of S. fergpirda reduction was determine for Chlorantraniliprole 20SC (91.680%) followed by Chlorantraniliprole +Thiamethoxome 14% WDG (78.307%), Chlorantraniliprole +Thiamethoxome 17.5%SC (63.683%), Emamectin Benzoate 019EC (54.823%), Lufeneron 05EC (34.797%) and lowest population reduction was recorded in control treatments. Therefore, findings of the current study Chlorantraniliprole 20SC was found more effective for the management of S. fergipirda on maize crop under field condition.

INTRODUCTION

Maize (*Zea mays* L.) belongs to the family Gramineae and one of the most important cereal crops after wheat and rice in Pakistan (Bukhsh et al. 2011), The maize crop is used all over the world for both food and feed, it contains high-value food for humans as well as stockpiles for animal feed. (Abebe and Feyisa, 2017; Adnan, 2020). The nutrition is found in the grains of Maize as it contains 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar, and 1% ash. (Chaudhary, 1983). The various factors involved in low maize production in Pakistan. Maize crop is infested by a number of insect pests such as armyworm (*Spodoptera fergipirda*), stem borer (Chilopartellus), thrips (Thrips tabaci), aphid (*Rhopalosiphum maidis*), shoot fly

(*Atherigona soccata*) and termite are main pest causing significant losses (Arabjafari and Jalai, 2007; Nabeel et al., 2018). Among all insect pests, the fall armyworm *Spodoptera fergipirda*, is one of the main destructive and serious pests for maize. (Assefa and Ayalew, 2019). Fall Armyworm *S. fergpirda* originated in the United States, but recent reports from the Asia Pacific and Africa. The Fall Armyworm has caused great international concern since its destruction in Asia in 2018 and Africa in 2016 (Deshmukh et al. 2021). Its damage has been reported from more than 80 crops such as maize, millet, rice, sugarcane, millet, and cotton being the main hosts of fall armyworm S. fergipirda (Abrahams et al. 2017; Cock et al. 2017; Montezano et al. 2018). The damage caused to the maize crop by the S. fergipirda has been recorded at about 15-73%. (Hruska and Gould, 1997; Lima et al., 2010). Many generations of *S. fergipirda* in a year and temperature have a significant role in its development (Belay, 2011). The larvae are the harmful stage of *S. fergipirda* because the first and second instars usually consume one side of the leaves and make them into skeletons, while the last instars eat all parts of their hosts (Abrahams et al. 2017). According to several reports, many of these pesticides have not been effective. Therefore, in addition to these pesticides, some new pesticides need to be re-examined for effective management of S. fergipirdas.

MATERIALS AND METHODS

The experiment was carried out in the field of Plant Protection Research Institute, Tandojam, in 2021. The experiment was arranged Randomized Complete Block Design (RCBD) where each treatment replicates three times. The six insecticides Emamectin Benzoate, Chlorantraniliprole + Thiamethoxome 17.5%SC, Lufeneron 05EC, Chlorantraniliprole + Thiamethoxome 14% WDG, Chlorantraniliprole 20SC and control were tested against *S. fergipirda* and subsequent application of insecticides was given at 20 days interval with help of hand knapsack sprayer. The size of the each replicated plot 50×33 sq ft. The data were taken population of S. fergipirda larvae based on the appearance and fresh body waste in the leaf whorl of 25 plants randomly from the experimental plot. The data was recorded before spray and after 48 hours, 96 hours and after one week. The collected data was analyzed using (ANOVA) Analysis of Variance and (LSD) least square difference with computer software STATISTIX 8.1. Moreover, the percentage reduction in pest population after the application of various insecticides was calculated using Abbots (1925) formula as given below:

$$\text{Corrected \%} = \left(1 - \frac{\text{n in T after treatment}}{\text{n in Co after treatment}}\right) * 100$$

RESULTS

First spray

The results showed (Table 1) that all the treatments were found significantly different from the control in reducing the larval population of *S. fergipirda* in the first spray at 48, 96, and one week after spray. The data indicated that the larval population before spray was non-significant (F = 0.55; P = 0.7375) difference among all treatments. The *S. fergipirda* larval population after 48 hours of spray, showed highly significant (F = 60.38; P = 0.0000) differences among the treatments. The minimum population of fall armyworm *S. fergipirda* (3.61±0.56/25 plants) was recorded for Chlorantraniliprole 20SC followed by Chlorantraniliprole + Thiamethoxome 14 % WDG (8.13±0.69/25 plants), Chlorantraniliprole + Thiamethoxome 17.5%SC (11.29±0.80/25 plants), Emamectin Benzoate 019EC (13.97±0.83/25plants) and Lufeneron 05EC (19.45±0.80/25 plants). The data showed that the maximum larval population of fall army worm *S. fergipirda* (24.05±1.65/25 plants) was found on the control treatment. The results indicated that the population of *S. fergipirda* after 96 hours of spraying showed (F = 108.34; P<=0.0000) a highly significant difference in all treatments. The lowest population (1.92±0.32/25 plants) of fall army worm *S. fergipirda* was observed on Chlorantraniliprole 20SC followed by Chlorantraniliprole + Thiamethoxome 14% WDG (8.58 ± 0.64/25 plants), Chlorantraniliprole + Thiamethoxome 17.5%SC (10.7 ± 0.82/25 plants), Emamectin Benzoate 019EC 019EC (11.09±0.86/25plants) and Lufeneron 05EC (14.61±0.79/25 plants). However, the highest population of fall army worm *S. fergipirda* (27.56±1.25) was recorded on control treatment. The data observed on the population of fall army worm *S. fergipirda* after one week of spray reveal a highly significantly difference (F = 75.31; P=0.0000) in the treatments. The results showed that the spray of Chlorantraniliprole 20SC found lowest population (2.06±0.44/25 plants) of fall army worm *S. fergpirda*, followed by Chlorantraniliprole + Thiamethoxome 14% WDG (9.01±0.63/25plants), Chlorantraniliprole + Thiamethoxome 17.5%SC (11.65±1.09/25 plants),

Emamectin Benzoate 019EC 019EC (12.53±0.74/25 plants) and Lufeneron 05EC (15.64 ± 1.03/25 plants). While the highest population (29.68±1.82/25 plants) of fall armyworm *S. fergipirda* was found on Control treatment.

The (Figure 1) showed that the corrected percentage of the population fall armyworm *S. fergipirda* reduction after 1st spray was recorded the highest reduction of pest population (84.98 %) was recorded for Chlorantraniliprole 20 SC treatments after 48 hours of spray, followed by Chlorantraniliprole ± Thiamethoxome 14 % WDG (66.18 %), Chlorantraniliprole ± Thiamethoxome 17.5 %SC (53.05%), Emamectin Benzoate 019EC 019 EC (41.81%) and Lufeneron 05EC (19.12 %). Moreover, overall maximum reduction percentage of population fall army worm *S. fergpirda* (90.377%) was found on Chlorantraniliprole 20SC followed by Chlorantraniliprole ± Thiamethoxome 14 % WDG (68.287 %), Chlorantraniliprole ± Thiamethoxome 17.5%SC (58.283 %), Emamectin Benzoate 019 EC 019EC (53.117 %) and Lufeneron 05EC (37.800 %) respectively.

Table 1: Efficacy of different insecticides against fall army worm S. fergperda on maize crop in 1st spray

Treatment	Dose/acre	Pre-Treatment	Post Treatment			Reduction Percentage
			48 hours	96 hours	One week	
Emamectin Benzoate 019EC	200g/acre	24.53±1.65a	13.97±0.83c	11.09±0.86c	12.53±0.74c	53.117%
Chlorantraniliprole+Thiamethoxome 14% WDG	150ml/acre	26.30±1.82a	8.13±0.69e	8.58±0.64d	9.01±0.63d	68.287%
Lufeneron 05EC	200ml/acre	24.37±1.78a	19.45±0.80b	14.61±0.79b	15.64±1.03b	37.800%
Chlorantraniliprole+Thiamethoxome17.5%SC	200ml/acre	27.13±2.15a	11.29±0.80d	10.7±0.82cd	11.65±1.09cd	58.283%
Chlorantraniliprole 20SC	50ml/acre	27.65±1.97a	3.61±0.56f	1.92±0.32e	2.06±0.44e	90.377%
Control	----	22.61±1.92a	24.05±1.65a	27.56±1.25a	29.68±1.82a	----

LSD values @ P < 0.05 [Pre-spray = 5.0848; 48-Hours = 2.6693; 96-Hours = 2.2770; One week = 2.9407

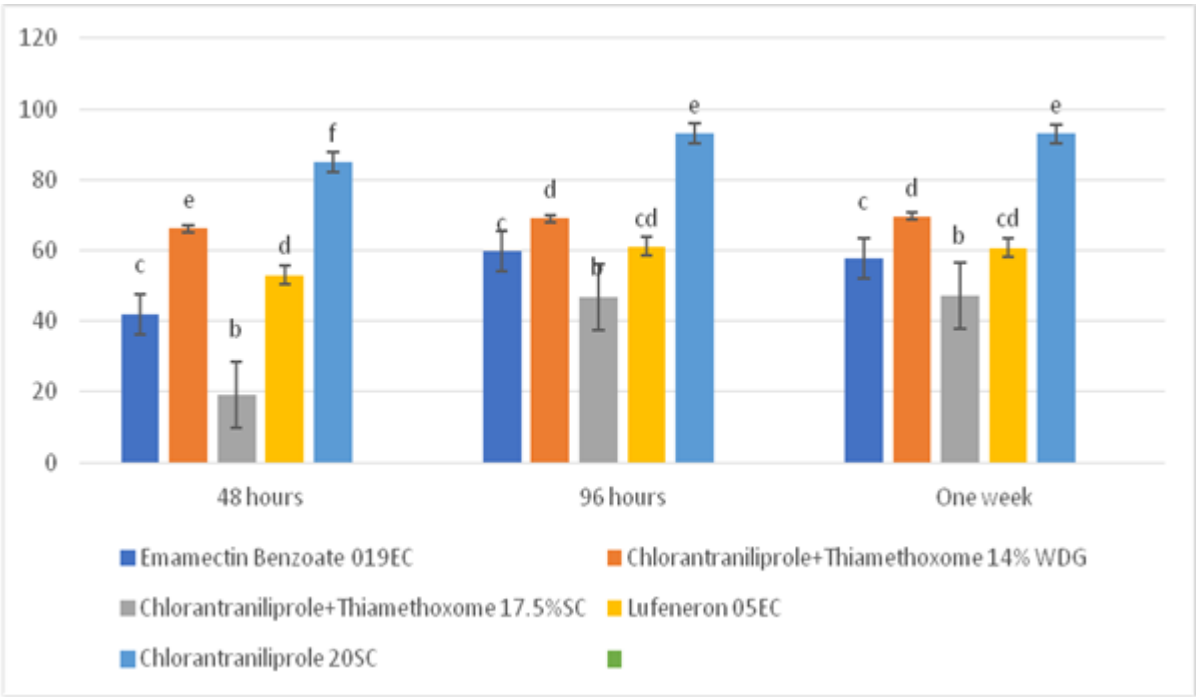

Figure 1: Corrected percentage population reduction of *S. fergipirda* on maize after 1st spray

Second Spray

The results of the second spray showed (Table 2) pre-treatment observation revealed that the non-significant difference (F=0.84; P = 0.5214) as the population of *S. fergipirda* ranged between (12.06±1.61 to 13.48±1.31/25 plants). Similarly, in the first spray data indicated that highly significant difference (F=40.71; P=0.0000) among all treatments after 48 hours of spray. The lowest *S. fergipirda* population (1.54±0.37/25 plants) was recorded for Chlorantraniliprole 20SC followed by Chlorantraniliprole± Thiamethoxome 14% WDG (3.18±0.53/25 plants), Chlorantraniliprole± Thiamethoxome 17.5%SC (5.58±0.82/25 plants), Emamectin Benzoate 019EC 019EC (6.86±0.64/25 plants) and Lufeneron 05EC (10.14±0.80/25 plants). While the highest population (14.48±1.03/25 plants) was recorded from the control treatment. The data indicated that a highly significant difference (F=48.00; P=0.0000) was recorded after 96 hours of spray. The minimum population of *S. fergipirda* (1.01±0.30/25plants) was recorded in Chlorantraniliprole 20SC after 96 hours of spray followed by Chlorantraniliprole ± Thiamethoxome 14% WDG (2.93±0.48/25 plants), Chlorantraniliprole± Thiamethoxome 17.5% SC (5.30 ± 0.68/25 plants), Emamectin Benzoate 019 EC 019 EC (6.18±0.77/25 plants) and Lufeneron 05 EC (9.06±0.76/25 plants) while the highest population (15.10±1.07/25 plants) was recorded on control treatment respectively. The results showed a highly significant difference (F=30.77; P = 0.0000) in the application of various insecticides after one week of spray. The data indicated that the highest population (1.30 ± 0.30/25 plants) of *S. fergipirda* was recorded in Chlorantraniliprole 20 SC followed by Chlorantraniliprole ± Thiamethoxome 14% WDG (4.02±0.53/25 plants), Chlorantraniliprole ± Thiamethoxome 17.5%SC (6.05±0.77/25 plants), Emamectin Benzoate 019EC 019 EC (8.05 ± 0.79/25 plants) and Lufeneron 05 EC (11.18 ± 0.96/25 plants).

The data indicated (Figure 2) that the maximum pest population reduction of *S. fergpirda* (91.680%) was recorded in Chlorantraniliprole 20SC treatment, followed by Chlorantraniliprole ± Thiamethoxome 14 % WDG (78.307 %), Chlorantraniliprole ± Thiamethoxome 17.5 % SC (63.683 %), Emamectin Benzoate 019 EC 019 EC (54.823 %) and Lufeneron 05EC (34.797 %) respectively.

Table 2: Efficacy of different insecticides against fall armyworm *S. fergperda* on maize crop in 2nd spray

Treatment	Dose	Pre-Treatment	Post Treatment			Reduction Percentage
			48 hours	96 hours	One week	
Emamectin Benzoate 019EC	200g/acre	13.48±1.31a	6.86±0.64c	6.18±0.77c	8.05±0.79c	**54.823%**
Chlorantraniliprole±Thiamethoxome 14% WDG	150ml/acre	11.65±1.57a	3.18±0.53d	2.93±0.48d	4.02±0.53de	**78.307%**
Lufeneron 05EC	200ml/acre	10.98±1.57a	10.14±0.80b	9.06±0.76b	11.18±0.96b	**34.797%**
Chlorantraniliprole±Thiamethoxome 17.5%SC	200ml/acre	9.90±1.44a	5.58±0.82cd	5.30±0.68c	6.05±0.77cd	**63.683%**
Chlorantraniliprole 20SC	50ml/acre	10.05±1.37a	1.54±0.37d	1.01±0.30d	1.30±0.30e	**91.680%**
Control	---	12.06±1.61a	14.48±1.03a	15.10±1.07a	17.05±1.89a	---

LSD values @ P < 0.05 [Pre-spray = 4.0761; 48-Hours = 2.0186; 96-Hours = 2.0055; One week = 2.8032]

DISCUSSION

The field experiment was conducted on the efficacy of different insecticides against *S. fergipirda* on maize under field conditions. It has been reported that S. frugiperda is a serious pest of field corn, cotton, and grain sorghum (Hardke et al. 2011). The current study was conducted to test the different insecticides against *S. frugiperda*. The findings of the present study that chlorantraniliprol 20 SC significantly reduced the *S. fergipirda* on maize crops under field conditions. Deshmukh et al. (2020) supported that the chlorantraniliprol 18.5 SC was found most effective pesticides against *S. fergipirda* followed by emmevtin benzoate 5 SG, spinetoram 11.7 SC, flubendiamide 480 SC, indoxocarb 14.5 SC, labdacyhalothrin 5 EC and novaluron 10 EC on maize. Similarly, the application chlorantraniliprol reduced the maximum infestation of *S. fergipirda* on maize whorls followed by Lambda-cyhalothrin, methoxyfenozide and control after 3 days of treatment (Hardke et al. 2012). Thrash et al. (2013)

agreed that the chlorantraniliprol and cyntraniliprol significantly reduce the larval population of *S. fergipirda* in the soybean field. Moreover, the mixture of insecticides chlorfenapyre + chlorantraniliprol and Lufenuron is recommended for the management of S. fergipirda in sugarcane crops in Guangxi, China (Song et al. 2020). Li et al. (2021) mentioned that Chlorantraniliprol is effective against the *S. fruguperda* through drip irrigation and its effect was longer than artificial or drone spray. Furthermore, Chlorantraniliprol had a very strong transport capacity to move from stems to leaves and concentrated in the upper leaves of maize. Chlorantraniliprole was not detected in any plant parts at the time of harvesting. Muraro et al. (2020) agreed that seeds of maize crops treated with Chlorantraniliprol alone or combined with imidacloprid reduce the infestation of *S. fruguperda* under field as well as laboratory conditions. Villegas et al. (2019) mentioned that seeds treated with chlorantraniliprol provide sufficient control against *S. fergipirda*, sugarcane borer and water weevil at an early stage of rice crop. Therefore, these findings that confirm the results of the current study.

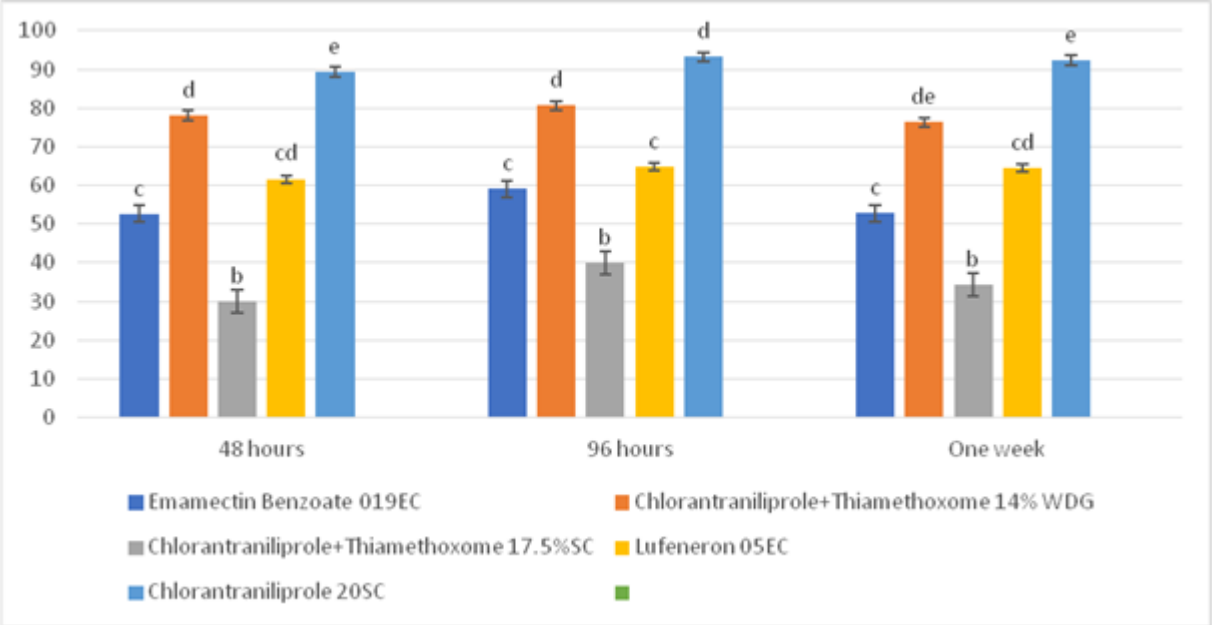

Figure 2: Corrected percentage population reduction of *S. fergipirda* on maize after 2nd spray

CONCLUSION

The present study concluded that among the five insecticides, all the insecticides were more efficient than the control in decreasing the *S. fergipirda* population. However, chlorantraniliprol 20SC insecticides were found most effective for reducing the *S. fergipirda* infestation on Maize.

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Perception of Climate Change among College Students in Lahore

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ABSTRACT

The climate is changing with time. There are various activities through which our climate changes. Human activities mainly contribute to the change of climate. If we see the impacts of climate change, they are extensive. Almost all the developing countries in the world are seriously threatened by the impacts of change in climate. Understanding the phenomenon of climate change is not that easy, it requires a lot of thinking and discussion. If we talk about Pakistan, it is most exposed to climate change and its impacts. This study basically examined the awareness of climate change among college students in Lahore. Additionally, the study also surveyed how human activities contribute to climate change and how the impacts can be mitigated. A total of 403 students were asked to fill in the responses in Lahore belonging to different ages, gender, education level, and economic status. The study found that individuals who had a higher level of education were more likely to be aware of the climate and the impact of their actions on the environment. This highlights the importance of education in promoting sustainable behavior and improving environmental quality. Overall, this study provides valuable insights into students' attitudes toward climate change and environmental responsibility, which can inform policy decisions aimed at promoting sustainable practices and protecting our planet for future generations.

INTRODUCTION

Climate change impacts are extensive. Physiological, geographical, social, political, and economic effects can be seen with changing climate. Global climate change is changing our relationship with the environment, altering stable climate factors, and making them dangerous, unpredictable, and threatening. Many developing countries in the world are seriously threatened by climate change. Climate change has not only put pressure on water resources but also changed land use and impacted the ability of ecosystems to sustain food production, ensure an uninterrupted supply of freshwater resources, provision of ecosystem services, and promotion of local multifunctional (Abbasi Z et al. 2020).

Each and everything in the world grows and changes. So, the climate of the world also changes with time. Various studies show that climate change is happening much faster than before. Humanity is currently facing dramatic changes in climate. Temperatures, sea level rise, ocean warming, winter shortening and warming, increased occurrence of severe cyclones, melting of glaciers, and many other most common extreme climate events. These changes will have many negative effects on humans and natural ecosystems. For developing mitigation strategies, regional and broad knowledge of climate change is required. A lot of research has been done on climate change awareness among students, educators, farmers, and others. These studies indicate that we need to focus on a fundamental understanding of communities/

people to increase their susceptibility to climate change (Mohsin et al. 2022).

There are studies one from the United States and the other from the United Kingdom that have been done to further explain the risk of severe rain. They have cautioned that these hazards are brought on by extreme climate change, thus we must gradually address the problem of global warming. The two floods of 500 years each in Just 15 Years occurred and one of them occurred in the United States the Great Flood of 1993, which wreaked havoc on cities along the Mississippi River and its tributaries in nine Midwestern states. Hundreds of levees burst, forcing thousands of Americans to leave their homes and lives behind, and the total cost of the destruction ranged from $12 to 16 billion in only 15 years (Singh et al. 2012).

A lot of people still question whether the climate is warming or not. A common challenge in understanding the problem of climate change is that science is complex, lengthy, and it requires thinking. Certain misguided judgments make the question wrong, in addition to conceptual flaws of global climate change like the difference between weather and climate (Singh et al. 2016).

The study was conducted on Karnataka's agriculture has been devastated by climate change, creating a shortage of food, and increasing poverty. Due to unpredictable rainfall patterns, crop yields are dropping, which has an impact on both farmers' and consumers' access to food. Food scarcity has a negative impact on livelihood growth and resilience, which is counterproductive. Researchers have claimed that climate change poses major concerns to farming households' ability to ensure food protection (Schweizer et al. 2005).

In the Palghar district of Maharashtra, more than 30% of women have a BMI underweight of 18.5 kg/m2, and more than 50% of infants aged 6 to 59 months have anemia in 2015. The Indian non-profit organization The Energy Research Institute launched a series of interventions in 2018 to reduce chronic malnutrition and anemia connected to food insecurity by exploiting the area's abundance of natural resources and biodiversity. The major objective of the program is to encourage tribal tribes to resume including nutrient-rich, locally cultivated wild foods in their daily diet. The facilitation of community focus groups by knowledgeable local health professionals and the introduction of nutrition initiatives in surrounding schools have increased social acceptance of these food sources (Wheeler et al. 2013).

A quarter of all carbon dioxide that is released onto land is absorbed by tropical forests, which are powerhouses in the carbon storage department. There is evidence that the 2005 and 2010 droughts may have reached a growth limit for tropical forests. Brazil has decreased deforestation in the Amazon by 60–70% since 2004, although additional decreases might not have a significant impact on the global carbon budget. With vast amounts of carbon being released by fires, Indonesia has the highest rate of deforestation and the largest area of forest cleared worldwide (Gairola et al. 2010).

Due to short-term crop output fluctuations and food insecurity in sensitive places, climate change has the potential to obstruct efforts to end world hunger. A "climate-smart food system" needs to be built through investments in adaptation and mitigation (Chang S et al., 2018). Healthcare systems in the Himalayan region that rely on medicinal plants are significantly affected by climate change. This study examined how Vaidyas perceived medicinal herbs and their impact on conventional medical practices. The locals employ 15 highly valuable medicinal herbs to treat illnesses, but due to changes in phenoplasts, and have shifted the collection season. To adapt to the changes, traditional healers have discovered various plant species as alternatives (Sanjay et al. 2010).

Global health initiatives have increased as a result of the terrible effects that climate change has on the world's poorest citizens. In order to address this, a collaborative learning initiative is proposed to raise awareness of climate change, strengthen the evidence base, incorporate climate change mitigation and adaptation concerns into program design, and align existing global health program targets and methods with more comprehensive frameworks for climate change and sustainable development (Nelson et al. 2009).

Pakistan is a country that is quite deprived in terms of resources with a population that is quite large and is increasing day by day very quickly. It has an exceptionally low natural resource base and socio-cultural conditions in particularly disadvantaged areas conditions. The population of Pakistan is estimated at about 190 million people and the growth rate of the annual population is 2.2%. Agriculture and power

generation in Pakistan rely severely on the irrigation water flowing from Himalayan glaciers. Being a dry land, Pakistan is always short of water for agriculture and urban/industrial use. In addition, Pakistani people, especially those living in slums and squatter settlements, suffer from heat stress and various diseases such as gastroenteritis, dengue fever, and malaria. Changing of climate is an extra load for this country as it is already facing a lot of issues and burdens. On the ranking list of the countries most affected by the change of climate, Pakistan is the 12th number (Shahid et al. 2016).

It is noticeably clear that Pakistan is one of those countries which are most exposed to climate change. Pakistan has experienced many severe floods, droughts, and storms during the past few years. However, there are very few studies present that have focused on studying why Pakistan is the most susceptible to the risk caused by climate change. Floods and droughts, along with multiple natural threats that people face, are major sources of economic and social risk to individuals and contribute to rising deaths. Especially in developing countries, rural populations are often vulnerable to floods due to their low levels of adaptability and wealth. The intensity and severity of floods in developing countries are primarily ecological and climate change related. The lack of professional and efficient identification of the impacts of changing climatic conditions on agricultural systems can have exceptional and negative impacts on food productivity and its security and contribute to poverty alleviation and sustainable development. Development efforts can also become an obstacle (Fahad et al. 2020).

Due to climate change, Lahore has experienced many major events recently. Winter is very short, and summer is longer than usual. Summer temperatures in Lahore in 2019 were extremely hot, with some days exceeding 45 degrees Celsius. As an agricultural city, Lahore also faces climate challenges, with hailstorms distorting crops. This suggests that the ice cap has melted. Pakistan has also suffered from flood problems in recent years (Ranal et al. 2018).

Climate change is an environmental crisis that requires widespread attention not only from policymakers but also from the general public. School, College, and University students were selected as the target group to determine public knowledge about climate change in Pakistan. There are many conceptual difficulties students face in such subjects due to limited knowledge and many misunderstandings. Due to limited local media coverage on the issue, students may believe anything and everything that can turn a simple scientific phenomenon into a debate in their minds (Gulraiz et al. 2021

Lahore is the capital of Punjab and is the second most populous city in the country. The city has a long history and has undergone remarkable expansion, growth, and development activities since the 1970s, including buildings, road construction, and loss of prime agricultural land, among many other human activities (Shirazi et al. 2012).

Therefore, the main objective of this study was to know the perception of climate change among college students in Lahore. The main purpose of this study is to raise awareness and educate young people about climate change.

METHODOLOGY

The research was carried out at Kinnaird College for Women and nearby institutes including, Lahore College for women university, university of Central Punjab, Punjab University, and KIPS School in Lahore, region of Punjab Pakistan. A survey was conducted in the adult population among students who examined climate change awareness in their region and filled out the questionnaire. The poll included a total of 403 students. A Google-formed-based questionnaire was developed and conducted online. The questionnaire was reviewed multiple times and kept simple. The responses were analyzed. The purposes of the survey and all the terms used in the survey were explained to the respondents and maintained confidentially. The survey was conducted on a limited sample of the city's population. As a result, the research sample was biased. The research shows the estimation of awareness regarding climate change in certain age groups of people. Secondary data was collected by using the internet and library to gain access to publish articles, journals, and reports. Primary data was collected through a questionnaire survey. The questionnaire included closed-ending questions that were filled by 800 students of urban communities. The survey shows different responses from students regarding climate change awareness. The questionnaire survey responses were statistically analyzed and compiled by using the IBM SPSS

software. Positive and Negative responses of defendants were calculated.

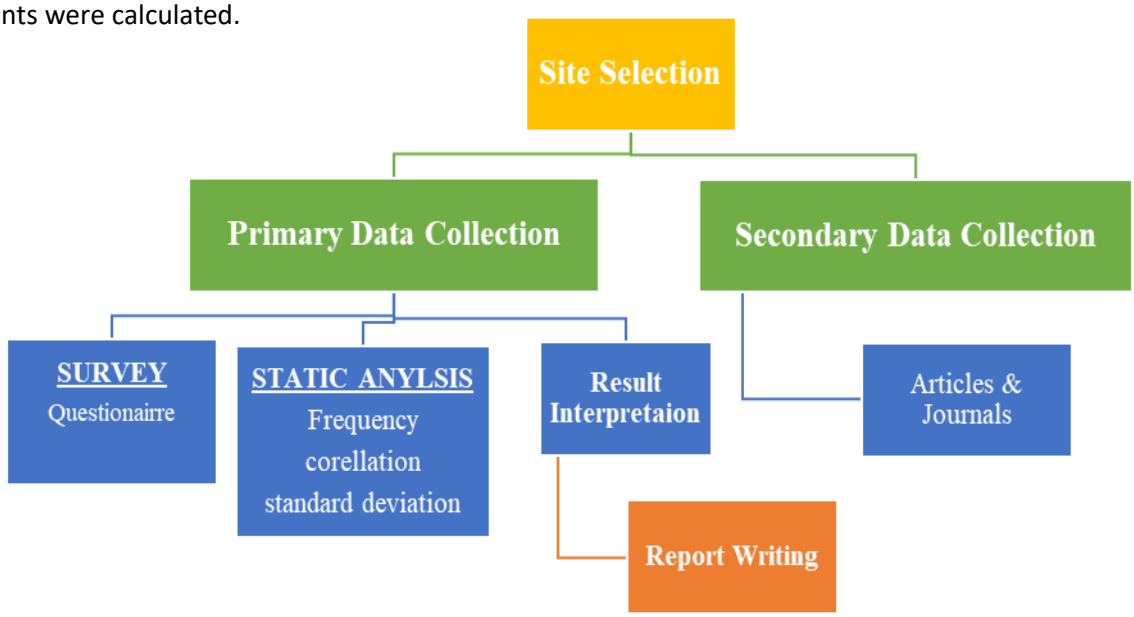

Figure 1. Research Methodology

RESULTS AND DISCUSSION

Firstly, frequencies between the variables were obtained using numeric values. In frequencies, cumulative percentages were also found. Frequencies were in two categories, Yes or No. Standard deviation and descriptive statistics were obtained. In Standard deviation minimum, maximum, and mean were also obtained. At last, Correlations were obtained between different variables. Correlations were obtained by correlating age, gender, socioeconomic status, and education level with different variables. Then Frequency, Standard deviation, and correlation results were discussed. The result of the questionnaire Survey has a different frequency. The respondents (81.1%) think that global climate is changing thus the results of that question show that the students at different educational institutes already have some knowledge about climate change because of its increasing effects on weather. The respondents (73.7%) think that human activities are really responsible for climate change which can be due to the increasing use of fossil fuels for vehicles and for energy etc. More than half of respondents (67%) think that deforestation is one of the causes of climate change as forests are the larger sinks of carbon. The forest is cleared for agriculture or woods which increases the release of carbon dioxide in the atmosphere that can cause climate change. In the questionnaire, respondents were asked about the UNFCC which showed that more than half of respondents (61.3%) know about the UNFCC which was signed in 1993 for addressing the problems that are increasing the greenhouse gas in the atmosphere due to anthropogenic activities that cause climate change. The respondents (67.5%) know about the international panel on Climate Change which is the policy maker on climate change to control the climate change activities. The respondents (71%) are aware that vehicular emissions are one of the causes of climate change, so they know that fossil fuel burning releases greenhouse gases like carbon dioxide and methane in the atmosphere which is enough to cause climate change. The respondents (66.5%) really knew that industrial emission is one of the causes of climate change that releases every kind of chemical in the atmosphere that can change the climate. Human health issues are due to climate change, so respondents (80%) think that yes, it is due to climate change that introduces the dangerous greenhouse gases in the atmosphere that cause asthma or skin allergies on exposure to climate change. In the Questionnaire respondents (78.2%) think that water-related issues are mainly due to climate change so they must know that climate changes increase the temperature which increases the chances of flooding that can disturb the water flow in dams. The respondents (81.9%) think that agricultural production is affected by climate change as they know

that temperature is changing that are affecting the growth of crops that grows in summer and in springs or winter and majority respondents (78%) agreed that climate change is responsible for the natural disasters like floods that occurred in SINDH due to change of temperature. According to respondents (84.6%), climate change can cause threats to nutritional security and malnutrition by increasing the chances of diseases in crops and by destroying the crop's nutritional value which led to malnutrition. The respondents (65.5%) agree that climate change has impacted food security in Pakistan by increasing the chances of drought and floods mainly in Sindh province. The majority of respondents (80.8%) agreed that higher temperatures and emissions of carbon dioxide in the atmosphere and drought and floods affect the staple food in the world. Most of the countries including Latin America and most parts of Africa have rice as their staple food so the areas that are facing drought due to increased temperature can have problems in cultivating the rice. More than half of respondents (75.4%) agreed that vector-borne diseases are due to climate change then they must know that the most viral disease carried by a vector in the world is dengue and over one-third of the world's population resides in warm, humid tropical areas, where the temperature is excellent for the mosquitoes that transmit dengue and the other lethal and extensively researched climate-sensitive vector-borne disease is malaria, which is brought on by plasmodium species and spreads between people by infected female Anopheles mosquitoes. In Questionnaire, the respondents (74.2%) agreed that physical hazards due to climate change can be health-related such as climate change causing floods that destroy people's personal property including their agricultural lands from where they eat, and these people can face malnutrition so climate change can cause physical hazards related health. The respondents (75.4%) agreed that lifestyle changes can help to cope with climate change that can be done by using public transport more than personal transport and by using more renewable energy sources that can decrease the release of carbon dioxide in the atmosphere and it can be done by planting the more trees. In Questionnaire, the respondents (66.3%) agreed that awareness about climate change is important to reduce the changes in climate and it can be done by spreading awareness in areas where people are less educated including villages where people still burn their lands to clear their land which is the old and destructive methods to clear the land that can cause climate change by increasing the temperature and by introducing the smoke in the air. The respondent (74.7%) International partnership and cooperation are important to cope up with the climate change because all countries are responsible for the causes of greenhouse gases especially developed countries all countries are suffering due to climate change so international partnership and cooperation are important regarding climate change. As shown in the table below, in Questionnaire the respondents (74.8%) agree that awareness and campaigns about climate change can help to control climate change and that campaigns about climate change can be done by individuals on social media where the person can engage a large amount of audience. The respondents (65%) agreed that helping the community on addressing climate change and food security by educating them about the activities that can cause threats to food security and the respondents (71.7%) also agreed that more scientific research is still needed various aspects and climate change because scientific new research can further help to understand why global temperatures continue to rising and how global warming is going to affect the world and different scientific studies will helps to address this issue before it gets worse.

The respondents (71%) are aware that vehicular emissions are one of the causes of climate change, so they know that fossils fuels burning release greenhouse gases like carbon dioxide and methane in the atmosphere that is enough to cause climate change. The respondents (66.5%) really knew that industrial emission is one of the causes of climate change that releases every kind of chemical in the atmosphere that can change the climate. Human health issues are due to climate change, so respondents (80%) think that yes, it is due to climate change that it introduces the dangerous greenhouse gases in the atmosphere that cause asthma or skin allergies on exposure to the climate change. In the Questionnaire respondents (78.2%) think that water related issues are mainly due to climate change so they must know that climate changes increase temperature that increases the chances of flooding that can disturb the water flow in dams. The respondents (81.9%) thinks that agricultural production is affecting by the climate change as they know that temperature is changing that are affecting the growth of crops that grows in summer and in springs or winter and majority respondents (78%) agreed that climate change is responsible for the natural disasters like floods that occurred in SINDH due to change of temperature. According to

respondents (84.6%) climate change can cause threats to nutritional security and malnutrition by increasing the chances of diseases in crops and by destroying the crop's nutritional value that led to malnutrition. The respondents (65.5%) agree that climate change has impacted food security in Pakistan by increasing the chances of drought and floods mainly in Sindh province. The majority of respondents (80.8%) agreed that higher temperatures and emissions of carbon dioxide in the atmosphere and drought and floods affect the staple food in the world. Most of the countries including Latin America and most parts of Africa have rice as their staple food so the areas that are facing drought due to increased temperature can have problems in cultivating the rice. More than half respondents (75.4%) agreed that vector borne diseases are due to climate change then they must know that the most viral disease carried by a vector in the world is dengue and over one-third of the world's population resides in warm, humid tropical areas, where the temperature is excellent for the mosquitoes that transmit dengue and the other lethal and extensively researched climate-sensitive vector borne disease is malaria, which is brought on by plasmodium species and spreads between people by infected female Anopheles mosquitoes. In Questionnaire, the respondents (74.2%) agreed that physical hazards due to climate change can be health related such as climate change causing floods that destroys the people's personal property including their agricultural lands from where they eat, and these people can face malnutrition so climate change can cause physical hazards related health. The respondents (75.4%) agreed that lifestyle changes can help to cope with the ate change that can be done by using the public transport more than personal transport and by using more renewable energy sources that can decrease the release of carbon dioxide in the atmosphere and it can be done by planting the more trees. In Questionnaire, the respondents (66.3%) agreed that awareness about climate change is important to reduce the changes in climate and it can be done by spreading the awareness in areas where people are less educated includes villages where people still burn their lands to clear their land which is the old and destructive methods to clear the land that can cause climate change by increasing the temperature and by introducing the smoke in the air. The respondent (74.7%) International partnership and cooperation are important to cope up with the climate change because all countries are responsible for the causes of greenhouse gases especially developed countries and all countries are suffering due to climate change so international partnership and cooperation are important regarding climate change. As shown in the Table below, in Questionnaire the respondents (74.8%) agree that awareness scampaignspaign about climate change help to con climate changes that campaigns about climate change can be done by individuals on social media where the person can engage largea amount of audience. The respondents (65%) agreed that helping the community on addressing climate change and food security by educating them about the activities that can cause threats to food security and the respondents (71.7%) are also agreed that more scientific research is still needed various aspects and climate change because scientific new research can further help to understand why global temperatures are continue to rising and how global warming is going to affects the world and different scientific studies will helps to address this issue before it gets worse.

The table below shows descriptive statistics. Mean (M) and Standard deviation (Std. Deviation) are shown in the above table. As shown in the table, information of 403 responses is included. The difference between maximum and minimum age of respondents is 18-22 years. Respondents are mostly females and males are very few. For Socio-Economic status maximum respondents' response is middle Class and minimum response is upper class. The maximum responses for Education Level are Undergraduate and Minimum Response is Postgraduate. Standard deviation measures the dispersion among data sets. Do you think that the global climate is changing? are (Mean:.8114 and St. Deviation: .39617), For do you think that human activities are contributing to climate change? are (Mean: 7.370 and St. Deviation: .44082), For do you think that deforestation contributes most significantly towards climate change? are (Mean: .6700 and St. Deviation: .47081). For Have you ever heard about UNFCC (United Nations Framework Convention on Climate Change)? are (Mean: 6.129 and St. Deviation: .48769), For have you ever heard about IPCC (International Panel on Climate Change)? are (Mean: .6749 and St. Deviation: .46898). For do you think that vehicular pollution is contributing to climate change? are (Mean:.7196 and St. Deviation: .44975), For do you think that industrial pollution is also major reason behind climate change? are (Mean: .6650 and St. Deviation: .47257), For do you think that health-related issues have connection to changing climate? are (Mean:.7940 and St. Deviation: .40490). For do you think that water-related issues (quantity as

well as quality of water) are mainly pertaining to changing climate change? are (Mean: .7618 and St. Deviation: .42652), For do you think that reduction in agricultural production is related to climate change? are (Mean:.8089 and St. Deviation: .39363), For do you think that climate change can lead to frequent natural disasters? are (Mean:.6799 and St. Deviation: .46709). For do you think that the impact of climate change threats nutrition security and causes undernutrition? are (Mean: .8561 and St. Deviation: .35145), For do you think Pakistan is currently facing impacts of climate change on food security are for (Mean: .6551 and St. Deviation: .47593), For do you agree higher temperatures, water scarcity, droughts, floods and greater CO2 concentrations in the atmosphere affect staple crop around the world? are (Mean: .7940 and St. Deviation: .40490). For do you think that vector borne diseases are also health related impact of climate change? are (Mean: .7444 and St. Deviation: .43673), For do you think that direct physical hazards of extreme climatic events are health-related impact of climate change? are (Mean: .7320 and St. Deviation: .44346), For do you think that various issues due to climate change are same at different places? are (Mean: .7841 and St. Deviation: .41194). For do you think that lifestyle changes would be effective in tackling climate change. (Mean: .7444 and St. Deviation: .43673), For do you think that awareness and education regarding climate change is important to prevent further climate change? are (Mean: .6526 and St. Deviation: .47673), For do you think that international partnership and cooperation is also essential in order to tackle climate change? are (Mean:.6873 and St. Deviation: .46415). For have you ever promoted awareness on climate change or participated in climate change awareness campaigns? (Mean:.7370 and St. Deviation: .44082), For if no, will you ever help community on addressing climate change and food security? are (Mean:.6501 and St. Deviation: .47752) and For do you think that more scientific research is still needed on various aspects and climate change? are (Mean: .7072 and St. Deviation: .45561). Total number of responses includes N: 403. All the values the M are laying within the range of (0 to +1) which confirms the normality of the data similarly the values of standard deviation are laying within in the range of (0.3 to 0.6) also shows the normality of data and the descriptive statistics of each item were also measured to get the data which is presented in the appendix. These values confirm the normality of each response.

Table 1: Frequencies and Cumulative Percentages between Different Variables

	Categories	Frequencies	Cumulative Percentage %
Global Climate is Changing	Yes	327	100
	No	76	18.9
Human Activities Are Contributing to Climate Change	Yes	297	100
	No	107	26.3
Deforestation Contributes Most Significantly Towards Climate Change	Yes	270	100
	No	133	33
Ever Heard About IPCC (International Panel on Climate Change)	Yes	272	100
	No	131	32.5
Ever Heard About UNFCC (United Nations Framework Convention on Climate Change)	Yes	247	100
	No	156	38.7
Vehicular Pollution Is Contributing to Climate Change	Yes	290	100
	No	113	28
Industrial Pollution is Also a Major Reason Behind Climate Change	Yes	268	100
	No	135	33.5
Health Related Issue in Human Have Connection to Climate Change	Yes	320	100
	No	83	20.6
Water Related Issues Are Mainly Pertaining to Changing Climate Change	Yes	307	100
	No	96	23.8
Reduction in Agricultural Production Is Related to Climate Change	Yes	326	100
	No	77	19.1
Climate Change Can Lead to Frequent Natural Disasters	Yes	274	100
	No	179	32

Impact of Climate Change Threats Nutrition Security and Causes Undernutrition	Yes No	345 58	100 14.4
Pakistan Is Currently Facing Impacts of Climate Change on Food Security	Yes No	264 139	100 34.5
Higher Temperatures, Water Scarcity, Droughts, Floods, And Greater CO_2 Concentrations in The Atmosphere Affect Staple Crops Around the World	Yes No	320 83	100 20.6
Vector Borne Diseases Are Also Has Health Related Impact of Climate Change	Yes No	300 103	100 25.6
Direct Physical Hazards of Extreme Climatic Events Are Health Related Impact of Climate Change	Yes No	295 108	100 26.8
Various Issues Due to Climate Change Are Same at Different Places	Yes No	316 87	100 21.6
Lifestyle Changes Would Be Effective in Tackling Climate Change	Yes No	300 103	100 25.6
Awareness and Education Regarding Climate Change Its Important to Prevent Further Climate Change	Yes No	263 140	100 34.7
International Partnership and Cooperation is Also Essential to Manage Climate Change	Yes No	277 126	100 31.3
Promoted Awareness on Climate Change or Participated in Climate Change Awareness Campaigns	Yes No	297 106	100 26.3
Helped Community on Addressing Climate Change and Food Security	Yes No	262 141	100 35
More Scientific Research is Still Needed on Various Aspects and Climate Change	Yes No	285 118	100 29.3

Table 2: Mean and Standard Deviation between Different Variables

	Mean	Std. Deviation
Gender	.5459	.49851
Age range	1.1836	.57392
Socio Economic	1.2581	.58836
Educational level	1.2084	.69556
Global Climate is Changing	.8114	.39167
Human Activities Are Contributing to Climate Change	.7370	.44082
Deforestation Contributes Most Significantly Towards Climate Change	.6700	.47081
Ever Heard About IPCC (International Panel on Climate Change)	.6129	.48769
Ever Heard About UNFCC (United Nations Framework Convention on Climate Change)	.7196	.44975
Vehicular Pollution Is Contributing to Climate Change	.6749	.46898

Industrial Pollution is Also a Major Reason Behind Climate Change	.6650	.47257
Health Related Issue in Human Have Connection to Climate Change	.7940	.40490
Water Related Issues Are Mainly Pertaining to Changing Climate Change	.7618	.42652
Reduction in Agricultural Production Is Related to Climate Change	.8089	.39363
Climate Change Can Lead to Frequent Natural Disasters	.6799	.46709
Impact of Climate Change Threats Nutrition Security and Causes Undernutrition	.8561	.35145
Pakistan Is Currently Facing Impacts of Climate Change on Food Security	.6551	.47593
Higher Temperatures, Water Scarcity, Droughts, Floods, And Greater CO_2 Concentrations in The Atmosphere Affect Staple Crops Around the World	.7940	.40490
Vector Borne Diseases Are Also Has Health Related Impact of Climate Change	.7444	.43673
Direct Physical Hazards of Extreme Climatic Events Are Health Related Impact of Climate Change	.7320	.44346
Various Issues Due to Climate Change Are Same at Different Places	.7841	.41194
Lifestyle Changes Would Be Effective in Tackling Climate Change	.7444	.43673
Awareness and Education Regarding Climate Change Its Important to Prevent Further Climate Change	.6526	.47673
International Partnership and Cooperation is Also Essential to Manage Climate Change	.6873	.46415
Promoted Awareness on Climate Change or Participated in Climate Change Awareness Campaigns	.7370	.44082
Helped Community on Addressing Climate Change and Food Security	.6501	.47752
More Scientific Research is Still Needed on Various Aspects and Climate Change	.7072	.45561

Pearson correlation was studied between multiple variables to determine the level of awareness regarding climate change between respondents of students of Lahore. The results of correlating variables with each other were as follows. Firstly, the Pearson correlation was performed between multiple variables like gender of respondents, awareness about global climate change, contribution of human activities to climate change and contribution of deforestation towards climate change. As a result, positive correlation was observed between respondent's gender and perception about climate change, human activities contribution to climate change and deforestation contribution towards climate change at 1% level of significance. Pearson's correlation was also performed between different variables like age of respondents, heard about UNFCC, contribution of vehicular pollution to climate change and heard about IPCC. Positive correlation was determined between age, UNFCC, vehicular pollution and IPCC at the 1% level of significance. Pearson's correlation was also performed between different variables like socioeconomic status of respondents, industrial population major reason behind climate change, water related issues pertaining to climate change and human health related issues connection to climate change. Positive correlation was determined between socioeconomic, industrial pollution, water related issues and human health related issues at the 1% level of significance. Pearson's correlation was also performed between different variables like education level of respondents, agricultural production related

to climate change, climate change may lead to frequent natural disasters and climate change impact threatens nutrition security causes undernutrition. Positive correlation was determined between education level, frequent natural disasters, agricultural production and threatens nutrition security at the 1% level of significance. Pearson's correlation was also performed between different variables like gender of respondents, Pakistan facing impacts of climate change on food security, higher temperatures, water scarcity, droughts, floods, and greater CO2 concentrations in the atmosphere affect staple crop around the world and vector borne diseases health related impacts of climate change. Positive correlation was determined between gender, Pakistan, and food security, affect staple crop and vector borne diseases at the 1% level of significance. Pearson's correlation was also performed between different variables like age of respondents, direct physical hazards of extreme climatic events health related impacts of climate change, issues due to climate change same at different places and changes in lifestyle for tackling climate change. Positive correlation was determined between age, direct physical hazards, issues same and changes in lifestyle at the 1% level of significance. Pearson's correlation was also performed between different variables like socioeconomic status of respondents, awareness, and campaign to prevent climate change, international partnership, and cooperation to manage climate change and promoted or participated in climate change awareness campaign. Positive correlation was determined between socioeconomic, awareness and campaign, international partnership and cooperation and promotion and participation at the 1% level of significance. Pearson's correlation was also performed between different variables like the education level of respondents, help in addressing the community, scientific research needed on various aspects and climate change. Positive correlation was determined between education level, addressing the community, and scientific research at the 1% level of significance.

Table No 3: Correlation Between Level of Education, Helping the Community and Scientific Research

		Gender	**Do you think global climate is changing**	**Do you think that human activities are contributing to climate change**	**Do you think that deforestation contributes most significantly towards climate change**
Gender	Pearson Correlation	1	.197**	.168**	-.025
Do you think global climate is changing	Pearson Correlation	.197**	1	.130**	-.109*
Do you think that human activities are contributing to climate change	Pearson Correlation	.168**	.130**	1	-.012
Do you think that deforestation contributes most significantly towards climate change	Pearson Correlation	-.025	-.109*	-.012	1
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					
		Age range	**Have you ever heard about UNFCC (United Nations Framework Convention on Climate Change)**	**Do you think that vehicular pollution is contributing to climate change?**	**Have you ever heard about IPCC (International panel on Climate Change)?**
Age range	Pearson Correlation	1	-.261**	-.166**	.074
Have you ever heard about UNFCC (United Nations Framework	Pearson Correlation	-.261**	1	-.167**	-.051

Convention on Climate Change)					
Do you think that vehicular pollution is contributing to climate change?	Pearson Correlation	-.166**	-.167**	1	.133**
Have you ever heard about IPCC (International panel on Climate Change)?	Pearson Correlation	.074	-.051	.133**	1
**. Correlation is significant at the 0.01 level (2-tailed).					

		Socio Economic	**Do you think industrial pollution is also a major reason behind climate change?**	**Do you think health related issue in human have connection to climate change?**	**Do you think that water related issues are mainly pertaining to changing climate change?**
Socio Economic	Pearson Correlation	1	.124*	-.058	.057
Do you think industrial pollution is also a major reason behind climate change?	Pearson Correlation	.124*	1	-.127*	-.175**
Do you think health related issue in human have connection to climate change?	Pearson Correlation	-.058	-.127*	1	-.155**
Do you think that water related issues are mainly pertaining to changing climate change?	Pearson Correlation	.057	-.175**	-.155**	1
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

		Educational level	**Do you think that reduction in agricultural production is related to climate change?**	**Do you think that climate change can lead to frequent natural disasters?**	**Do you think that the impact of climate change threats nutrition security and causes undernutrition?**
Educational level	Pearson Correlation	1	-.254**	-.039	.113*
Do you think that reduction in agricultural production is related to climate change?	Pearson Correlation	-.254**	1	.045	.052
Do you think that climate change can lead to frequent natural disasters?	Pearson Correlation	-.039	.045	1	.325**
Do you think that the impact of climate change threats nutrition security and causes undernutrition?	Pearson Correlation	.113*	.052	.325**	1
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

		Gender	Do you think Pakistan is currently facing impacts of climate change on food security?	Do you agree higher temperatures, water scarcity, droughts, floods, and greater CO2 concentrations in the atmosphere affect staple crops around the world?	Do you think that vector borne diseases are also has health related impact of climate change?
Gender	Pearson Correlation	1	.041	-.033	.037
Do you think Pakistan is currently facing impacts of climate change on food security?	Pearson Correlation	.041	1	-.060	-.030
Do you agree higher temperatures, water scarcity, droughts, floods, and greater CO2 concentrations in the atmosphere affect staple crops around the world?	Pearson Correlation	-.033	-.060	1	.025
Do you think that vector borne diseases are also has health related impact of climate change?	Pearson Correlation	.037	-.030	.025	1
		Age range	**Do you think that direct physical hazards of extreme climatic events are health related impact of climate change?**	**Do you think that various issues due to climate change are same at different places?**	**Do you think that lifestyle changes would be effective in tackling climate change?**
Age range	Pearson Correlation	1	-.031	-.053	-.120*
Do you think that direct physical hazards of extreme climatic events are health related impact of climate change?	Pearson Correlation	-.031	1	-.045	-.098
Do you think that various issues due to climate change are same at different places?	Pearson Correlation	-.053	-.045	1	-.003
Do you think that lifestyle changes would	Pearson Correlation	-.120*	-.098	-.003	1

be effective in tackling climate change?						

*. Correlation is significant at the 0.05 level (2-tailed).

		Socio Economic	**Do you think that awareness and education regarding climate change its important to prevent further climate change?**	**Do you think that international partnership and cooperation is also essential to manage climate change?**	**Have you ever promoted awareness on climate change or participated in climate change awareness campaigns?**	
Socio Economic	Pearson Correlation	1	.072	.041	.099*	
Do you think that awareness and education regarding climate change its important to prevent further climate change?	Pearson Correlation	.072	1	.036	-.022	
Do you think that international partnership and cooperation is also essential to manage climate change?	Pearson Correlation	.041	.036	1	-.123*	
Have you ever promoted awareness on climate change or participated in climate change awareness campaigns?	Pearson Correlation	.099*	-.022	-.123*	1	
	Sig. (2-tailed)	.046	.666	.013		
	N	403	403	403	403	
*. Correlation is significant at the 0.05 level (2-tailed).						

		Educational level	**If no, will you ever help community on addressing climate change and food security?**	**Do you think that more scientific research is still needed on various aspects and climate change?**
Educational level	Pearson Correlation	1	.130**	.036
If no, will you ever help community on addressing climate change and food security?	Pearson Correlation	.130**	1	.077
Do you think that more scientific research is still	Pearson Correlation	.036	.077	1

needed on various aspects and climate change?				
**. Correlation is significant at the 0.01 level (2-tailed).				

CONCLUSION

Climate change is changing our relationship with the environment. As time passes, the climate is changing rapidly. This is mainly due to activities performed by humans. Climate change affects our environment and the well-being of living organisms. For developing mitigations and strategies for climate change, a lot of research is required. The phenomenon of climate change is very difficult to understand, and it requires a lot of effort. Pakistan is on 12th rank out of all the countries most exposed to climate change. We know that Pakistan is already facing a lot of social and economic issues, climate change is an additional stress and load for this country. People of Pakistan are greatly affected by climate change. If we talk about Lahore, its population is exposed to climate change and its impacts. The world needs to study climate change in detail, so the impacts and future are predicted. The main aim of conducting this survey was to analyze climate change awareness among the students of Lahore. The survey was filled by 403 students in Lahore. Out of 403, 220 were female whereas 183 were male. Out of 403 responses, 257 Students age ranged from 19-22 years, 110 students age ranged above 22 years and only 36 students age ranged from 16-18 years. Social economic status of 237 students were middle class where 135 students belonged to upper class and only 31 students were from lower class. The education level of 191 students was Undergraduate while 148 students' education level was Postgraduate and only 64 students were from Intermediate.

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Research Article

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Analysis of Dry Season Vegetable Production among Farmers in Benue State, Nigeria

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ABSTRACT

The study was carried out to analyze dry-season vegetable production among farmers in Benue State, Nigeria. Data were collected through the use of a structured questionnaire from a sample of 182 respondents. Frequency, percentage, mean score, standard deviation and factor analysis were used for data analysis. Findings indicated that 52.2% of the respondents were aged between 31 and 40 years, the majority (71.4%) were female, married (78.6%) and 74.2% had a household size of 3-6 persons, among others. Results also revealed that the major reasons for engaging in dry season vegetable production in the study area were improving food security and nutrition (M=2.93), income generation (M=2.90), access to vegetables for household consumption (M=2.90), eradicate extreme hunger and poverty (M=2.89) and employment generation (M=2.54). Findings further revealed that major perceived challenges of dry-season vegetable production in the study area were named infrastructural, input related and environmental factors based on the item loading for factors 1, 2 and 3 respectively. The study concluded that the respondents were engaged in dry-season vegetable production in order to increase household consumption and generate additional income for economic empowerment. It is recommended that creating an enabling environment for the business to thrive as well as provision of infrastructural and credit facilities will enhance increase in production.

INTRODUCTION

Vegetables are important components of human diets and can easily be cultivated on small areas of land. Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) recommended a daily vegetable intake of 200g per person but the Nigerian national average is below this value (Kintomo et al. 2014). This inadequate intake of fresh vegetables may further be worsened during the dry season when moisture scarcity limits the area under cultivation and the number of vegetables that can be grown and supplied to the urban areas (Ojo et al. 2010).

Nigeria as a country is unable to meet its domestic requirements for vegetables, fruits, floriculture, herbs and spices. According to Food and Agriculture Organization (FAO) (2010), Nigeria imported a total of 105,000 metric tonnes of tomato paste valued at 16 billion nairas to bridge the deficit gap between demand and supply in the country from 2009 to 2010. Kalu (2013) attributed these situations to socio-economic constraints surrounding the key actors in

the tomato value chain, institutional weakness and declining agricultural research.

In Nigeria, there are two distinct seasons, the rainy and the dry seasons. The rainy season is the normal cropping season and this starts in April and ends in October while the dry season starts in November and ends in March. During the rainy season, production of vegetables is high resulting in the saturation of the market, but during the dry season there is usually a scarcity of this important farm produce thereby leading to a high price due to short supply (Ibekwe et al. 2010). Dry season vegetable production if practiced with the required agricultural techniques have the propensity of uplifting the financial condition of the farmers and hence better their standard of living.

The demand for vegetables also outstrips the supply; causing scarcity of the commodity. Omeh (2012) buttressed this fact when he opined that vegetable is used in a variety of dishes, and it is widely consumed raw as well. It is in high demand in Nigeria and sells for reasonably good prices. If farmers have high yields in their crops and the demand for such crops is high, this consequently gives rise to high prices which eventually accrue more income to the farmers. Under the analyzed condition, vegetable farmers in Benue State should have no relationship with poverty, but the poverty rate recorded in the State is as high as 74.1 percent (National Bureau of Statistics, 2012). Hence, this study focused on the analysis of dry season vegetable production among farmers in Benue State, Nigeria in order to fill this existing knowledge gap. The following research questions were pertinent to this study: What are the socio-economic characteristics of dry-season vegetable farmers in the study area? What are the reasons for engaging in dry-season vegetable production in the study area? What are the perceived challenges of dry season vegetable production in the study area?

Specifically, the study sought to:

i. Describe the socio-economic characteristics of dry-season vegetable farmers in the study area;
ii. Ascertain the reasons for engaging in dry season vegetable production in the study area; and
iii. Identify the perceived challenges of dry season vegetable production in the study area.

METHODOLOGY

The study was carried out in Benue State, Nigeria. Benue State is one of the 36 States located in the North-Central part of Nigeria. The State has 23 Local Government Areas that are grouped into 3 agricultural zones, namely; the Northern zone, the Eastern zone and the Central zone. It has its headquarters in Makurdi. Benue State derives its name from the river Benue, the second largest river in Nigeria after the Niger. The state was created out of the Benue Plateau State in 1976. Benue State has a population of 4,219,244 people (Nigeria Population Commission, 2006) and a total land mass of 34,095km2. It is located between longitude 80E and 100E and latitude 6030N and 8o8N (Benue State Agricultural and Rural Development Authority (BNARDA), 1998). The state shares boundaries with Cross River and Ebonyi States to the south, Enugu State to the south-west, Kogi State to the west, Taraba State and Nasarawa State to the East and North, respectively. It shares an international boundary with the Republic of Cameroon to the South East (BNARDA, 1998).

The population for this study consists of all dry season vegetable farmers in Benue State, Nigeria. However, since it was impractical to study the entire population, a sample size of the population was taken for the study. In the first stage, the population of the study was stratified into three agricultural Zones, namely; Zones A, B and C. In stage two, six Local Government Areas where vegetables were predominantly produced were purposively selected from each of the three agricultural zones.

In the first stage, the population of the study was stratified into three agricultural Zones, namely; Zones A, B and C. In stage two, six Local Government Areas where vegetables were predominantly produced were purposively selected from each of the three agricultural zones. The LGAs were Logo and Kastina-Ala from Zone A, Makurdi and Tarka from Zone B and Otukpo and Ohimini from Zone C. In the third stage, two rural communities were purposively selected from each of the LGAs based on the level of involvement in dry-season vegetable production. The rural communities were Wende and Aganyi in Logo LGA, Abaji and Ayua from Kastina-Ala LGA, Nyongu and Northbank in Markudi LGA, Mbakyaa and Gwarche in Tarka LGA, Anmeji and Ehatokpe in Ohimini LGA and Asa1 and Upu in Otukpo LGA.

Finally, a sampling frame was developed for each of the rural communities, and using the proportional allocation of 20% (0.2), a total sample size of 182 respondents was selected.

Data were collected using a questionnaire. Frequency, percentage, mean score, standard deviation, and factor analysis were used to analyze data collected for the study.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

Age (years)

Table 1 shows that most (52.2%) of the respondents were within the age bracket of 31–40 years, 31.9% were within the age bracket of 41–50 years, 10.4% were aged between 21 and 30 years, while 4.1% were aged 51 years and above. The mean age of the respondents was 38 years. This implies that most of the farmers were within the productive age and have the physical strength to cope with the rigor of dry-season vegetable production. This result is similar to the findings obtained by Oladimeji and Abdulsalam (2012) who reported that dry-season farmers in their study area had a mean age of 38 years.

Sex

The majority (71.4%) of the respondents were female, while 28.6% were male (Table 1). This implies that women were more involved in dry-season vegetable production in the study area than their male counterparts. This result however disagrees with the findings of Dam (2012) who reported that in Benue State, dry-season vegetable farming is mostly dominated by men.

Marital Status

About 79% of the respondents were married, 9.9% of the respondents were single, 3.3% are divorced, and 8.2% were widowed (Table 1). This implies that a very large proportion of the farmers were married. This finding agrees with Adesope et al. (2014) who reported that most vegetable farmers in their study area were married.

Household size (numbers)

Results in Table 1 show that the majority (74.2%) of the dry season vegetable farmers had household sizes of between 3 and 6 persons, 23.1% had household size of 7-10 persons, while 1.6% had household size of more than 10 persons. The mean household size was about 6 persons. This implies that family labour was readily available for dry-season vegetable production in the study area. The significance of household size in agriculture hinges on the fact that the availability of labour for farm production, the total area cultivated for different crop enterprises, the amount of farm produce retained for domestic consumption, and the marketable surplus are all determined by the size of the farm household (Amaza et al. 2009).

Level of education

About 38% of the respondents in the study area had primary education, 31.3% had secondary education, 7.7% had tertiary education, and 23.1% of the respondents had non-formal education (Table 1). This is an indication that the farmers in the study area were to some extent educated and literate. This characteristic may have enabled them to make production management decisions that enhance dry season vegetable production in the area. Ogundari (2006) noted that education is needed to enhance productivity among farming households in Nigeria. The educational level of farmers is very important in farm management because a high literacy level of the respondents would afford them the opportunity to understand and adopt modern farm practices, thereby enhancing productivity and profitability.

Annual income (Naira)

Results in Table 1 show that about 57% of the respondents obtained between ₦50, 000.00 and ₦100, 000 annually, 29.7% had between ₦100, 001 and ₦150, 000, while 11.5% had ₦150, 001 - ₦200, 000. It shows that the respondents obtained low income from dry season vegetable production. This finding agrees with Ajani and Igbokwe (2014) who opined that small-scale farmers do not earn much from their farms.

Farm size (hectares)

Findings in Table 1 show that most (65.9%) of the respondents had a farm size of ≤ 1 ha, 28.6% had a farm size of 1.1–2ha, while only 5.5% had a farm size of 3 ha and above. The mean farm size was 1.40 hectares. This implies that the majority of the

respondents were small-scale farmers who practice on a subsistence level. This is consistent with the findings by Dam (2012) who reported that vegetable farmers had farm sizes that were generally small and often less than a hectare.

Table 1: Distribution of socio-economic characteristics of the respondents (n=182)

Socio-economic characteristics	Frequency	Percentage (%)	Mean Score
Age (years)			
≤20	1	0.5	38.04
21-30	19	10.4	
31-40	95	52.2	
41-50	58	31.9	
>50	9	4.9	
Sex			
Male	52	28.6	
Female	130	71.4	
Marital status			
Married	143	78.6	
Single	18	9.9	
Divorced	6	3.3	
Widow/widower	15	8.2	
Household size (numbers)			
<3	2	1.1	5.96
3-6	135	74.2	
7-10	42	23.1	
>10	3	1.6	
Level of education			
Tertiary	14	7.7	
Secondary	54	31.3	
Primary	69	37.9	
Non-formal education	42	23.1	
Annual income (Naira)			
≤50,000	2	1.1	162747.25
50,001-100,000	103	56.6	
100,001-150,000	54	29.7	
150,001-200,000	21	11.5	
>200,000	2	1.1	
Farm size (hectares)			
<1	120	65.9	1.40
1-3	52	28.6	
>3	10	5.5	
Farming experience (years)			
≤5	16	8.8	6.80
6-10	137	75.3	
11-15	26	14.3	
>15	3	1.6	
Major occupation			
Artisan	30	16.5	
Farming	120	65.9	

Civil service	12	6.6	
Petty trading	20	11.0	
Extension contact			
No	171	94.0	
Yes	11	6.0	
Membership of formal organization			
Yes	27	14.8	
No	155	85.2	
Type of formal organization			
None	155	85.2	
Cooperative society	12	6.6	
Farmer's association	9	4.9	
Fadama User group	6	3.3	
Access to credit facilities			
Yes	39	21.4	
No	143	7 8.6	

Reasons for engaging in dry season vegetable production

Farming experience (years)

The majority (75.3%) of the respondents had farming experience of between 6 and 10 years, 14.3% of them had farming experience of 10-15 years, while 8.8% of them had farming experience of ≤ 5 years (Table 1). This shows that dry-season vegetable farmers in the study area were relatively experienced. Farming experience plays a significant role in agricultural production. It is expected that the higher the farmers' experience in farming, the better the production capacity of the farmers (Adeyemo et al. 2010).

Level of education

About 38% of the respondents in the study area had primary education, 31.3% had secondary education, 7.7% had tertiary education and 23.1% of the respondents had non-formal education (Table 1). This is an indication that the farmers in the study area were to an extent educated and literate. This characteristic may have enabled them to make production management decisions that enhance dry season vegetable production in the area. According to Gama (2013), the level of awareness and adoption of agricultural innovations are affected by the literacy status of farmers. Those who are literate are expected to be more innovative because of their ability to get information quickly and ability to take risks. Ogundari (2006) noted that education is needed to enhance productivity among farming households in Nigeria. The educational level of farmers is very important in farm management because a high literacy level of the respondents would afford them the opportunity to understand and adopt modern farm practices, thereby enhancing productivity and profitability.

Extension contact

Table 1 further showed that the majority (94%) of the respondents did not have contact with extension agents in the last one year, while 6% had extension contact. This implies that there was poor interaction between farmers and extension agents on dry season vegetable production, which may likely result in inefficiency in production. Increased extension contacts can lead to more knowledge on improved dry season vegetable production technologies thereby increasing productivity and profitability. Umar et al. (2009) argued that increased extension contacts would increase the adoption of improved farm production technologies. They further argued that the frequency of extension contact is very essential as it guides the farmers from awareness to the adoption stage of innovation.

Findings in Table 2 show reasons for engaging in dry season vegetable production in the study area which include improving food security and nutrition (M=2.93), income generation (M=2.90), access to varieties of vegetables for household consumption (M=2.90), eradicating extreme hunger and poverty (M=2.89) and employment generation (M=2.54). All the standard deviations are less than one. This shows that there are uniformity in the responses of the respondents. This also implies that there are various reasons why respondents engage in dry-season

vegetable production in the study area which could be attributed to the overriding importance of vegetables. This is consistent with the findings by Ali et al. (2002) who opined that vegetables generate more jobs per hectare, on-farm, and off-farm, than staple-based agricultural enterprises.

Table 2: Mean score of reasons for engaging in dry season vegetable production

Reasons	Mean Score	Standard deviation
Income generation	2.90	0.89
Employment generation	2.54	0.86
Consolidate land ownership	1.84	0.84
Utilize opportunity created by nearby markets	2.24	0.93
Utilize available land areas	2.34	0.92
Produce raw materials	1.64	0.74
Beautify the surroundings	1.43	0.54
Access to varieties of vegetable for household consumption	2.89	0.85
Eradicating extreme hunger and poverty	2.90	0.82
For healthy consumption	1.74	0.78
Medicinal purposes	1.77	0.77
Improving food security and nutrition	2.93	0.84

Perceived challenges of dry season vegetable production

Table 3 shows the outcome of factor loadings from principal component analysis after varimax rotation of the perceived challenges of dry season vegetable production in the study area. These constraints were listed according to the proportion of variance associated with them and were classified under three major factors, namely; infrastructural, input related and environmental factors.

Factor 1 (infrastructural factors): Infrastructural factors were inadequate irrigable land and water (0.888), high cost of irrigation equipment (0.845), inadequate credit facilities (0.838), pests and diseases problem (0.763), polluted water (0.762), inadequate farm inputs (0.705), high cost of transportation (0.697), high cost of hired labour (0.639) and inadequate market (0.542). This is consistent with the findings of Nnadi et al. (2012) who opined that the greatest limitation of the smallholder farmers is capital. Access to agricultural credit has been positively linked to agricultural productivity in several studies. Yet, this vital input has eluded smallholder farmers in Nigeria.

Factor 2 (input-related factors): Variables that loaded under input-related factors were lack of capital (0.923), high cost of fertilizer (0.923), poor visits by extension agents (0.796), high cost of agrochemicals (0.788), low access to credit facilities (0.692), land tenure insecurity (0.545), poor quality harvest (0.612), An important institutional constraint is the absence of a clear title to land. Group ownership of land in Nigeria has been associated with such problems as limited tenure security, restrictions on farmers' mobility, and the inevitable fragmentation of holdings among future heirs (International Food Policy Research Institute, 2005).

Variables that loaded under factor 3 (environmental factors) include post-harvest losses (0.854), poor storage and preservation facilities (0.846), inadequate information on new technologies (0.666) and natural disasters such as drought (0.575). These constraints altogether pose a great threat to dry season vegetable production in the study area. This is in line with Ebewore and Achoja (2013) who posited that a major challenge faced by the majority of the vegetable farmers was poor storage and preservation.

Table 3: Factor analysis of perceived challenges of dry season vegetable production

Challenges	Components		
	Factor 1	Factor 2	Factor 3
Inadequate irrigable land and water	0.888	0.200	0.238
High cost of irrigation equipment	0.845	0.307	0.292
Inadequate credit facilities	0.838	0.256	0.261
Pests and diseases problem	0.763	0.215	0.221
Polluted water	0.762	0.306	0.314
Inadequate farm inputs	0.705	0.298	0.023
High cost of transportation	0.697	0.362	0.239
High cost of hired labour	0.639	0.061	0.201
Inadequate market	0.589	0.076	-0.066
Lack of capital	0.273	0.923	0.082
High cost of fertilizer	0.233	0.796	0.219
Poor visits by extension agents	0.191	0.788	0.210
High cost of agrochemicals	0.321	0.692	0.217
Low access to credit facilities	0.264	0.569	0.292
Land tenure insecurity	0.205	0.545	0.329
Post-harvest losses	0.140	0.236	0.854
Poor storage and preservation facilities	0.045	0.236	0.846
Inadequate information on new technologies	0.201	-0.202	0.666
Natural disasters such as drought	0.477	0.405	0.575

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
Factor 1: Infrastructural Factors
Factor 2: Input-Related Factors
Factor 3: Environmental Factors

Conclusion and Recommendations

The study concluded that majority of the respondents were middle-aged, female, married, literate and have small household size. The respondents indicated that reasons for engaging in dry-season vegetable production were to increase household consumption and generate additional income for economic empowerment. It is recommended that creating an enabling environment for the business to thrive as well as provision of infrastructural and credit facilities will enhance increase in production. The study further recommends the need for the respondents to join cooperative society in order to have easy access to credit facilities that will enhance productivity.

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Research Article

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Effects of Planting Population, Planting Position and Number of Nodes per Cutting on Cassava (*Manihot esculenta* Crantz) Seed Yield

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ABSTRACT

A field study was conducted at National Cereals Research Institute, Uyo Out-Station in Akwa Ibom State in 2012 and 2013 to evaluate the effects of plant population, planting position, and the number of nodes per cutting on cassava seed yield. The experiment was laid out in a randomized complete block design, replicated thrice in 4 x 3 x 4 factorial arrangements. Factor A treatments were four plant populations per hectare (10,000, 12500, 16666.67, and 20,000). Factor B treatments were three planting positions: slanting, vertical, and horizontal while factor C treatments were a number of nodes per stem cutting (2, 3, 4, and 5). The result of the establishment percentage showed a significantly different ($p<0.05$) in the treatment of the number of nodes per cutting. Treatment of 5 nodes per plant had a significant establishment percentage (100%) in 2012 and 2013 while treatment of 2- nodes per plant had poor establishment percentages of 60.00 and 60.50 %, respectively. Treatment of 20,000 plant/hectare produced a significantly higher number of stem bundles/ha; 815.30 and 875.22 in 2012 and 2013. The 10, 000 plants/hectare, had the least number of stem bundles/ha; 306.00 and 309.33. Horizontal planting produced a significantly higher number of bundles/ha; 921.68 and 943.17 in both years, followed by 643.41 and 705.30 bundles recorded in a slant position. The least number of stem bundles; 314 and 330.66 was recorded in vertical position. Seed yield as influenced by the number of nodes per cutting also showed a significant difference ($p<0.05$). Treatment of 5 nodes had significant cassava seed yield of 745.34 and 722.12 bundles/ha while the least; 431.68 and 474.33 were recorded in the treatment of 2 nodes. The study also revealed that plant population per hectare, planting position and number of nodes per cutting influences cassava storage yielded. Farmers were advised to adopt a 20,000 plants population per hectare with 4 nodes per stem cutting and plant horizontal position for higher stem multiplication but if storage root is the sole target, farmers should plant at least 4 nodes per cutting, plant in horizontal position in plant population of 12,500 stands per hectare.

INTRODUCTION

Cassava is referred as food security crop in Nigeria. It is a major staple produced and consumed in the diets of so many Nigeria, particularly in rural areas. It is primarily cultivated as an annual crop in the humid tropics (Bellotti et al. 2011). In Africa, cassava is the single most important source of dietary energy for a large proportion of the population (Cock, 2011). Cassava is a major food crop in Nigeria and is strategically valued for its role in food security, poverty alleviation and as a source of raw material for agro-allied industries with huge potential for the export market (Egesi et al. 2006; Okpara et al. 2022). All parts of cassava plants are utilized for food and animal feed but storage roots are the most used part. The leaves are widely consumed in some regions in Africa, Asia and South America (Njoku et al. 2014) as a source of protein, minerals, vitamins, fiber and amino acids (Ceballos et al. 2008). In Nigeria, especially southeast region, cassava could be processed into different local diets such as gari, fufu or apu, abacha, akpu, mmiri etc. Cassava generates income for farmers and provides employment to the farmers, processors and traders.

Cassava starch is an important industrial raw material. Cassava starch is preferred in the laundry and textile industries. The blended flavor of cassava starch, its non-degradation tenderly and excellent freeze stability make it a favorite recommended as a diluent in chemical and drug manufacturing or as a carrier in cosmetics, pills and capsules (Kadere and Makhoha, 2007). It's used in manufacturing ethanol and demand for ethanol has increased dramatically in the world over the last few years. Many countries already have ethanol gasoline blend programs and the majority of these are ethanol importers. The use of cassava in producing ethanol contributed to meeting up ethanol demand as the world market potential for ethanol for 2012/2013 was estimated at 7 billion liters, 6 billion for ethanol- fuel and 1 billion for ethanol-no fuel (Marco and Mpoko, 2010).

The scarcity of planting materials in all the cassava-growing states of Nigeria is a major challenge in the expansion of cassava farms. The major target of farmers is cassava with high storage root yield during maturation, without thinking about how to generate more stem cutting or seed. The only ultimate way to reduce the scarcity of cassava stem cutting is to adopt better agronomic practices that could lead to high storage root and seed yields. The choice of which enterprise to engage depends on the individual farmer. Some farmers prefer the production and marketing of cassava seed while most of the prefer storage root production and further processing of the roots into different cassava produce. Plant population probably influences crop vegetative and yield traits. In cassava, space between plant rows influences plant height, stem diameter, number of leaves, and storage root yields of different cassava varieties (Akpan and Ikeh, 2018). Several studies have been conducted with cassava, at plant populations that ranged from 6,666 plants ha-1 (Rojas et al. 2007) to 27,777 plants ha-1 (Guerra et al. 2003). Larger populations (of up to 50,000 plants ha-1) have been tested to determine their effects on the above-ground part of the plant (Lima et al. 2002). Akpan and Ikeh (2018) have demonstrated that different intra-row spacing had a significant effect on cassava growth and yield, but the response is on a varietal basis. In other words, an increase in row spacing may increases, reduces, or maintains cassava storage root and seed yields, based on the cassava varietal differences with respect to their growing habits or morphology.

Cassava cutting may be planted horizontally, vertically, or in an inclined position. The position of cassava varies depending on the plant variety, soil characteristics, ease of operation, tradition, and climatic conditions (Chantaprasan and Wanapat, 2003). The studies of Crawford (2005) in Jamaica concluded that horizontal planting of 25 cm stakes is best if soil moisture is limited at planting time. Similarly, Chan (1990) found a significant difference in cassava tuber yield among horizontal, vertical, and inclined positions of 15cm stakes. Krochmal (2009) studies on Virgin Islands reported that it would be better to plant 20 or 25-cm stakes with three buds horizontally at 5-10 cm under the soil surface than planting them in a horizontal method. Harper (1993) studies in Thailand found that planting position depends on soil and climatic conditions. Narmilan and Puvanitha (2020) reported that planting methods of cuttings and varietal characters had a profound influence on the growth and root yield of cassava cultivars in Sir Lanka. Chew (1994) reported no significant difference between the three planting positions in Malaysia. Different authors at different location reported differences in storage root yields at different planting orientation but no literature have ever reported on stem multiplication.

Considering that improved cassava planting is scarce in Nigeria, one of the ways of making adequate improved planting materials available to farmers is to embark on large-scale field multiplication of cassava stems through different conventional and non-conventional methods. A lot of work has been done on the agronomic aspect of cassava improvement in Nigeria but the issue of meeting the increasing demand for improved cassava variety planting materials in Nigeria has not been addressed. Recently, training of cassava farmers on seed production (Seed multiplication) by the National Root Crop Research Institute (NRCRI), International Institute for Tropical Agriculture in collaboration with the National Seed Council of Nigeria has thrown more light on possible ways of reducing the challenges of inadequate cassava planting material in Nigeria and to ensure that farmers produce clean and quality planting materials through cassava seed entrepreneurs (CSCs) programme. Therefore, this study was carried out to evaluate the influence of cassava plant population, planting position, and number of nodes per stem cutting on cassava seed yield as well as storage root yields.

MATERIALS AND METHOD

The trail was conducted at the research farm of the National Cereals Research Institute (NCRI) Uyo out station located at Owot Uta Ibesikpo/Asutan local Government Area of Akwa Ibom State during the 2012 and 2013 cropping seasons. Ibesikpo/Asutan lies at latitude 0405N, longitude 07056, and altitude 38m above sea level. Ibesikpo/Asutan has an annual rainfall of 2500mm and monthly sunshine of 3.14 hours and a mean annual temperature of 28^0C with an annual relative humidity of 79% and evaporation rate of 2.6cm2. The rainfall pattern of the location is bimodal. Rainfall usually starts in March and ends in November with a short period of relative moisture stress in August, traditionally referred to as 'August Break" (Peters et al. 1989). The soil physicochemical properties of the experimental site before planting were as follows; pH5.7, organic matter 1.67%, available P, 88.24mg/kg, total Nitrogen, 0.06%. The particle size analysis indicated 90.40% sand, 3.30% silt, and 6.30% of clay.

The land was plowed, harrowed, and ridged. The experiment design used was 4 x 3 x 4 factorial. Factor A treatments were four plant populations per hectare (10,000, 12500, 16666.67, and 20,000) while Factor B treatments were three planting positions: slanting, vertical and horizontal while factor C treatments were a number of nodes per stem cutting (2, 3, 4 and 5). Each plot size was 6m x 6m with inter and intra-block spacing of 1.5m paths, respectively. Planting was done in May, 2012 and 2013. The Cassava variety used was TME 419. Weeding was done at 4 and 12 weeks after planting (WAP), followed by slashing at 8 months after planting (MAP). The inorganic fertilizer (NPK-15:15:15) at a rate of 400kg/ha was applied on the blanket recommendation two months after planting.

The following parameters were assessed during the trial; establishment percentage, number of sprouted shoots, number of branches per plant, plant height, number of stem bundles per hectare, number of storage roots per plant, and storage tuber yield in tons per hectare. All the data collected were subjected to analysis of variance. Significant means were compared with the least significant difference at 5 percent probability.

RESULTS

The result of the establishment percentage showed a significantly different ($p<0.05$) in the treatment of the number of nodes per cutting (Table 1). Treatment of 5 nodes per plant had a significant establishment percentage (100%) in 2012 and 2013 while treatment of 2- nodes per plant had poor establishment percentages of 60.00 and 60.50 %, respectively.

The effect of plant population on cassava height at harvest indicated a significant difference ($P<0.05$) among the spacing treatments. Spacing of 10,000 plant population per hectare (p/ha) had the tallest cassava of 198.68 and 203.40 cm in the 2012 and 2013 cropping seasons, respectively whereas the shortest was 177.55 and185.30 cm respectively observed in 20,000p/hectare treatment (Table 2). Cassava height as influenced by planting orientation y differed significantly with the vertical position having the tallest (209.34 and199.34 cm) while the shortest (163.11 and 173.43 cm) was observed in the horizontal position. Cassava height as influenced by the number of nodes per stem cutting showed no significant difference among the treatments (Table 2).

The number of stems per stand at harvest as influenced by plant population, planting position and number of nodes per stem cuttings were significantly different (Table 2). A plant population of 20,000 per hectare had a significantly higher number of stems per

plant (2.93 and 3.38) in 2012 and 2013, respectively. The least number of stems per stand at harvest (1.53 and 1.48) respectively was recorded in the spacing of 10,000 p/hectare. Among the planting positions, the horizontal position produced a significantly higher number of stems per stand at harvest (4.89 and 4.55) in both cropping seasons while the least number of stems per stand (1.33 and 1.09) was recorded in the vertical position. Treatment of 5 nodes per stem cutting had a significantly higher number of stems per stand (3.79 and 3.46) in the 2012 and 2013 trials, respectively. The least number of stems per stand was recorded in the treatment of 2 nodes per stand (1.34 and 1.34) respectively.

Table 1: Establishment Percentage and Number of Shoots per Stand

Treatments	Establishment (%)		Number of Shoots per Stand	
Plant population/ha	2012 4WAP	2013 4WAP	2012 4WAP	**2013 4WAP**
10,000	99.00	100.00	2.31	**2.51**
12,500	100.00	100.00	2.11	**3.81**
16666.67	99.00	100.00	2.51	**3.60**
20,000	100.00	100.00	3.06	**2.75**
LSD (P<0.05)	NS	NS	NS	**NS**
Planting Position (P)				
Slant	99.00	98.50	2.75	**2.66**
Vertical	95.50	99.50	1.82	**1.53**
Horizontal	100.00	100.00	4.32	**4.81**
LSD (P<0.05)	**NS**	**NS**	**1.45**	1.55
Number of Nodes (N)				
2	60.00	60.50	1.01	**1.12**
3	70.00	70.00	1.83	**1.75**
4	100.00	95.00	2.41	**2.39**
5	100.00	100.00	3.95	**3.84**
LSD (P<0.05)	**7.05**	**6.81**	**1.03**	1.12
Interactions				
S x P	**NS**	**NS**	**NS**	NS
S x N	**NS**	**NS**	**NS**	NS
P x N	**NS**	**NS**	**0.78**	0.46
S x P x N	NS	NS	NS	NS

*NS= not significant

The effect of plant population, planting position, and number of nodes per stem cutting on cassava stem girth at harvest showed no significant difference in all the treatment factors in both cropping seasons (Table 2). Cassava stems girth as influenced by plant population treatments ranged from 7.33 - 7.60 cm and 7.82 -8.45 in the 2012 and 2013 cropping seasons, respectively. In the treatment of planting position, it ranged from 6.68-7.78 cm and 7.33-8.01 cm in both cropping seasons. In a number of node treatments, cassava stems girth ranged from 6.85-7.85 cm and 7.43-7.85 cm in both cropping seasons.

The number of cassava branches per plant as influenced by plant population, planting position and the number of nodes per stem cutting differs significantly (P<0.05) in both cropping seasons (Table 3). The effect of plant population on the number of branches per plant varied significantly different (p<0.05) in both cropping seasons (Table 3).

Table 2: Cassava Height (cm), Number of Stems per Stand and Stem Girth (m) at Harvest as Influenced by Spacing, Planting Orientation, and Number of Nodes per Stem Cutting.

Treatments	Plant height (cm) at harvest		Number of Stems per stand at harvest		Stem Girth (m) at Harvest	
Plant population/ha	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
10,000	198.68	203.40	1.53	1.48	7.33	8.45
12,500	180.68	193.40	1.98	2.01	7.60	7.99
16666.67	179.75	192.33	2.48	3.11	7.55	7.82
20,000	177.55	185.30	2.93	3.38	7.51	7.82
LSD (P<0.05)	**3.90**	**4.68**	**1.15**	**1.54**	**NS**	NS
Planting Position (P)						
Slant	176.78	183.40	2.41	2.33	7.78	8.01
Vertical	209.34	199.34	1.33	1.09	7.33	7.59
Horizontal	163.11	173.43	4.89	4.55	6.68	7.33
LSD (P<0.05)	**5.67**	**2.46**	**2.55**	**1.96**	**Ns**	Ns
Number of Nodes (N)						
2	193.33	185.31	1.34	1.34	6.84	7.85
3	191.34	194.34	2.33	2.40	7.75	7.56
4	189.45	179.36	3.43	3.75	7.81	7.44
5	173.45	173.04	3.79	3.46	7.85	7.43
LSD (P<0.05)	**NS**	**NS**	**1.13**	**1.11**	**NS**	NS
Interactions						
S x P	**NS**	**NS**	**NS**	**0.35**	**NS**	NS
S x N	**NS**	**NS**	**NS**	**0.67**	**NS**	NS
P x N	**NS**	**NS**	**0.55**	**0.41**	**NS**	NS
S x P x N	NS	NS	NS	NS	NS	NS

A pant population of 10,000 /ha had a significantly higher number of branches per plant (16.33 and 13.42) in the 2012 and 2013 cropping seasons, respectively. The least number of branches per plant (6.41 and 5.45), respectively was recorded in a plant population of 20,000/ha. Among the planting positions, vertical planting produced a significantly higher number of branches per plant (15.84 and 12.35) in the 2012 and 2013 cropping seasons, respectively. The least number of branches per plant (9.01 and 8.55), respectively, was observed in the horizontal planting position. The 5 nodes per stem cutting had a significantly higher number of branches per plant (13.81 and 14.29) in the 2012 and 2013 cropping seasons, respectively. The treatment of 2 nodes per stem cutting had the least number of branches per plant (4.45 and 3.39), respectively.

The number of storage roots per plant as influenced by plant population, planting position, and number of nodes per cutting varied significantly (P<0.05) in both cropping seasons (Table 3). Planting at a population of 20,000/ha had the significantly highest number of storage roots per stand (10.45 and 9.66) in the 2012 and 2013 cropping seasons, respectively while the least (4.99 and 5.31) was obtained from a plant population of 10,000/ha. Among the planting positions, results showed a significant difference (p<0.05) in the number of storage roots per plant (Table 3). Horizontal planting treatment had a significantly higher number of storage roots per stand (10.40 and 10.35) compared to the least number of storage roots (5.16 and 5.19) recorded from the vertical planting position. The result of nodes per cutting differed significantly different in both cropping years. They showed a significant increase in the number of storage roots per stand with the increase in the number of storage roots per plant. Stem cutting of 5 nodes per cutting had 8.14 and 8.63 storage roots per stand in both cropping seasons while treatment of 2 nodes per stem cutting has an average of 3.34 and 3.40 storage roots per stand in 2012 and 2013, respectively. The result further showed no significant difference (p>0.05) when the mean number of storage roots from 5 nodes was as compared to 4 nodes per plant, in both cropping seasons.

Table 3: Number of Stems per Plant, Number of Tubers per Plant and Tuber Yields as Influenced

Treatments	Number of branches/Stand		Number of Storage Root/Plant	Storage Root Yield (t/ha)		Number of Stem Bundles/ha		
Plant Population/ha	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	2013
10,000	16.33	4.99	5.31	8.76	28.34	29.06	306.00	**309.33**
12,500	11.40	6.16	6.38	6.55	33.45	34.06	681.45	**631.43**
16666.67	9.34	9.01	9.75	12.39	28.74	31.43	725.14	**753.11**
20,000	6.41	10.45	9.66	10.14	18.44	18.38	815.30	**875.22**
LSD (P<0.05)	**2.11**	**2.16**	**1.76**	**2.01**	**3.17**	**3.73**	**13.56**	15.98
Planting orientation (P)								
Slant	15.84	12.35	8.11	8.42	29.38	28.61	643.41	**705.30**
Vertical	12.83	12.30	5.16	5.19	28.95	26.75	314.32	**330.66**
Horizontal	9.01	8.55	10.40	10.35	30.34	31.41	921.68	**943.17**
LSD (P<0.05)	**2.12**	**1.86**	**2.08**	**2.65**	**NS**	**2.01**	**18.77**	18.45
Number of Nodes (N)								
2	4.53	3.39	3.34	3.40	18.75	18.07	431.68	**474.33**
3	9.69	7.43	4.34	4.39	28.34	27.45	582.71	**586.30**
4	12.75	10.81	7.40	8.09	29.88	30.07	731.14	**716.30**
5	13.81	14.29	8.14	8.63	30.05	31.22	745.34	**722.12**
LSD (P<0.05)	**3.67**	**3.81**	**1.55**	**1.92**	**2.44**	**2.85**	**12.90**	11.78
Interactions								
S x P	**0.98**	**0.56**	**1.01**	**0.72**	**NS**	**NS**	**3.10**	2.98
S x N	**0.16**	**0.23**	**NS**	**NS**	**NS**	**NS**	**NS**	NS
P x N	**0.12**	**0.17**	**0.43**	**0.55**	**NS**	**NS**	**0.12**	0.09
S x P x N	0.08	0.03	NS	NS	NS	NS	NS	NS

Cassava storage root yield per hectare as influenced by plant population, planting position, and number of nodes per cutting varied significantly (P<0.05) in both cropping seasons (Table 3). The plant population of 125000 stands per hectare produced significant storage root yield; 33.45 and 34.06 t/ha in the 2012 and 2013 cropping seasons, respectively. This was followed by 28.74 and 31.43 t/ha respectively harvested from a plant population of 16666.67 stands/hectare. The least storage root yield (25.66 and 28.08 t/ha) was harvested from a plant population of 20,000 stands/hectares in the 2012 and 2013 cropping seasons, respectively. Cassava storage root yield as influenced by planting position varied significantly different (Table, 3). Horizontal planting position produced significantly higher storage root yield (30.34 and 31.41 t/ha) in the 2012 and 2013 cropping seasons. This was followed by 29.38 and 28.61 t/ha, respectively recorded in slant (inclined) planting position. The least storage root yield (28.95 and 26.75 t/ha) in both cropping seasons was recorded in the vertical planting position. Cassava storage root yield as influenced by the number of nodes per cutting showed a significant difference (p<0.05) in both cropping seasons. Treatment of 5 nodes produced a significantly larger storage root yield (30.05 and 31.22 t/ha) in both cropping seasons. The treatment of 4 nodes per stem cutting had storage root yields of 29.88 and 30.17 t/ha in the 2012 and 2013 cropping seasons, respectively. Treatment of 2 nodes per stem cutting, produce the least storage root yield (18.75 and 18.07 t/ha) in the 2012 and 2013 cropping seasons, respectively.

The number of cassava stem bundles per hectare as influenced by plant population, planting position and the number of nodes per stem cutting varied significantly (P<0.05) in both cropping seasons (Table 3). Plant population of 20,000 stands per hectare produced significantly higher stem bundles per hectare; 815.30 bundles in 2012 and 875.22 bundles in 2013. This was followed by 725.14 and 753.11 bundles per hectare respectively, recorded from a plant population of 16666.67 stands per hectare. The least number of stem bundles per hectare (306 and 309.33) was recorded in a plant population of 10,000 stands per hectare. Comparing the planting positions, horizontal planting produced the highest stem bundles per hectare; 921.68 in 2012 and 943.17 in 2013. Inclined (slant) planting positions produced 643.41 and 705.30 bundles in the 2012 and 2013 cropping seasons, respectively. The least number of

bundles; 314.32 and 330.66, respectively, was recorded in the vertical planting position. Comparing the treatments of the number of nodes per stem cutting, the result showed a significant increase in the number of stem bundles from 2 to 5 nodes per stem cutting. Planting of 5 nodes per stem cutting produced the highest number of stem bundles per hectare; 745.34 and 722.12 per hectare in the 2012 and 2013 cropping seasons, respectively. The results showed no significant difference between the number of stem bundles per hectare recorded in 5 nodes and (731.14 and 716.30) recorded in 4 nodes per stem cutting. The least number of stem bundles per hectare; 431.68 and 474.33 in the 2012 and 2013 cropping seasons respectively were recorded in 2 nodes per stem cutting.

DISCUSSION

The establishment percentage of cassava as influenced by spacing and planting orientation showed no significant difference ($P<0.05$) in both cropping seasons. The higher establishment percentage achieved in the study could be due to the high moisture content of the soil. The experiment was conducted during raining season. Adequate soil moisture is one of the factors that enhanced early germination and establishment of seeds. This observation agreed with the findings of Ikeh et al. (2012) that provided that soil moisture is sufficient, cassava can sprout and grow all year round. Ikeh (2017) also reported that relatively adequate soil moisture content and viable cassava planting material significantly influenced cassava sprouting and establishment percentage. The effect of the number of nodes per stem cutting on establishment percentage varied significantly different in both the 2012 and 2013 cropping seasons. The treatment of 5 nodes per stem cutting had the highest sprouting percentage while the least establishment percentage was recorded in 2 nodes per stem cutting. The result indicated an increase in the number of nodes per stem cutting with the increase in establishment percentage. The lower establishment percentage recorded in the number of 2 and 3 nodes agrees with the findings of IITA (1990) and Ikeh (2017) that cutting with few buds are more likely to lose the viability of their buds during propagation due to lower food reserves and more susceptible to pathogen attack and rapid dehydration. The low sprouting percentage recorded in the 2 nodes per cutting also agrees with the report of El-Sharkawy (2004) that sprout emergence and early growth of the plants from stem depends on endogenous nutrients stored in the stems and the adaptability to the local climate or the environment rather than on soil nutrients,

The variations in the number of sprouted shoots, number of stems per stand, number of stem bundles per hectare, number of tuber of stem bundles and tuber yield among all the treatments in each factor showed that plant population, planting position and number of nodes per cutting had effect in stem multiplication and tuber yield. The study agreed with the findings of IITA (1990); Chew (1994) that planting position of the cutting influences several growth characteristics of the plant. The significant effect of the number of nodes per cutting is in line with the finding of Udoh et al (2021) that longer stem cuttings have been reported to give higher yields than short ones, although no significant storage root yield was recorded between cassava stakes of 5 nodes and 7 nodes, irrespective of cassava varieties. The interaction result showed that planting position and the number of stem cuttings had a significant effect on the number of stems per stand and the number of stem bundles per hectare. The high storage root yield recorded in a plant population of 12500 could be due to an increase in plant population per hectare (12,500 plants) with less competition for light, nutrients, and space compared to 20,000 stands per hectare where competition for nutrients, space, and light may be more compared to 12,500 plant population. This could be one of the factors that resulted in to decrease in storage root yield in the plant population of 20,000 stands per hectare. The high number of stem bundles recorded horizontally could be due to the higher number of stems per stand observed in the treatment compared to vertical and slant planting positions.

CONCLUSION

The study showed that cassava plant population, planting position, and the number of nodes per stem cuttings were among the cultural practices that influenced the number of cassava seeds and storage root yield. Cassava farmers in Uyo agro-ecology were advised to adopt a 20,000 plants population per hectare with 4 nodes per stem cutting and plant horizontal position for higher stem multiplication but if storage root is the sole target, farmers should plant at least 4 nodes per cutting, plant in the horizontal position in plant population of 12,500 stands per hectare.

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Response of *Syngonium podophyllum* Plant Growth and Chemical Composition to Chlorophyllin Fertilizer

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ABSTRACT

The study investigated the effect of spraying Chlorophyllin, derived from chlorophyll, on *Syngonium podophyum* plant growth and chemical composition. A pot experiment was conducted in a greenhouse in Cairo, Egypt, using three concentrations of Chlorophyllin (0, 100, 200, and 300 ppm) applied three times over 9 months. The results showed that the highest growth parameters (plant height, root length, number of leaves, stem thickness, number of successors, shoot fresh or dry weight, and leaf area) were recorded with Chlorophyllin spray at 100, 200, and 300 ppm. Chlorophyllin application had no significant effect on other parameters such as stem diameter and fresh and dry weight. The study concluded that Chlorophyllin spraying significantly promoted plant growth and could be used as a growth enhancer.

INTRODUCTION

Syngonium podophyllum (Araceae) is a parasitic climber with large leaves that are deeply lobed in adults (Balick, 1998). Podophyllum leaves are used to treat pain, dry skin, fungal infections, itching, rashes, and bruises (Sosa, et al. 2002). The leaves and bark of this plant have traditionally been used in local folk medicine for their wound-healing properties (Kumar, 2014). Microorganisms assembled the system by inoculating the roots with *Aspergillus niger*, an artificially constructed (SPANCS) that had the highest capacity to remove uranium from wastewater with a similar inhibitory effect as biomass (Hu, et al. 2015); evolved into leaves in ornamental plants (Howard, 1996); under different potential stresses (Chauvel, 2010); it cleans the air and acts as a cleansing anti-pollutant by absorbing it in bisected leaves. Given the calcium oxalate contained in the plant sap, it is considered slightly toxic. The leaves can cause mouth irritation, and vomiting is a common side effect.

Some plants need certain nutrients in the soil to thrive. These are known as fertilizer components and usually come from conventional fertilizers. This article deals with the extraction of natural chlorophyll from agricultural waste. As a foliar fertilizer, it can significantly promote plant growth. This new type of fertilizer helps plants grow bigger and produce better yields. We've found that adding powdered green pigment to water makes an excellent fertilizer (El-Tayeb, 2022).

Chlorophyllin is a water-soluble, green pigment derived from chlorophyll and commonly used as a food color additive and dietary supplement. It has a number of potential health benefits including

antioxidant, anti-inflammatory, and antimicrobial effects. It is also used to treat digestive issues and improve the skin's appearance. Chlorophyllin has also been studied for its ability to reduce the odors of certain pollutants, including those associated with urinary incontinence, bad breath, and wound odor. In this article, one more application as a plant growth enhancer will be tested on *Syngoniumpodo phyumplant*.

Materials and Methods

During the 2019 and 2020 seasons, a pot experiment with podophyllum was carried out in the NRC net greenhouse atDokki, Cairo, Egypt. Use a mixture of loam and sandy soil (1:1) by volume. Treatments consisted of three concentrations of Chlorophyllin formula (0, 100, 200, and 300 ppm) (provided by INRAD corp., Egypt) followed by 3 daily sprays (4, 8 and 12 o'clock). Chlorophyllin formula and spray time were taken into account in a completely randomized 5-replicate design. For propagation, homogeneous (10-15 cm) long, 1-month-old plants with 3-4 leaves were transplanted during the first week of July 2019 and 2020. All plants were fertilized in the usual amount at the right time. Pots were watered daily to near-field capacity with tap water for 9 months Representative plant samples were taken randomly from 3 replicates of each treatment, and growth parameters included (plant height, root height, number of leaves, leaf area, number of successors, stem diameter, shoot fresh weight, shoot dry weight, % chlorophyll, carbohydrate compound %, protein %, carotenoid %, Na%, N%, k%, and P%). The following chemical constituents were determined: 1- The pigment content (mg/g FW) of chlorophyll A, B, and carotenoids was determined according to the methods described by (Saric, et al. 1967) and (Lichtenthaler, 1987). 2- Carbohydrate content (mg/g DW) was determined according to the method described by (Dubois, et al., 1956). 3- Elemental content (mg/g DW) of Na %, N %, k %, and P% was determined according to the method described (Black, et al., 1965). Data were collected using a completely randomized design and permutation of factors according to (Snedecer and Cochran, 1982).

RESULTS AND DISCUSSION

Effects of Chlorophyllin Spraying on Growth Characteristics and Chemical Components of *Syngonium podophyllum*.

The data in Tables (1, 2, and 3) show that the highest growth parameters, expressed in terms of plant height, root length, number of leaves, stem thickness, number of successors, shoot fresh or dry weight, and leaf area, were obtained from plants were sprayed with Chlorophyllin 100, 200 and 300 ppm. Spraying 100 ppm of Chlorophyllin significantly increased plant height (cm). When we sprayed 300 ppm of chlorophyllin, root length, number of leaves, number of successors, and leaf area all increased significantly. On the other hand, these treatments had no significant effect on other parameters such as trunk diameter, fresh and dry weight. Regarding the effect of Chlorophyllin foliar sprays (0, 100, 300, and 200ppm) on total chlorophyll and carotenoids, total chlorophyll and carotenoids were increased by the use of Chlorophyllinfoliar sprays, especially at medium doses (200ppm). On the other hand, spraying one treatment (100, 200, and 300 ppm) had no significant beneficial effects on the carbohydrates, proteins, Na, P, K, and N of Synecarpa plants during the growing season.

Data in Tables 4, 5, and 6 suggest that *Syngonium* plants don't experience common significant changes in growth when treated at 4, 8 or 12o'clock. Plants treated at 12 o'clock grew the most branches and leaves; *Syngonium* treated for 8 hours grew the most shoots; and those treated for 4 hours grew the most leaves. Data presented in this table also show that plants treated for 12 hours with *Syngonium* had the highest weight of both leaves and shoots. Treatments showed no significant effect on plants' total chlorophyll, carbohydrates, protein, carotenoids, Na, P, K, or N percentages. Additionally, spraying at 12 o'clock aboveground yielded high levels of all previous minerals in the plant.

Tables 7, 8, and 9 display the results of experiments that show variation in growth parameters depending on spraying intervals and chlorophyllin concentrations. Variable growth effects were not substantial enough to alter any growth parameters. However, higher values of plant height, root length, leaf number, stem diameter, shoot fresh and dry weight, and leaf area were observed when chlorophyllin was sprayed at 300 ppm at 12 o'clock intervals. At8 o'clockwith200ppm spray, protein, carotenoids, and N in chlorophyllin creased; they also increased the amount of chlorophyll in leaves. This can be seen through the effects of interacting with Chlorophyllin foliar sprays. Using Chlorophyllin to

increase the plant's K, P and Na levels by 100 ppm produced the highest results. When compared to other treatments, spraying 300 ppm at 8 hoo'clock increased carbohydrate levels in plants.

Table 1: Effect of Chlorophyllin concentrations on growth parameters of *Syngonium* plants.

Measurements / Treatments	Plant height	Root length	leaves number	Stem diameter	Successors number	Leaf index area	Fresh weight of shoots	Dry weight of shoots
0 ppm Chlorophyllin	34.22	36.22	11.11	0.81	1.11	128.58	45.89	9.44
100 ppm Chlorophyllin	47.28	45.44	13.67	0.75	1.33	193.93	75	12.78
200 ppm Chlorophyllin	39	46.33	15.11	0.71	1.89	182.28	79.33	14.22
300 ppm Chlorophyllin	45	64.54	17.22	0.81	3	241.39	84.56	14.67
L.S.D. 0.05	12.28	25.01	3.72	0.11	0.74	84.98	57.14	7.51

Table 2:. Effect of Chlorophyllin concentrations on chemical constituents and elements % of *Syngonium* plants.

Measurements / Treatments	Total chlorophyll content (mg / g f.w.)	Carbohydrate's content (mg / g d.w.)	Protein %	Carotenoid's content (mg / g f.w.)	Sodium (Na %)	Phosphorus (P %)	Potassium (K %)	Nitrogen (N %)
0 ppm Chlorophyllin	**1.47**	**2.95**	**14.60**	**1.87**	**2.33**	**0.29**	**4.90**	**2.34**
100 ppm Chlorophyllin	**1.47**	**1.90**	**10.61**	**1.94**	**2.38**	**0.33**	**5.63**	**2.27**
200 ppm Chlorophyllin	**1.93**	**2.82**	**13.83**	**2.52**	**1.82**	**0.21**	**3.47**	**2.21**
300 ppm Chlorophyllin	**1.75**	**2.94**	**13.71**	**2.31**	**2.01**	**0.25**	**3.71**	**2.20**
L.S.D. 0.05	**0.29**	**0.31**	**0.62**	**0.39**	**0.19**	**0.03**	**0.31**	**0.10**

Table 3: Effect of spraying times on growth parameters of Syngonium plants.

Measurements / Treatments	Plant height	Root length	leaves number	Stem diameter	Successors number	Leaf index area	Fresh weight of shoots	Dry weight of shoots
8o'clockmorning	39.83	41.25	15.08	0.77	1.75	170.47	55.75	11.67
12 o'clockNoon	43.54	52.83	14.33	0.77	2	204.31	83.17	13.33
4o'clockafter noon	40.75	50.33	13.42	0.77	1.75	184.85	74.67	13.33
L.S.D. 0.05	10.63	21.66	3.22	0.09	0.64	73.59	49.49	6.50

Table (5). Effect of spraying times on chemical constituents and elements % of *Syngonium* plants.

Measurements / Treatments	Total chlorophyll content (mg / g f.w.)	Carbohydrate's content (mg / g d.w.)	Protein %	Carotenoid's content (mg / g f.w.)	Sodium (Na %)	Phosphorus (P %)	Potassium (K %)	Nitrogen (N %)
8o'clock morning	**1.65**	**2.52**	**12.08**	**2.11**	**2.12**	**0.31**	**4.27**	**2.36**
12 o'clockNoon	**1.78**	**2.77**	**14.57**	**2.34**	**2.16**	**0.29**	**4.75**	**2.33**
4 o'clock after noon	**1.54**	**2.67**	**12.91**	**2.04**	**2.13**	**0.21**	**4.26**	**2.07**
L.S.D. 0.05	**0.25**	**0.27**	**0.54**	**0.34**	**0.16**	**0.03**	**0.27**	**0.09**

Table 6. Effect of interaction of Chlorophyllin concentrations and spraying times on growth parameters of *Syngonium* plants.

Measurements / Treatments	Plant height	Root length	leaves number	Stem diameter	Successors number	Leaf index area	Fresh weight of shoots	Dry weight of shoots
8o'clock morning+ 0 ppm	35	30.33	13	0.83	1.33	105.25	50.67	10
8hours8 o'clock morning + 100 ppm	42	38	13.67	0.76	1.67	157.7	57.67	11.33
8 o'clock morning + 200 ppm	35.33	45.67	16.67	0.72	2	177.08	60	15
8 o'clock morning + 300 ppm	47	51	17	0.77	2	241.83	54.67	10.33
12 o'clock Noon + 0 ppm	34.67	48.67	12	0.82	1	158.17	58	10.33
12 o'clock Noon +100 ppm	51.5	40.33	15	0.67	1	194.83	79.67	11.33
12 o'clock Noon +200 ppm	37.67	41.67	13.33	0.72	1.33	196	58.33	10.33
12 o'clock Noon +300 ppm	50.33	80.67	17	0.87	4.67	268.25	136.67	21.33
4 o'clock after noon + 0 ppm	33	29.67	8.33	0.77	1	122.33	29	8
4 o'clock after noon + 100 ppm	48.33	58	12.33	0.82	1.33	229.25	87.67	15.67
4 o'clock after noon + 200 ppm	44	51.67	15.33	0.71	2.33	173.75	119.67	17.33
4 o'clock after noon + 300 ppm	37.67	62	17.67	0.8	2.33	214.08	62.33	12.33
L.S.D. 0.05	21.27	43.32	6.45	0.17	1.29	147.18	98.98	13.01

Table (7). Effect of interaction of Chlorophyllin concentrations and spraying times on chemical constituents and elements %of *Syngonium* plants.

Measurements / Treatments	Total chlorophyll content (mg / g f.w.)	Carbohydrate's content (mg / g d.w.)	Protein content %	Carotenoid's content (mg / g f.w.)	Sodium (Na %)	Phosphorus (P %)	Potassium (K %)	Nitrogen (N %)
8 o'clock morning + 0 ppm	1.55	2.91	15.29	1.85	1.96	0.27	4.19	2.45
8 hours 8 o'clock morning + 100 ppm	1.10	1.27	4.17	1.40	2.73	0.46	6.32	2.38
8 o'clock morning + 200 ppm	2.59	2.43	15.58	3.40	1.82	0.26	3.36	2.49
8 o'clock morning + 300 ppm	1.34	3.46	13.30	1.78	1.96	0.24	3.20	2.13
12 o'clock Noon + 0 ppm	1.97	2.80	14.35	2.51	2.33	0.30	4.75	2.30
12 o'clock Noon + 100 ppm	2.04	2.73	14.70	2.78	2.31	0.34	5.76	2.35
12 o'clock Noon + 200 ppm	1.41	2.40	14	1.79	1.96	0.23	4	2.24
12 o'clock Noon + 300 ppm	1.68	3.15	15.23	2.26	2.03	0.30	4.48	2.44
4 o'clock after noon + 0 ppm	0.88	3.14	14.18	1.23	2.71	0.29	5.76	2.27
4 o'clock after noon + 100 ppm	1.26	1.70	12.95	1.64	2.10	0.20	4.80	2.07
4 o'clock after noon + 200 ppm	1.78	3.64	11.90	2.37	1.68	0.14	3.04	1.90
4 o'clock after noon + 300 ppm	2.24	2.21	12.60	2.90	2.03	0.20	3.44	2.02
L.S.D. 0.05	0.51	0.54	1.07	0.68	0.34	0.05	0.54	0.17

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Research Article

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Intercrop Combination and Tillage Practice On Weed Cover Score And Weed Dry Weight In Maize / Groundnut Mixture In Anyigba, Kogi State, Nigeria

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ABSTRACT

There is no reliable study of worldwide damage due to weeds. However, it is widely known that losses caused by weeds have exceeded the losses from any category of agricultural pests such as insects, nematodes, diseases. Trials were conducted in the rainy seasons of 2020 and 2021, at Latitude 70 301 and Longitude 70 091 E in the Southern Guinea Savannah agro-ecological zone of Nigeria to evaluate the effect of tillage practice and crop combination on weed incidence. The treatment consisted of five intercropping patterns and three tillage practices in a factorial experiment (tillage practices and intercropping pattern) assigned in a Randomized Complete Block Design with four replications. Analyzed data at 3WAP, 6WAP and 6WAP show a significant ($p \leq 0.05$) effect of intercrop combination on Weed Cover Score in the 2021 cropping season though no such significance was observed in the 2020 season. Analyzed data also show a significant ($p \leq 0.05$) effect of planting pattern on weed dry weight in the 2021 cropping season though no such significance was observed in the 2020 season. Regarding tillage practice, non-significant ($p \geq 0.05$) effects of tillage practice on weed dry weight were observed in the 2020 cropping season, which was also at variance with the significant ($p \leq 0.05$) effect of tillage practice observed on weed dry weight in 2021 season. For both seasons, there were consistencies in the outcomes, with the highest weed dry weight observed in the Zero tillage followed by seeding on the flat and lastly when seeds were sown on ridges. Unless mitigated the highest crop losses should be expected on Zero tillage plots with the least when seeds are sown on ridges.

INTRODUCTION

In sub-Sahara Africa, about 70% of farmers are smallholders accounting for 90 percent of the total farm output characterized by poor yields arising from production constraints such as diseases, pests, and weeds (Cadini and Angelucci, 2013; Oyewole and Ibikunle, 2010; Oyewole et al. 2012). Of all the constraints weed competition is the most critical that poses the greatest problems on traditional arable crops, thus threatening food security in the sub-region (Dixit et al., 2008; Oyewole and Ibikunle, 2010; Oyewole et al. 2012). The economic losses due to weed

competition are now recognized as major obstacles in maize production. More so, maize being a sensitive crop is highly vulnerable to weed infestation particularly during the first four weeks of its life hence varying degrees of percentage reductions caused by weed interference have been reported in the crop (Adigun and Lagoke, 1999). For instance; uncontrolled weed growth in pure maize fields has led to about 60 to 65% and 40 to 60% suppression in the overall grain yields of the crop from different ecological zones of Nigeria (Badmus et al. 2006).

Weed management is the most challenging component of maize production. Successful weed control is important for achieving maximum yield in maize grain and silage crops. Weeds that are not controlled compete for light and the crop's nutrient and water resources, and yield losses may be up to 70% of the potential yield. Although many maize farmers have developed successful management practices for weed control there are instances when weeds become a problem. These include times when herbicide use fails because of environmental conditions, weeds become resistant to recommended herbicides or the crop is being grown on leased land where weed control has been poor in the past. Effective weed control in maize requires attention to detail. If weeds get away there are immediate and ongoing losses for the maize grower (FAR Focus, 2013). The critical time for weed control in maize is between crop emergence and canopy closure. Weeds may emerge at any time during this period but are more likely to appear after rain. Successful weed management depends firstly on knowing what you are trying to manage. This may not be as easy as it sounds as most weed management practices depend on an early strike at the weed, when it has just two to four leaves. At this growth stage, all weeds may look similar, especially grass weeds (FAR Focus, 2013).

Weeds affect everyone in the world by reducing crop yield and crop quality, delaying or interfering with harvesting, interfering with animal feeding (including poisoning), reducing animal health, preventing water flow, as plant parasites, among others. Weeds are common everywhere and cause crop losses annually, with the global cost of controlling weeds running into billions of dollars (Kraehmer and Baur, 2013). The potential crop yield loss without weed control was estimated at 43% on a global scale (Oerke, 2006). While, (Rao, 2000) has reported that, of the total annual loss of agricultural produce from various pests, weeds account for 43%, insects 30%, diseases 20%, and other pests 5%. Annual worldwide losses to weeds were estimated to comprise approximately 10-15% of attainable production among the principal food sources. Reduction in crop yield has a direct correlation with weed competition. Weeds are the most acute pest in agriculture with an estimated annual global damage of around 40 billion dollars per year (Monaco et al. 2002). Generally, an increase in one kilogram of weed growth corresponds to a reduction in one kilogram of crop growth (Rao, 2000).

The yield of maize obtained in Nigeria is far below expectation due to numerous factors which include weed infestation, low soil fertility and availability of labor. Yield losses of between 60–80% have been attributed to uncontrolled weed infestation in maize (Lagoke et al. 1998) and this finding was confirmed by (Imoloame and Omolaiye, 2016), who reported 89% yield loss in maize as a result of uncontrolled weed infestation. Weed infestation is of supreme importance among biotic factors that are responsible for low maize grain yield. Worldwide maize production is hampered up to 40% by competition from weeds which are the most important pest group of this crop (Chikoye et al. 2004).

Also, the main problems limiting the production of groundnut are poor cultural practices and inadequate weed management. Weed causes much damage to the groundnut crop during the first 45 days of its growth. Reports have shown that groundnut cannot compete effectively with weeds, particularly 3-6 weeks after sowing. The average yield loss due to weed is about 30%; while at ICRISAT 100% yield loss has been observed. Therefore, early removal of weeds is important before flowering and during pegging (Page et al. 2002). If early weeding is done well, and crop spacing recommendations followed, then the weeds that come up later are smothered with the vigorous growth of the crop. Once flowering and pegging begin it is advisable to weed by hand pulling rather than by using hoe, as this is less likely to disturb any developing pods. Weed management rather than complete eradication of weed is the intent to regulate the population and maintain appropriate weed levels, taking into account both economic and ecological aspects that is, at a threshold level that does not cause economic loss to the crop and also does not adversely affect the environment (Harkansson, 2003).

The growth of groundnut is slow initially and the crop forms only a thin canopy offering little competition to most weeds at the stage (Zimdahl, 1980). Uncontrolled

weed growth has been reported to cause a yield reduction of 50-80% in groundnut. Weed depresses groundnut yields by competing with the crop for light, minerals, and nutrients and also harvest operations. It is therefore important that weeds be controlled for profitable production (Brecke and Colvin 1991). With the increasing reports of negative environmental effects of continuous use of pesticides, the need to either totally eliminate or reduce its usage cannot be over-emphasized; an important key to this is the employment of agronomic practices, which may assist in achieving either reduction or elimination of pesticide utilization among farmers. The above justifies a study on cropping patterns and tillage practices on weed parameters in the study area.

The need to maximize land productivity in the humid tropics has become more evident (Steiner, 1991). This has not been achievable with monoculture with single harvests per season, as gains in production per unit area under this system have not been impressive in the tropical environment (IITA, 1990). Intercropping of two or more crops especially the family Poaceae with Fabaceae is popular in many countries because yields are often higher than pure cropping systems (Lithourgidis et al. 2006).

Tillage is crucial for crop establishment, growth, and ultimately, yield (Atkinson et al. 2007). A good soil management program protects the soil from water and wind erosion, provides a good, weed-free seedbed for planting, destroys hardpans or compacted layers that may limit root development, and allows maintenance or even an increase of organic matter (Wright et al., 2008). Many farmers perform tillage operations without being aware of the effect of these operations on soil physical properties and crop responses (Ozpinar and Isik, 2004). Poor crop establishment and low soil fertility are particularly constraining for crop production. Tillage practice is therefore key as cultivation implements impose varying degrees of alterations to both the surface soil and sub-soil. As such it is crucial to determine the best practice for tillage practices to maximize crop establishment and yield.

MATERIALS AND METHODS

Trial was conducted in the rainy seasons of 2020 and 2021 in Latitude 70 301 and Longitude 70 091 E in the Southern Guinea Savannah agro-ecological zone of Nigeria. The experiment sited at the Kogi State University Anyigba Students' Research and Demonstration Farm consisted of five intercropping patterns Sole Maize, Sole Groundnut, Two rows of maize and one row of groundnut, Two rows of groundnut and one row of maize, One row of maize and one row of groundnut and three tillage practice methods (planting on ridge, planting on flat land and zero tillage). Factorial combinations of the treatments (tillage practice and intercropping pattern) fully randomized were laid out in a Randomized Complete Block Design with four replications. Plot size measuring 3m x 4.5m (sixty plots) were used for the experiment.

For the tillage practice involving planting seeds on the flat, the land was ploughed, harrowed and made into flat beds, while for those crops sown on the ridge, the experimental site was ploughed, harrowed and ridged 75cm apart while for the zero tillage, conventional tillage practices were not done before seed sowing. Factorial combinations of these treatments (tillage practice and intercropping pattern) fully randomized were laid out in a Randomized Complete Block Design with four replications. Plot sizes measuring 3m x 4.5m (sixty plots) were used for the experiment.

One improved variety of maize (TZESR) and one local variety of groundnuts (Angba-chido) obtained from IITA – Ibadan and ADP Anyigba, Kogi state, respectively were used. Row replacement methods were employed in seeding the groundnut plots; moving from sole cropped plots, which were then gradually replaced with rows of maize until attaining sole maize plots. While the groundnut stands were seeded 23 cm x 75 cm, the maize stands were seeded 25 cm x 75 cm. Two seeds of groundnut as well as maize were planted per hole, which were thinned to one seedling per stand at two weeks after planting (2 WAP). NPK 15:15:15 was applied to all the plots as the basal application (45kg N/ha, 45kg P2O5 and 45kg K2O/ha) and top dressed with Urea at 6 WAP. Percentage seedling emergence was determined ones at two weeks after planting (2 WAP).

Average of three quadrant throws were used in the determination of weed parameters (weed floral, weed cover score, weed biomass) at 3, 6 and 9 WAP after cropping. For weed dry weight samples within the quadrant throws were oven dried at 750C for 48 hours allowed to cool before weighing using the Metler Toledo electric weighing scale. For Weed Cover Score, a scale of 1 - 9, was used where 1 was complete absence of weeds, and 9 was complete coverage of the plot by weeds. All weed data were transformed using

the square root transformation method before analysis.

RESULTS AND DISCUSSION

Effect of Planting Pattern, Tillage Practice and Their Interactions on Weed Cover Score:

Weed infestation is reported to be of supreme importance among biotic factors that are responsible for low maize and groundnut yields (Selvakumar and Sundari, 2006). Analyzed data at weeks 3, 6, and 9 show a significant ($p \leq 0.05$) effect of intercrop combination on Weed Cover Scores in the 2021 cropping season though no such significance ($p \geq 0.05$) was observed in the 2020 season (Table 1) at week 3, 6 and 9. The significant effect of intercrop on Weed Cover Score in the 2021 cropping season, is similar to the observation made by Rao (2000) and Hamzei. and Seyedi (2015), of the significant effect of intercropping on weed suppression in maize, but Rao (2000) emphasizes that intercropping system alone is not sufficient to ensure adequate weed management practices, because of varied canopy coverage occurrence among the intercrops. The variation in observation between seasons is in line with Oyewole (2004) who observed that research outcomes could vary between seasons due to various factors, such as weather, pests, and agronomic factors, among other reasons. In both cropping seasons, among sole crops, sole maize performed better than sole groundnut in reducing Weed Cover Score, thus lowered Weed Cover Scores were consistently observed in sole maize when compared with sole groundnut (Table 1). The observation is understandable, noting that maize, as an erect and taller crop, should be better at shading than the crawling groundnut (Oyewole, 2004). In the 2020 and 2021 cropping seasons, the more the inclusion of maize stands among the intercrops, the more the reduction in Weed Cover Scores (Table 1), which could translate into an increase in yield as observed by Oyewole, et.al. (2016), who noted that observed reduction in Weed Cover Scores is likely to affect the competitive ability of the associating weeds negatively.

Table 1: Effect of planting pattern, tillage practice, and their interactions on Weed Cover Score

Treatment	Weed cover score (Scale of 1 - 9)						
	2020				2021		
	3 WAP	6 WAP	9 WAP		3 WAP	6 WAP	9 WAP
Intercrop Combination							
Sole maize	1.40^{a}	1.43^{a}	1.38^{a}		2.75^{ab}	3.23^{a}	3.62^{a}
Sole groundnut	1.58^{a}	1.62^{a}	1.49^{a}		3.00^{a}	3.49^{a}	3.85^{a}
2maize:1g/nut	1.52^{a}	1.58^{a}	1.45^{a}		2.25^{c}	2.58^{b}	2.63^{b}
2g/nut:1maize	1.69^{a}	1.69^{a}	1.52^{a}		2.38^{bc}	2.66^{b}	2.72^{b}
1maize:1g/nut	1.54^{a}	1.59^{a}	1.52^{a}		2.42^{bc}	2.59^{b}	2.70^{b}
LSD (0.05)	0.43ns	0.43ns	0.19ns		0.37*	0.27*	0.37*
Tillage (T)							
Ridge	1.42^{a}	1.46^{a}	1.43^{a}		2.23^{b}	2.63^{b}	2.93^{b}
Flat	1.52^{a}	1.51^{a}	1.53^{a}		2.28^{b}	2.84^{b}	2.94^{b}
Zero Tillage	1.70^{a}	1.78^{a}	1.47^{a}		3.18^{a}	3.26^{a}	3.45^{a}
LSD (0.05)	0.33 ns	0.33 ns	0.15 ns		0.28*	0.21*	0.28*
Interaction							
P x T	ns	ns	ns		ns	ns	ns
C.V %	13.70	13.2	15.1		17.4	11.1	14.3

As par tillage practice, data collected at week 3, 6 and 9 indicate non-significant ($p \geq 0.05$) effect of tillage practice on Weed Cover Scores in 2020 cropping season, which was at variance with the significant ($p \leq 0.05$) effect of tillage practice observed in 2021 season (Table 1) within the same period. In both seasons, there were consistencies in the outcomes among tillage practice, with the highest Weed Cover Scores observed in the Zero tillage followed by seeding on the flat and lastly when seeds were sown on ridges; even where such were not statistically significant, such as in 2020 cropping season. No

significant interactions were observed between intercrop combination and tillage practice on Weed Cover Scores at 3WAP, 6WAP, and 9WAP in the 2020 and 2021 cropping seasons. Generally, tillage practice played a significant role in moderating Weed Cover Scores, where Zero tillage encouraged higher Weed Cover Scores in both seasons. Since the reduction in crop yield has a direct correlation with weeds, to mitigate their effects where Zero tillage is practiced, there may be the need for some form of weed control mechanisms, such as the use of herbicides. With a Weed Cover Score range between 1 – 9, where 1 was an indication of a plot devoid of weeds, a score of 9 for a plot completely covered by weeds, the least score observed in the 2020 cropping season was 1.39 while the highest Weed Cover Score was 1.69. In the 2021 season, the least Weed Cover Score was 2.25 while the highest Weed Cover Score was 3.85. With Weed Cover Scores ranging between 1.39 and 3.85 across seasons, was an indication of plots either almost weed-free to plots about 1/3 covered by weeds.

Table 2: Effect of planting pattern, tillage practice, and their interactions on Weed dry weight (g/m2) in 2020 and 2021 cropping season

Treatment	Weed dry weight (g/m^2)					
	2020			2021		
	3 WAP	6 WAP	9 WAP	3 WAP	6 WAP	9 WAP
Intercrop Combination						
Sole maize	20.66^{a}	20.66^{a}	9.85^{a}	27.26^{a}	21.79^{a}	13.85^{a}
Sole groundnut	18.25^{a}	18.19^{a}	9.92^{a}	27.06^{a}	20.53^{ab}	13.12^{a}
2maize:1g/nut	19.61^{a}	19.47^{a}	9.70^{a}	22.69^{b}	18.20^{b}	11.62^{b}
2g/nut:1maize	20.16^{a}	20.13^{a}	9.99^{a}	23.15^{b}	18.36^{b}	12.83^{ab}
1maize:1g/nut	20.00^{a}	19.74^{a}	9.11^{a}	20.90^{b}	17.85^{b}	12.73^{ab}
LSD	3.23ns	3.47ns	1.20ns	2.73*	3.27*	1.82*
Tillage (T)						
Ridge	18.74^{b}	18.50^{b}	9.21^{a}	21.75 ^{a}	16.65^{b}	11.26^{b}
Flat	18.98^{ab}	18.9^{ab}	9.96^{a}	22.02^{b}	17.45^{b}	11.69^{b}
Zero Tillage	21.48^{a}	21.51^{a}	9.98^{a}	28.86^{a}	23.94^{a}	15.53^{a}
LSD	**2.50***	**2.70***	**0.93ns**	**2.12***	**2.53***	**1.41***
Interaction						
P x T	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**
C.V %	19.8	21.5	15.0	13.7	20.5	17.2

Effect of Intercrop Combination, Tillage Practice, and Their Interactions on Weed Dry Weight

Analyzed data show a significant ($p \leq 0.05$) effect of planting pattern on weed dry weight in the 2021 cropping season though no such significance was observed in the 2020 season (Table 2). Regarding tillage practice, non-significant ($p \geq 0.05$) effects of tillage practice on weed dry weight were observed in the 2020 cropping season, which was also at variance with the significant ($p \leq 0.05$) effect of tillage practice observed on weed dry weight in the 2021 season. For both seasons, there were consistencies in the outcomes, with the highest weed dry weight observed in the Zero tillage followed by seeding on the flat and lastly when seeds were sown on ridges.

Unless mitigated, the highest crop losses should be expected on Zero tillage plots with the least where seeds were sown on ridges. The report has shown that an increase of one kilogram of weed growth corresponds to a reduction in one kilogram of crop growth (Rao, 2000). No significant interactions were observed between intercrop combination and tillage practice on weed dry weight at 3WAP, 6WAP, and 9WAP in the 2020 and 2021 cropping seasons.

Effect of Intercrop Combination, tillage practice, and their interactions on Maize and groundnut yields in 2020 and 2021 cropping seasons:

Generally, crops have been grown under conventional agricultural practices in Nigeria for years (Antenyi, 2021). The basis for conventional tillage is annual

ploughing or tilling of the soil, but this is usually supplemented with a number of other practices, including the removal or burning of crop residues, land leveling, harrowing, fertilizer application, and incorporation; all of these practices cause soil disturbance, compaction, and deterioration, with anticipated effects on crop yields (Antenyi, 2021).

Table 3: Effect of Intercrop Combination, tillage practice, and their interactions on maize cob weight and seeds/cob in the 2020 and 2021 cropping season

Treatment	2020 cropping season				2021 cropping season			
	Cob Weight (t/ha)	Seeds / cob	Grain Yield (t/ha)	Land Equivalent Ratio	Cob Weight (t/ha)	Seeds / cob	Grain Yield (t/ha)	Land Equivalent Ratio
Intercrop Combination								
Sole maize	207.33[a]	316.25[a]	2.37[a]	-	954.32[a]	2492.33[a]	5.95[a]	
2maize:1g/nut	107.59[b]	256.75[b]	1.57[b]	1.28	437.65[c]	1133.50[b]	4.54[b]	1.19
2g/nut:1maize	108.67[b]	254.83[b]	1.70[b]	1.29	472.22[b]	1199.25[b]	4.77[b]	1.28
1maize:1g/nut	103.27[b]	271.17[b]	1.70[b]	1.38	481.48[b]	1205.42[b]	4.65[b]	1.32
LSD	23.527*	51.000*	0.44*	-	32.660*	271.050*	0.346*	
Tillage (T)								
Ridge	87.51[a]	216.05[a]	1.37[a]	1.06	414.44[c]	1026.65[b]	3.88[a]	1.38
Flat	101.19[a]	223.80[a]	1.53[a]	1.25	515.19[a]	1434.95[a]	4.08[a]	1.40
Zero Tillage	95.07[a]	219.55[a]	1.51[a]	1.28	477.78[b]	1156.70[b]	3.99[a]	1.42
LSD	33.715ns	39.510ns	0.344ns		22.757*	209.951*	0.265ns	
Interaction								
P x T	**ns**	**ns**	*		*	*	*	
C.V %	21.4	28.2	26.0		25.4	27.3	10.3	

Maize (Table 3), Stover yield responded significantly to intercrop combination as well as tillage practice in both cropping seasons. However, 100-seed weight was not significantly (P≥0.05) influenced by intercrop combination, tillage practice, or their interactions in both cropping seasons. Planting maize seeds on the flat gave the best grain yield, with maize seeds planted on ridges giving the lowest grain yield in both seasons.

On the groundnut component of the mixture (Table 4), Haulm yield/ha, pod yield/ha, harvest Index (HI), and shelling percentage responded significantly to intercrop combination in both cropping seasons, while 100-seed weight responded to intercrop combination only in 2021 cropping season. No significant effect of tillage practice was observed on all parameters taken nor were there significant interactions between intercrop combination and tillage practice on the investigated parameters; an indication that tillage was not a necessary treatment in groundnut cultivation in the study area. Relative to LER, among intercrop combination, the highest LER were observed when one row of maize was intercropped with one row of groundnut, with the least LER observed when two rows of maize were intercropped with one row of groundnut. This was similar to observations made by Oyewole (2004), in a millet/groundnut intercrop in the Sudan savanna ecological zone; where he observed that intercropping was generally advantageous when compared with sole cropping. Also, the observation was similar to the findings by Antenyi (2021), where intercropping was observed to be better than sole cropping in a maize/cassava intercrop. Finally, among the tillage practice, zero tillage gave the highest LER with planting on ridges giving the least LER. Intercropping was generally advantageous, an observation that was in line with Oyewole (2004), Selvakumar and Sundari (2006), and Hamzei. and Seyedi (2015).

Table 4: Effect of Intercrop Combination, tillage practice, and their interactions on days to flowering and yield-related parameters in 2020 and 2021 cropping seasons

Treatment	Days to Flowering		Haulm Yield (kg/ha)		Pod yield (kg/ha)		Harvest Index (%)		100-seed weight (g)		Shelling %	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Intercrop Combination												
Sole groundnut	32.67^{a}	26.83^{a}	711.11^{a}	637.04^{a}	1532^{a}	1367^{a}	53.26^{a}	36.74^{a}	47.83^{a}	48.32^{a}	61.00^{a}	79.42^{a}
2maize:1g/nut	34.17^{a}	28.17^{a}	355.56^{b}	289.89^{b}	1283^{c}	1226^{b}	28.32^{c}	22.64^{b}	44.83^{a}	39.76^{b}	53.17^{b}	60.65^{b}
2g/nut:1maize	33.25^{a}	27.67^{a}	362.96^{b}	266.67^{b}	1332^{b}	1234^{b}	33.23^{bc}	23.48^{b}	44.83^{a}	38.55^{b}	54.20^{b}	54.18^{b}
1maize:1g/nut	33.33^{a}	28.83^{a}	377.78^{b}	266.67^{b}	1384^{b}	1221^{b}	38.44^{b}	22.14^{b}	44.83^{a}	38.79^{b}	55.19^{b}	54.96^{b}
LSD (0.05)	1.600ns	2.830 ns	77.120*	66.100*	70.6*	27.8*	7.060*	2.780*	4.000ns	4.980*	5.080*	6.500*
Tillage (T)												
Ridge	27.50^{a}	22.40^{a}	311.11^{a}	310.11^{a}	1276^{a}	1212^{a}	27.67^{a}	21.24^{a}	35.80^{a}	31.59^{a}	43.47^{a}	49.56^{a}
Flat	26.35^{a}	22.10^{a}	377.78^{a}	288.89^{a}	1322^{a}	1204^{a}	32.20^{a}	20.42^{a}	36.70^{a}	32.19^{a}	44.55^{a}	51.23^{a}
Zero Tillage	26.20^{a}	22.40^{a}	378.78^{a}	288.89^{a}	1320^{a}	1213^{a}	32.08^{a}	21.34^{a}	36.90^{a}	35.48^{a}	46.12^{a}	48.74^{a}
LSD (0.05)	1.240ns	0.640ns	67.900ns	78.790ns	54.7ns	21.5ns	5.470ns	2.150ns	3.100ns	3.860ns	3.940ns	5.040ns
Interaction												
P x T	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V %	7.3	4.5	28.9	31.1	27.9	16.1	27.9	16.1	13.3	18.3	13.8	15.8

CONCLUSION

Weed management is the most challenging component of maize production. Successful weed control is important for achieving maximum yield in maize grain and silage crops. Weeds that are not controlled compete for light and the crop's nutrient and water resources, and yield losses may be up to 70% of the potential yield. Although many maize farmers have developed successful management practices for weed control there are instances when weeds become a problem. For both seasons, there were consistencies in the outcomes, with the highest weed dry weight observed in the Zero tillage followed by seeding on the flat and lastly when seeds were sown on ridges. Thus, unless mitigated the highest crop losses should be expected on Zero tillage plots with the least when seeds are sown on ridges. Intercropping was generally advantageous compared with sole cropping, thus recommended for the experimental area. Generally, the inclusion of maize in the system had positive effect on both Weed Cover Scores as well as Weed Dry weight; as reductions in these parameters were observed. However, higher maize population inclusion in the mixtures may give better results and should be encouraged.

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ANNEXURES

Rainfall Data For 2020

MONTHS	RAINFALL MONTHLY MEAN (mm)	MIN TEMP (^{O}C)	MAX TEMP (^{O}C)
JANUARY	0.0	19.6	23.8
FEBRUARY	0.0	20.6	26.5
MARCH	4.1	24.6	27.0
APRIL	1.7	25.1	27.7
MAY	3.6	24.5	27.0
JUNE	3.9	23.9	25.2
JULY	9.8	23.6	25.5
AUGUST	5.0	23.4	25.2
SEPTEMBER	6.1	23.5	24.4
OCTOBER	11.1	25.4	26.2
NOVEMBER	0.52	25.3	27.8
DECEMBER	0.00	20.5	25.3

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