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Editorial message

Dear Readers and Contributors,

Welcome to the edition of the Journal of Agriculture & Forestry Research (JAFR), Issue 2, Number 6.

As we continue to evolve, the Journal of Agriculture & Forestry Research remains committed to excellence in scholarly publishing. We extend our gratitude to the authors, reviewers, and editorial team for their dedication and hard work in bringing this issue to fruition. The collective effort of the research community is essential in advancing our understanding of agriculture and forestry, and we are proud to be a conduit for this knowledge.

We invite our readers to delve into the rich content of Issue 2, Number 6, and engage in the dialogue that these articles inspire. Your feedback and contributions play a crucial role in shaping the future of agricultural and forestry research. Thank you for your continued support, and we look forward to the ongoing journey of discovery and innovation in the pages of JAFR.

Sincerely,

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Research Article Open access

Modeling Carbon Stock-Dendrometric Parameters Relationship and Tree Species Diversity in Abu-Gadaf Natural Forest Reserve, Sudan

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ABSTRACT

This study modeled the relationships between aboveground carbon stock and tree densitometric parameters (diameter and height) as well as the species diversity in Abu-Gadaf Natural Forest Reserve, Sudan. Forty-six sample plots were systematically inventoried across the low and highland areas of the reserve, and tree diameter at breast height, total height, density, and regeneration trends were measured. The Shannon, evenness, and richness indices were assessed using the recommended equations and the polynomial regression for carbon stock-dendrometric parameters modeling. The study findings illustrated that highland areas have high species richness, evenness, and Shannon index value with 45 tree species and excellent regeneration for dominant tree species. However, the lowlands accommodate 30 tree species with low tree density and aboveground biomass. Moreover, the carbon stock-tree diameter relationship exhibited a strong polynomial correlation with R2 value of 0.93 in comparison to carbon stock-tree height ones. While the reserve hosts a considerable number of tree species, particularly in the highland areas, several none regenerated species in the lowland sites need a quick intervention for further conservation. Accordingly, the participatory approach of community forestry can successfully guide the restoration plan of the influenced areas across the reserve.

Keywords: Carbon Stock, Forest, Regeneration, Species Diversity, Tree Density, Tree Diameter

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1. INTRODUCTION

Natural forest reserves contribute significantly to the mitigation of climate change (Bai et al. 2022), rural community development (Khamis and Abdalla, 2017), and locals' livelihood satisfaction (Suleiman et al. 2017). They clean the atmosphere by absorbing CO_2 and releasing O_2 as a byproduct of the photosynthesis process (Ibrahim et al. 2018). The protected forest sites store about 115 Mg/ha of carbon within aboveground biomass Worldwide (Dimobe et al. 2019) and 82.8 Mg/ha in the African continent (Dimobe et al. 2019). However, under the rapid human population growth, increasing consumption, and intensive pressure on forest resources, more CO_2 can be released, and more forested lands will be lost.

Though carbon stock can vary between aboveground and underground biomass based on plant type, plant organs, and elevation, exploring the correlations between tree species diversity and carbon storage aboveground can support the sustainable management of forest resources and accelerate the reduction of CO_2, particularly for low-income countries like Sudan. Sudan as a Sub-Saharan African country characterized by a dry climate in the north and a wet and rainy one in the south with rich biodiversity commonly found across the country riverine, urban, natural, institutional, community, private forests, and biosphere reserves (Hassan et al. 2022; Ibrahim et al. 2018; Tahir and Yousif, 2013). While several studies have addressed the effects of anthropogenic activities and climatic variability on forest population dynamics, species diversity, forest composition, soil fertility, and wild animal species (Hasoba et al. 2020; Hassaballah et al. 2020; Mohammed, Elhag, et al. 2021), few were concerned with species diversity and carbon storage. This study fills this gap and models the relationship between carbon storage and tree species diversity in Abu-Gadaf natural forest reserve.

Abu-Gadaf Natural Forest Reserve (ANFR) is a state natural forest present in the Blue Nile Region offering various ecological, economic, and social functions to local communities in Abu Gadaf, Amri, and Mukla villages as specific, and the Blue Nile and Sudan as general. The rural community around the reserve keeps domestic animals such as goats, sheep, cows, and camels, as well as, practice farming, charcoal production, edible forest fruits gathering, and honeybee collection (Hassan et al. 2022; Mohammed, Hassan, et al. 2021). Moreover, the current documented biotic and abiotic disturbances in ANFR can change the forest structure and influence its diversity and carbon sinks. Therefore, this study could potentially contribute to the conservation and sustainable management of ANFR resources and its vulnerable species.

The sustainable management of forest reserves and similar conserved sites requires detailed information about the reserves' species diversity, stand characteristics, dendrometric properties, site index, biotic and abiotic disturbances, healthy status, and site dynamics, achievable through forest inventory (Heym et al. 2021; Mohammed et al. 2022). While dendrometric parameters like diameter at breast height and total tree height can easily be assessed using ground measurement, tree volume and biomass can precisely computed and predicted using linear and non-linear models (Dimobe et al. 2019; Ibrahim et al. 2015; Zhou and Hemstrom 2009). Moreover, allometric models can accurately be initiated to assess the aboveground biomass for mixed tree species or specific ones (Dimobe et al. 2019; Tetemke et al. 2019). Therefore, for the computation of biomass above ground, this study used a model recommended for tropical forest trees (Dimobe et al. 2019).

The study suggests that areas with adult and codominant trees store more carbon than juvenile ones. Additionally, sites frequently distressed with unpermitted utilization (harvesting, grazing, browsing, and ground fire) have less species diversity, stocking density, and juveniles. Accordingly, the outcomes of this study will form a solid ground for the integrative management of ANFR and other similar ecosystems.

2. MATERIALS AND METHODS

2.1. Study area

The study took place in ANFR, which is found in Blue Nile Region at 11º 25' 00" N, 11º 31' 00" N, 34º 50' 00" E, and 34º 55' 00" E (Figure 1) (Mohammed, Hassan, et al. 2021). The reserve is characterized by a mean monthly minimum and maximum temperature and rainfall of 22 ºC, 43 ºC, 20 mm, and 300 mm, respectively (Mohammed, Hassan, et al. 2021). Though the forest topographically has flat and rocky

sites, the well-established tree species are *Acacia seyal*, *Boswellia papyrifera*, *Combretum hartmannianum*, and *Ziziphus spina-christi* (Hassan et al. 2022). Moreover, non-timber forest product trade and fuelwood business are among the common income producing practices in the area Hassan et al. 2022). In addition to that, as ANFR is closer to the Dinder Biosphere Reserve, various wild animals can frequently observed in the forest during the rainy season, particularly Warthog, waterbuck deer, *Acacia seyal* monkey, and migratory birds (Mohammed, Hassan et al. 2021).

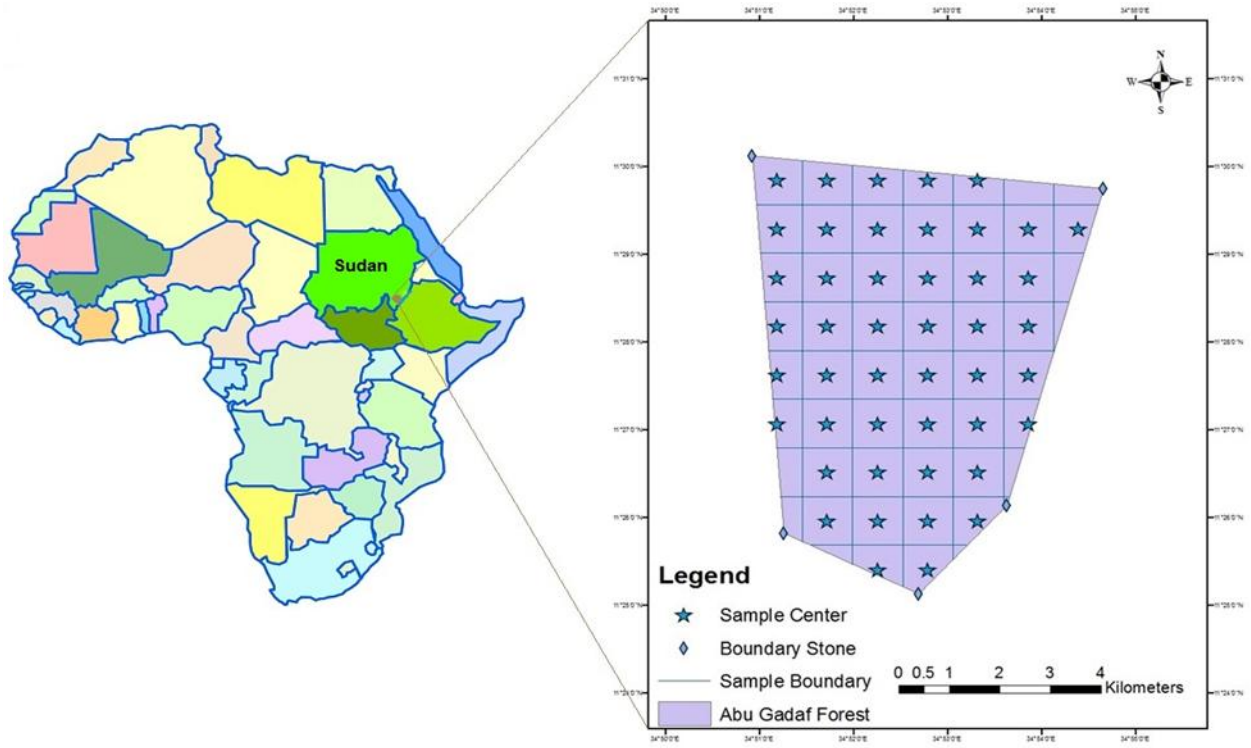

Figure 1. The map displaying the study area and the inventoried sample plots.

2.2. Data collection

The study used the stratified sampling design with a systematic layout of sample plots within the stratum. Data collection occurred from December 2021 to May 2022 in 46 sample plots of 1000 m^2. The dendrometric features like diameter at breast height (DBH), total tree height (H), and crown properties were measured for all inventoried trees with DBH ≥ 5 cm (Mohammed et al. 2022). While biomass stock was computed using equation 1, the amount of carbon was assessed by multiplying the value of aboveground biomass by 0.47 (a default C fraction as documented by the Intergovernmental Panel on Climate Change) as recommended by (Dimobe et al. 2019; Gebeyehu et al. 2019; He et al. 2022). Moreover, the Shannon and richness indices were calculated as a proportion of a specific species to overall ones and the total number of species, respectively (Dimobe et al. 2019; Mohammed, Hassan, et al. 2021). Additionally, evenness was computed as a division of the Shannon diversity index to the species richness index (Dimobe et al. 2019).

Aboveground biomass (AGB) = $0.0673 * (\rho * DBH^2 * H)^{0.976}$ …… (1)

Where ρ is the mean wood density as computed from the international database records (Dimobe et al. 2019), and H is the overall tree height.

2.3. Data analyses

The allometric linear models in R software were performed for dendrometric parameters-carbon stocks and diversity indices-carbon stocks

relationships (Dimobe et al. 2019). Trees were classified into five classes based on DBH for further comparison and correlations. Moreover, analysis of variance and Tukey test were run within the stratum and between strata comparisons for detailed comparison purposes and determination of the statistically significant differences, respectively (Hassan et al. 2022; Mohammed et al. 2022). Besides that, tree density and relative abundance were assessed as the total number of stems per hectare and the abundance of a specific tree species to the overall ones of all species multiplied by 100, respectively (Mohammed, Hassan, et al. 2021). The excellent, good, fair, poor, and none regeneration trends were classified based on references (Idrissa et al. 2018; Mohammed, Hassan, et al. 2021) as reported in Table 1.

Table 1: The criterions for regeneration trends classification

No	Trend	Criteria
1	Excellent	Seedlings are twice saplings and saplings are greater than adults
2	Good	Seedlings are greater than saplings and saplings are greater than adults
3	Fair	Seedlings equal saplings and saplings are greater than adults
4	Poor	No seedlings, only saplings and adults
5	None	No seedlings and saplings, only adult trees

3. RESULT AND DISCUSSION

3.1. Tree species diversity and composition

The lowland areas display less tree species diversity in comparison to highland ones for Shannon diversity index, species evenness index, and species richness index, with significant differences between sites (Figure 2). While diameter at breast height and total tree height in the highland area were greater than that of lowlands by > 60%, the tree density of adult tree species in the lowlands was half that of highlands, with significant differences within and across the sites (Figure 2). Moreover, *Acacia seyal, Anogeissus leiocarpus, Balanites aegyptiaca, Boswellia papyrifera, Combretum hartmannianum, Lannea fruticosa, and Ziziphus spina-christi* dominate both high and land areas with clear representation of Fabaceae family members (Table 2). The forest accommodates 45 and 30 tree species in its high and lowland areas, respectively (Table 2).

These significant differences between the low and highlands of Abu-Gadaf natural forest reserve in terms of species diversity show how lowland areas were severely affected by human practices in forms of unpermitted harvesting, mechanized farming, overgrazing by livestock, and forest fire due to honeybee collection. These findings are in line with (Dunne et al. 2011; Ibrahim and Hassan, 2015; Kikoti et al. 2015; Suleiman et al. 2017; Yeneayehu et al. 2019), who illustrated that human activities influenced the species diversity in the natural forests and game reserves of Kenya, Sudan, Tanzania, Nigeria, and Ethiopia, respectively. Moreover, the high appearance of Fabaceae family members can be associated with the wide ecological range of their species as well as their high adaptability. However, the small diameter at breast height and low total tree heights in the lowland areas alert for further conservation and protection measures, particularly for vulnerable species and those with a limited relative abundance and importance value index.

3.2. Biomass, carbon stocks, and dendrometric relationships

While medium and large-sized trees showed significant differences between sites for both aboveground biomass and carbon stock, small-sized trees exhibited no variation between low and highlands for the two parameters (Figure 3). The biomass of adult and mature trees (large-sized trees) in highlands was double that of lowlands and significantly differed (Figure 3). The carbon stock-diameter at breast height

relationship illustrated a strong polynomial correlation with R^2 value of 0.93 (Figure 4). However, the total tree height-carbon stock relationship displayed a weak correlation with 0.32 as R^2 (Figure 4).

Table 2: The present/absent, importance value index, and regeneration trends of tree species assessed in the high and lowlands of Abu-Gadaf natural forest reserve

Species	Present (+) and Absent (-) of		Importance Value Index		Regeneration Trends	
	Highland	Lowland	Highland	Lowland	Highland	Lowland
Acacia polyacantha Willd.	+	+	3.412	3.439	I	I
Acacia senegal (L.) Willd.	+	+	10.961	19.22	II	III
Acacia seyal Del.	+	+	18.22	25.68	III	IV
Adansonia digitata L.	+	+	9.179	10.02	I	I
Anogeissus leiocarpus (DC.) Guill.	+	+	20.51	16.88	IV	III
Balanites aegyptiaca (L.) Del.	+	+	18.10	15.29	IV	III
Boscia senegalensis (Pers.) Lam.	+	-	3.575	-	I	0
Boswellia papyrifera (Del.)	+	+	15.83	16.02	III	III
Combretum aculeatum Vent.	+	+	2.566	6.376	I	I
Combretum ghasalense Engl. &	+	-	6.560	-	I	0
Combretum glutinosum Perr. ex	+	+	9.095	11.18	III	III
Combretum hartmannianum	+	+	26.70	23.95	IV	III
Combretum micranthum G. DON	+	-	4.188	-	I	0
Combretum molle R. Br ex G.	+	-	2.068	-	0	0
Commiphora africana (A. Rich.)	+	+	3.093	3.810	I	I
Dalbergia melanoxylon Guill. et	+	+	5.054	6.261	II	II
Dichrostachys cinerea (L.) Wight	+	+	2.657	7.069	I	0
Diospyros mespiliformis Hochst.	+	+	4.417	5.435	I	0
Entada africana Guill. et Perr.	+	+	2.175	6.351	I	0
Ficus sycomorus	+	+	1.049	4.568	0	0
Gardenia lutea Fresen.	+	+	3.843	4.789	I	I
Grewia bicolor Juss.	+	-	1.520	-	0	0
Grewia flavescens Juss.	+	-	1.844	-	0	0
Grewia mollis Juss.	+	-	2.134	-	0	0
Hyphaena thebiaca (L.) Mart.	+	+	6.139	7.518	II	II
Lannea fruticosa (Hochst. ex. A.	+	+	16.88	25.12	III	IV
Lannea kerstignii Engl. & K.	+	+	1.499	1.835	0	0
Lannea nigritana (Scott Elliot)	+	+	8.951	7.921	II	II
Lannea schimperi (Hochst. ex. A.	+	-	4.212	-	0	0
Maerua angolensis DC.	+	-	2.690	-	0	0
Piliostigma reticulatum (DC.)	+	-	2.136	-	0	0
Pseudocedreca kotschyi	+	-	7.035	-	0	0
Pterocarpus lucens Lepr. ex Guill.	+	-	5.846	-	0	0
Sclerocarya birrea (A. Rich)	+	+	5.660	12.07	II	II
Sterculia africana (Lour.) Fiori.	+	+	6.132	7.474	I	I
Sterculia setigera Del.	+	+	13.66	8.786	II	II
Stereospermum kunthianum	+	-	2.138	-	0	I
Strychos innocua Del.	+	+	2.959	6.302	I	I
Syzygium guineense (Willd.) DC.	+	-	4.492	-	I	0
Tamarindus indica L.	+	+	2.130	6.810	I	I
Terminalia brownii Fresen.	+	+	1.549	3.937	0	0
Terminalia laxiflora Engl.	+	+	5.949	7.286	I	I
Terminalia macroptera Guill. &	+	+	6.196	7.568	I	0
Ziziphus abyssinica Hochst. ex. A.	+	-	1.228	-	0	0
Ziziphus spina-christi (L.) Desf.	+	+	12.77	11.07	III	III

Symbols 0, I, II, III, and IV are referred to none, poor, fair, good, and excellent regeneration trends.

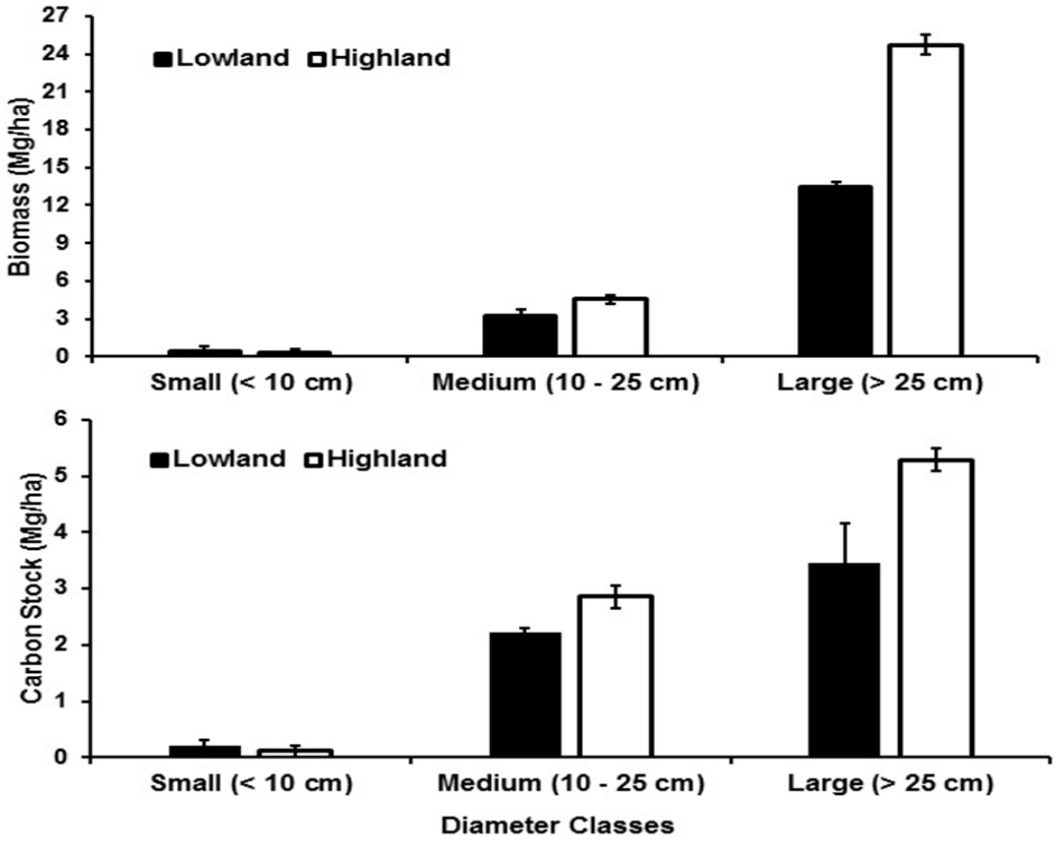

Figure 2: Tree diversity, dendrometric parameters, and density for the cruised tree species in the low and high lands of Abu-Gadaf natural forest reserve (α = 0.05).

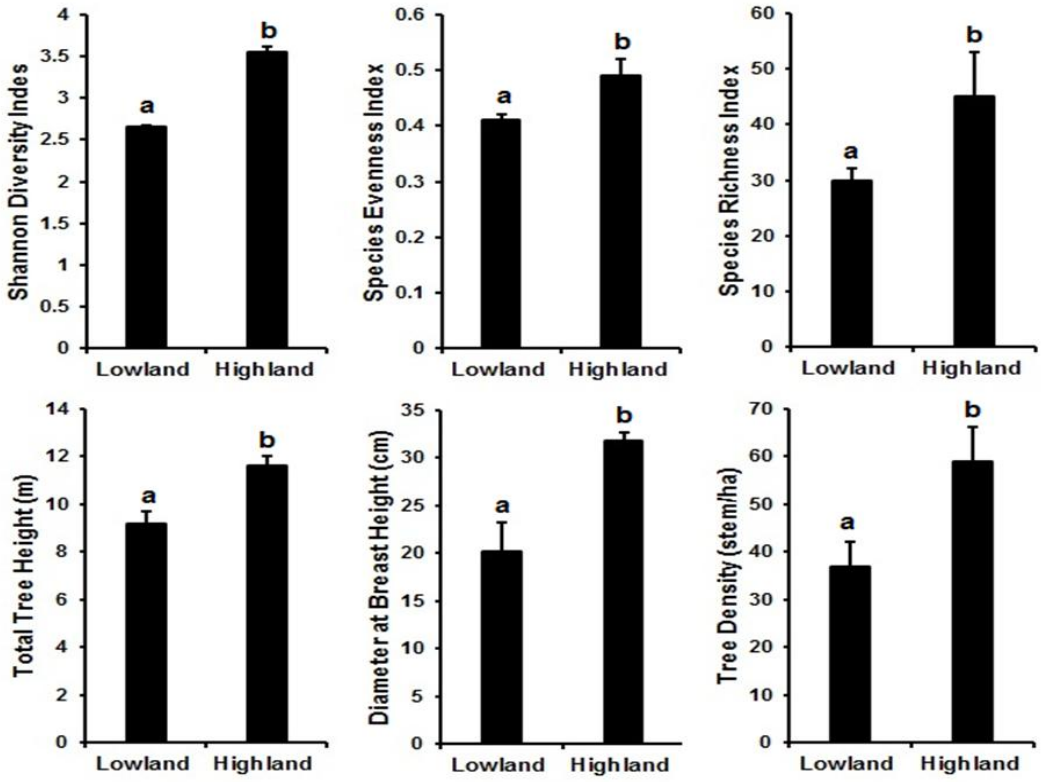

Figure 3: Aboveground biomass and carbon stock for different diameter classes of the identified tree species in the low and highland sites of Abu-Gadaf natural forest reserve (α = 0.05).

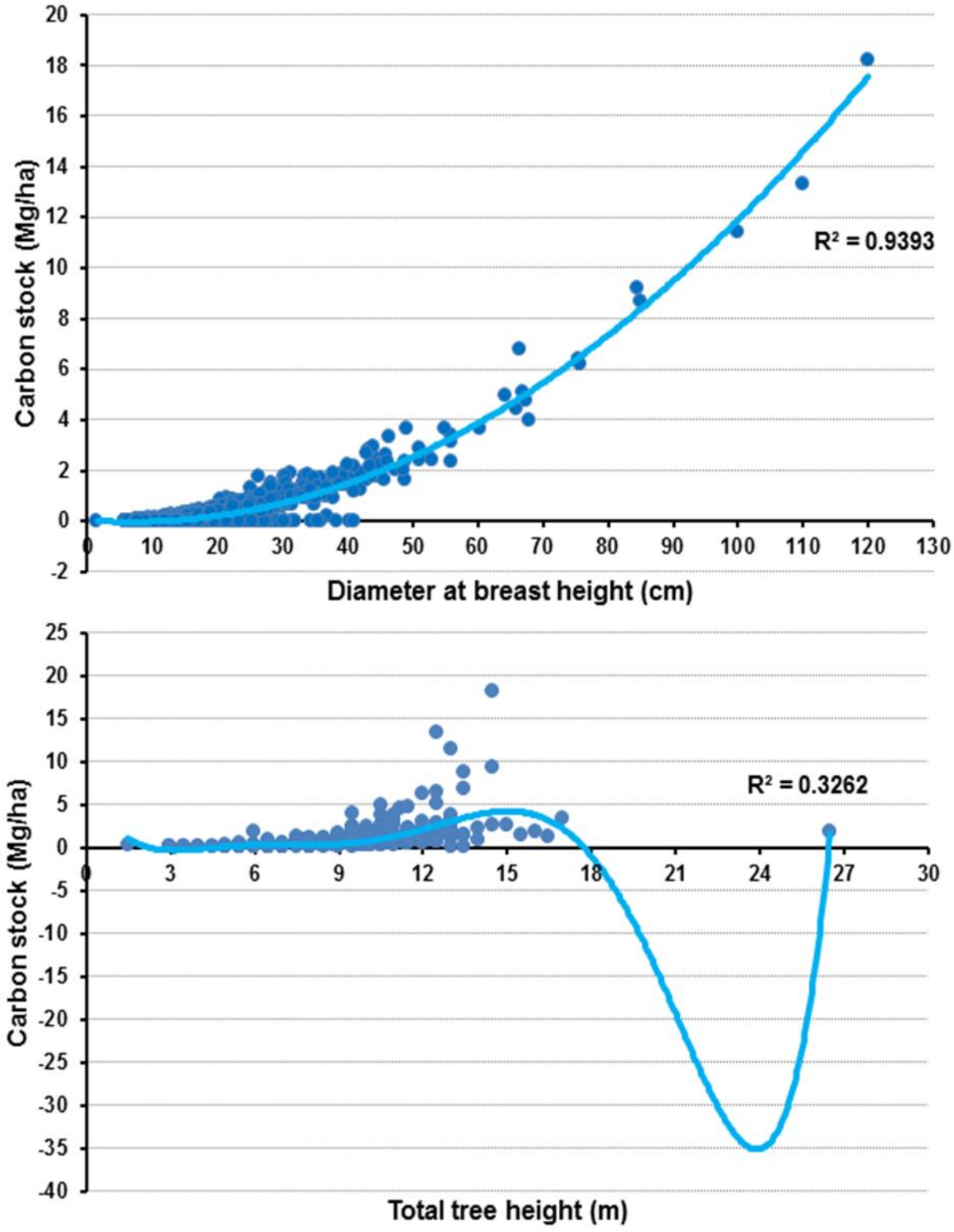

Figure 4: Polynomial relationships between the average tree diameter at breast height, total tree height, and the carbon stock for the identified tree species in Abu-Gadaf natural forest reserve

The high values of aboveground biomass and carbon stock for the medium and large-sized trees highlight the importance of dominant and codominant trees in sequestrating and storing CO_2 through their vigorous rates of photosynthesis and metabolism. Though young plants (seedlings and saplings) have a rapid growth rate at favorable conditions, still have fewer cells and cell divisions compared to adult and mature trees. However, the tree crown and

diameter properties vary according to the tree species (broadleaved or narrowleaved), biotic disturbances (grazing, browsing, harvesting, invasive species, and diseases), abiotic disturbances (lighting, flooding, earthquakes, extreme weather, and pollution), and site conditions (soil health, competition, immigration, and migration), and therefore, the biomass content and carbon stock. These findings are consistent with (Amahowe et al. 2018; Dimobe et al. 2019; Ouédraogo et al. 2019; Zhu et al. 2021).

Furthermore, the observed variation between high and lowland sites of the Abu-Gadaf natural forest reserve in terms of biomass and carbon stock is directly associated with intensive pollarding activities as well as livestock browsing. The researchers (Carozzi et al. 2022; Chen and Tang, 2016; Osem et al. 2017) concluded similar results. Moreover, the strong relationship between tree diameter and carbon stock illustrates the potential of tree diameter to predict the tree carbon stock if properly modeled. Therefore, as forest inventory consumes time and human resources, modeling approaches can overcome these constraints and pave the road for growing stock assessment in both accessible and inaccessible forest sites.

4. CONCLUSION

The study findings illustrated that highland areas have high species richness, evenness, and Shannon index value with 45 tree species and excellent regeneration for dominant tree species. However, the lowlands accommodate 30 tree species with low tree density and aboveground biomass. Moreover, the carbon stock-tree diameter relationship exhibited a strong polynomial correlation with R2 value of 0.93 in comparison to carbon stock-height ones. While the reserve hosts a considerable number of tree species, particularly in the highland areas, several none regenerated species in the lowland sites need a quick intervention for further conservation. Accordingly, the participatory approach of community forestry can successfully guide the restoration plan of the influenced areas across the reserve. Species like Acacia senegal, Balanites aegyptiaca, Boswellia papyrifera, and Ziziphus spina-christi can potentially use for afforestation of the degraded sites due to their economic values and high resiliency.

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Black Soldier Fly Frass for Improved Soils, Crop Yields and Environment among Smallholders-Mixed Farming System in Kenya

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ABSTRACT

The production and yields of major crops are in decline in sub-Saharan Africa (SSA) due to deterioration in soil nutrients and increasing prices of farm inputs. Farmers have used manure and artificial fertilizers to improve the production of crops. Some of these fertilizers have caused adverse effects on our environment resulting in climate change. The use of frass, although minimally used by farmers, has proved to be effective in reducing greenhouse gas emissions, providing nutrient-rich feeds to livestock and organic fertilizers to crops. This article highlights the importance of keeping black soldiers fly and adopting frass to eradicate problems smallholder farmers face in soil, crop, and environmental management. The fly's larvae feed and break organic wastes including wastes from poultry and cattle, making them free from foul odor and emission of massive carbon dioxide and methane. The larvae can also be used as livestock feeds whereas the unused organic material becomes fertilizer rich in high levels of nitrogen, phosphorus, and potassium compared to other organic and inorganic fertilizers used in SSA. For improved production, farmers need to switch to this multipurpose insect. A simulation analysis is necessary to show the future adoption of the technology. With increased awareness and training, more than a million farmers in SSA are likely to adopt this practice in less than ten years.

Keywords: Crops, Soil nutrition, Organic waste, Carbon dioxide, Climate change, Environmental management

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1.0. INTRODUCTION

The interaction between human beings, crops, and livestock has been in existence for a longer period, as their existence is mutually related. Human beings depend entirely on livestock and plants for their nutrition (Soetan et al. 2010; Day, 2013). In case the crops and animals are produced in a proper manner,

they are likely to address food insecurity and malnutrition among small-scale farmers (Sekaran et al. 2021). Food insecurity and malnutrition has been caused by poverty, infertile soils, lack of or expensive farm inputs and natural calamities like drought (Tadesse et al. 2008; Nzabuheraheza and Nyiramugwera, 2017; Fagariba et al. 2018; Umesha et al. 2018; Gautam and Kumar, 2019). These four main causes may be outweighed by the adoption of a new fertilization method.

The use of black soldier fly (BSF) frass insect fertilizers has not gained track in most developed nations due to inadequate information or lack of political will to champion the technology (Anyega et al. 2021). In Kenya, this soil amendment method has been spearheaded by ICIPE but still few farmers have adopted it (Okello, 2022). Those adopted have put more emphasis on their use as a source of proteins for livestock and less on soil fertility amendments (Shumo et al. 2019; Anyega et al. 2021; Alagappan et al, 2022; Beesigamukama et al., 2022). Due to high costs of inputs and environmental damage caused by the use of artificial fertilizers, the use of insect frass can help cushion farmers' expenses and safeguard our ecosystem (Kim et al. 2021). Fertiliser is in organic form and has the ability to transform unfertile or degraded land through fertility enrichment (Beesigamukama et al. 2021; Beesigamukama et al. 2022). This can boast the socio-economic wellbeing of small-scale farmers since they will spend less money on inputs (fertilizers and chemicals) acquisition due to organic matter improvement and nutrients being held in the soil for over a longer period of time (Terfa, 2021; Kragt et al. 2023).

In Kenya, the agriculture sector has registered poor output for more than five years, in comparison with its population, and yet it is the backbone of our nation having dominated the Kenyan economy (Maiyo, 2015; Hijbeek et al. 2021). The boost comes majorly on cash crops meant for exports like tea, fruits and coffee while cereals and vegetables for subsistence have been baited down (Mohajan, 2014). The sector directly contributes 26% of the Gross Domestic Product (GDP) and indirectly 27% of GDP through linkages to other divisions (Orindi and Ochieng, 2005; Meiguranet al. 2016). About 40 % of the entire Kenyan population are directly or indirectly employed in the sector, with about 70% of them coming from rural areas (Emongor, 2014). One of the factors that has affected agricultural food production has been associated with unfertile soils (Chikowo et al. 2014; Zingore et al. 2015; Fischer et al. 2020; Asiloglu et al. 2021). Thus, to maintain consistent yield and supply of food products to the daily increasing population, the issue of soil infertility has to be dwelt with, once and for all. Soil infertility has been attributed to changes in soil chemical, physical and biological properties. The changes in soil properties are mainly as a result of use of inorganic fertilizers, use of chemicals for weed, pest and disease control and poor agronomic practices (Page, 2020). Most small-scale farmers are fighting with soil acidity which has led to unavailability or adsorption of nutrients (Kiplagat, 2014; Abate et al. 2017; Laekemariam and Kibret, 2021). The fight can be won through zero use of inorganic fertilizers and other artificial chemicals on the farm (Zingore et al. 2015). Given that most Kenyan soils have been exploited to an extent that crops cannot do well without fertilization, it calls for other alternative measures. The use of organic materials like crop residues, plant and animal waste materials have not achieved the desired outcome since these materials have become few due to many competing uses attached to them, with preferences directed to other uses rather than soil amendments (Michael, 2021; Shaji et al. 2021).

The use of insect frass fertilizer is likely to bring many improvements to farming since the growth of the insect larvae has proved to be much cheaper and can be carried out by anyone regardless of education, income and weather conditions (Poveda, 2021; Terfa, 2021; Beesigamukama, 2022, Subramanian & Tanga, 2022). In that case, this paper review has been developed to provide a lot of insight on the effects of insect frass fertilizer on farmers and encourage their adoption across the country.

2.0 BODY

2.1.0 BSF Frass

The BSF, scientifically known as Hermetia illucens, is among the common flies in the family Stratiomyidae (Moretta et al. 2020; Gujarathi & Pejaver, 2013). The fly is spread widely across the globe with adults

found in an array of locations near larval habitats (Zhang, 2020). There are over 2,700 species of soldier fly insects and mostly inhabit wetlands, decaying organic matter, damp soils, animal wastes and under tree barks (Gahukar, 2016; Shumo, 2019). The species are native to the tropical terrestrial ecoregion of Americas (Triplehorn, 2005). In the last few decades, the fly has spread throughout all the continents become predominant in northern and southern part of Africa (Poveda 2021; Subramanian & Tanga, 2022). The fly has an ability to adapt to various ecological conditions making it useful to many farmers. BSF is a beneficial and non-pest fly with the ability to rest on vegetables and flowers in bright sunlit areas (Diener et al. 2015). The adults are inactive, weak fliers and will spend more time resting especially animal production facilities (Čičková et al. 2015; Sarwar, 2020). The adult fly does not feed on wastes, since it lacks mouthparts (Rana et al. 2015; Lievens et al. 2021; Tettamanti et al. 2022). BSF does not bite and neither does it transmit diseases to human beings and animals (Rana et al. 2015). The presence of the fly keeps away pathogens causing insects like housefly (Goddard, 2003). Their larvae are scavengers and flourish on any decomposing organic material, including compost heap, manure, algae, plant refuse and mold (Forsyth & Miyata, 2011; Diener et al. 2015). This ability helps to sustainably manage waste and reduce bad smell and control diseases (Banks et al. 2014; Nguyen et al. 2015). Statistics show that the insect has the ability to reduce food waste by about 75% while converting the waste into feedstuff containing 42% proteins and 37% fats (Barragan-Fonseca et al. 2017). The fly has multiple uses that need to be exploited through rearing it. Besides livestock feeds and source of manure, the fly can be a source of food to human beings, BSF larvae can produce geese for pharmaceutical industry, production of chitin and bioremediation experiments (Gordon, 2013; Albagli et al. 2015; Oonincx et al. 2015; Wang & Shelomi, 2017; Martín et al. 2023).

2.1.1 Morphological characteristics

BSF has a wasp-like look with black and/or blue in color. The adult flight has a length of 15 to 20 mm, making it a medium-sized flight (Sheppard et al. 2002). The dominating body color is black with either blue or green metallic reflection on the thorax and some may have a reddish end of their abdomen (Terfa, 2021; Kang, 2023). They also have two translucent openings in the first (basal) abdominal segment. The fly has a wide head, whose antennae being twice the head size (Wang, 2020). The antennae is elongated, projected over the head and lacks sensory organs of touch. They have membranous wings that overlap and horizontally folded when at rest (Guerreiro et al. 2020). The fly female's abdomen is usually reddish at the top while the male is bronze. On the other hand, their upper legs are black with white-yellow forelegs- tarsi (Kang, 2023). Their larvae are similar to housefly and blowfly but can be differentiated by the presence of a thin black-gray stripe on their posterior ends (Nyakeri et al. 2017; Raksasat et al. 2021). The larvae have a dull, whitish color with a projecting head containing mouth parts used for chewing (Nyakeri et al. 2017).

2.1.2 Feeding and reproduction

The BSF goes through five main stages (Figure 1) in its entire life cycle, namely egg, larval, prepupal, pupal, and adult (da Silva & Hesselberg, 2020). Adult fly breeds either in compost, manure or outdoor toilets through laying of eggs (Raksasat et al. 2021; Terfa, 2021). Commercial special scents and traps should be put at specific areas for the fly to lay eggs (Figure 2, section b) Mating occurs in shaded areas while the male and female are in flight but not at rest where the female deposits about 500 to 900 eggs especially close to the edges of decomposing materials (Julita et al. 2020). Just after partaking oviposited, the female dies (Lievens et al. 2021). The eggs are oval, creamy in color, and about 25mm in length. The eggs color can sometimes turn dark over time (da Silva & Hesselberg, 2020). The incubation periods vary, taking a minimum of 4 to 21 days for the eggs to hatch (Nyakeri et al. 2017). The wide variation depends entirely on temperature and seasons. Larvae passed through six instars in a period not exceeding 14 days to complete its development (Hall and Gerhardt, 2002). A mature larva has a length of approximately 20 mm, whereas a newly hatched one can have a minimum length of 8mm (Diclaro & Kaufman, 2009; Oliveira et al. 2015). A larvae will immediately start feeding on organic matter upon egg hatching and its consumption rate will increase after the 3rd instar. In the 6th instar larvae undergo

melanization giving the cuticle a dark coloration thus becoming pre-pupae (Li et al. 2023). At the pre-pupae stage, it stops feeding and empties its digestive tract (Wong et al. 2019; Alagappan et al. 2022b). This makes it move away from the food source to dry crevices and then turn into pupae in 7-10 days (Rodrigues et al. 2022; Jalil et al. 2023). The pupae in a period of 8 days give of not feeding gives rise to an adult (Jalil et al. 2023). The young adult fly feeds only on water as it relies mostly on the fat stored during its larvae stage (Lievens et al. 2021). The adult BSF stays remotely away from human beings and does not harm crops, spread diseases, or cause any pollution or invasion of buildings (Shumo et al. 2019; Wong et al. 2019; Anyega et al. 2021). Mature BSF are inactive thus easily controlled (Figure 2, section c).

Of all the stages, the larvae stage is the most active one (Guerreiro et al. 2020). The larvae are scavengers and consume all kinds of decomposing organic wastes like algae, manure, mold, composite heap and beehives waste products (Zhang, 2020). Their feeding habit is necessitated with large and strong chewing mouthparts that allow them to break and prey on waste (Rana et al. 2015).

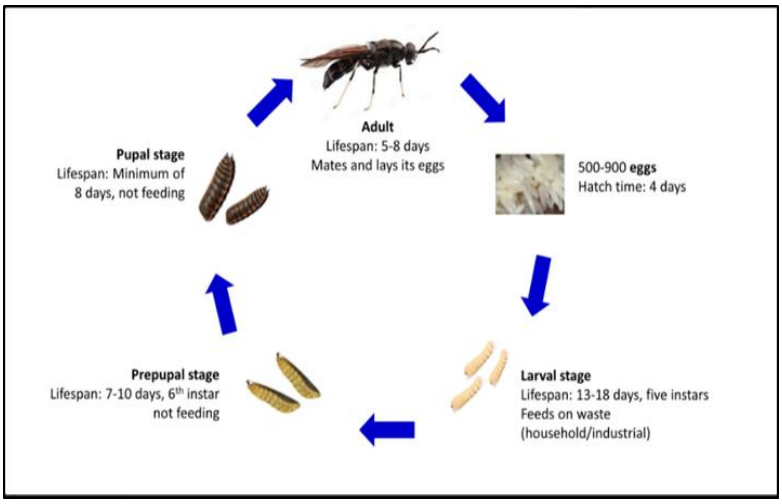

Figure 1: A diagrammatic representation of the life cycle stages of black soldier fly. Source: https://encyclopedia.pub/8454

Figure 2: Black soldier fly structures a) banana leaves used as organic waste/food, b) The laying area and traps to attract female BSF to lay eggs, c) adult black soldier fly in their nest.

2.1.2 Factors favoring growth of fly frass

The insect is known to adapt to various environmental conditions; thus, it can grow well in both optimal and adverse conditions (Chia et al. 2018). The optimal relative humidity and moisture ranged from 50 – 70% with optimal light intensity of 135–200 µmol/m^2 (Alvarez et al. 2019; Barrett et al. 2023). Lower relative humidity reduces their survival

rates, whereas light intensity dictates their mating rates (Kim et al. 2021). Insects do well in a temperature of 26-27^{0}C (Chia et al. 2018). High temperature reduces the lifespan of both adult flies and the pupals (Chia et al. 2018). On the other hand, competition among larvae can affect the density and decomposition rate of the organic materials (Kragt et al. 2023). Therefore, the density needs to be controlled based on the volume of the substrate available to atcrease the survival rate of larvae and uniformity of the performance of the colony (Opare et al. 2022). The ratio of substrates to larvae in kilograms should be 1:2 for effective results (Kragt et al. 2023). The type of organic material also affects larvae growth (Kim et al. 2021; Alagappan et al. 2022). This growth rate is as high as above 80% when materials like poultry feeds, fruit, vegetable and other food waste are used (Mahmood et al. 2023). On the contrary, digested sludge may lower they fly's growth to less than 40% (Opare et al. 2022; Rodrigues et al. 2022). The high salinity of the substrate leads to decreased growth rates and larvae development (Richardson et al. 2021). The quality of the feeds greatly affects the fertility rate, survival rate, size of the adult and larvae (Mahmood et al. 2023).

2.1.4 Challenges in production of fly frass by small-scale farmers

Keeping frass fly does not require many resources but the enterprise has been encompassed with several challenges which calls for proper training and capacity building before engaging in the exercise to avoid losses and frustrations (Shumo et al. 2019; Wang & Shelomi, 2017). The insect requires a well-controlled conditions for them to grow well, find mates and produce eggs (Chia et al. 2018). Setting up such climate-controlled environment with suitable UV wavelengths may be a major set-back, especially in rural areas, especially in cold areas (Malawey et al. 2021; Sign et al. 2021). The conditions in the love cages, if not conducive, may affect the laying of eggs among the insects thus reducing the number of lavas (Zim et al. 2023). Poor conditions result in protracted incubation time and increased rate of eggs failure (Star et al. 2020). For instance, wetness in the eggs may destroy all the eggs. Thus, the correct temperature and humidity within the cages must be considered (Surendra et al. 2020; Opare et al. 2022).

BSF requires high quality and diverse organic waste feeds (Wong et al. 2019). Producing them commercially may affect the dietary measures since the farmers may lack constant supply of food waste. The safety (free from toxin) of wastes cannot be easily determined by local farmers (Surendra et al. 2020; Kim et al. 2021). Also, determining the required moisture content may be a challenge without proper training on the same (Alvarez et al. 2019). At some point, waste food might be a breeding place of ants or mites, thus affecting the growth and multiplication of the fly (da Silva & Hesselberg, 2020).

Harvesting of larvae may be a cumbersome exercise, especially when done manually (Basri et al. 2022). In most cases the larvae are mixed with frass, thus separating them can be a very rigorous exercise, especially where the mixture contains high moisture content (Beesigamukama et al. 2020). To avoid losing many frass during harvesting of larvae, it is advisable to use mechanical methods which may be costly to the farmer (Alvarez, 2012).

The larvae become livestock feeds in the long run (Kragt et al. 2023). Although the larvae are sterilized using hot water, maintaining the required temperature may be a problem, especially when larvae are added to boiled water, they may lower the temperature (Mertenat et al. 2019). This requires a suitable heating mechanism to keep the water hot even with addition of the larvae (Alagappan et al. 2022b). During drying of larvae, farmers need to adopt a method that will not diminish the nutritional value of the larvae (Nyakeri et al. 2017; Shumo et al. 2019).

2.2 Smallholders Mixed Farming System

Smallholder farmers are the majority in Kenya, accounting for up to 70% of agricultural products marketed within and outside the country (Ali-Olubandwa et al. 2010). It is only a small percentage (10 – 20%) that operate formally contributing to the value chain (Ng'endo et al. 2015). Small-scale farmers contribute about 22% of Gross Domestic Product (GDP) and over 56% of employment opportunities (Samberg et al. 2016). The declining number could be attributed to many challenges faced by small-scale farmers. Most of the smallholder farmers cultivate less than five acres of land, making them counted

among the world's poor who depend on less than two dollars a day (Rao & Qaim, 2011). Most have resorted to mixed farming to intensively maximize the small area of land by producing diverse produce with the anticipation that one of the produce may fetch good yield and/or returns (Ali-Olubandwa et al. 2010). Mixed farming involves both the growth of crops and keeping of livestock (Abate et al. 2017). This practice began in United States and Japan mainly for domestic consumption and later extended to entire Asia and Africa (Keatinge et al. 2011). In Kenya, mixed farming was adopted after independence when the land was subdivided among the residents (Keatinge et al. 2011). The increase in population has contributed to further subdivision of the land impacting negatively on mixed farming. In Kenya, mixed farming is dominated, both, in rural and urban areas (Ntale & Litondo, 2013). Despite the fact that harvesting crop residues are fed directly to animals, the issue of soil fertility has been partially addressed since the manure obtained from reared animals may be applied on the farm to increase its fertility (Ali-Olubandwa et al. 2010; Abate et al. 2017).

2.2.1 Importance of mixed farming in enhancing Frass usage

Across the world and specifically in Kenya, mixed farming has been mirrored with many advantages that outweighed its disadvantages (Ntale & Litondo, 2013). In the case of crop failure or fluctuations, the farmer may depend entirely on livestock to meet their daily needs (Jaleta et al. 2013). This implies that there will be continuous availability of organic waste for the BSF to feed on (Figure 2, section a). The opposite may be true in case the livestock section becomes unprofitable. On the other hand, the farmer gets income continually throughout the season since livestock products are obtained throughout the year (Tibesigwa et al. 2017). This is opposed to crop production where income generation happens during the harvesting period of crops. This brings income stability among farmers (Tadesse et al. 2008). Unlike depending only on crops or animal production, involvement in both is likely to fetch a large income (Ali-Olubandwa et al. 2010). A reliable income obtained from the farm assists the farmer to easily obtain farm inputs, as well as acquiring the necessary materials and manpower for BSF.

The mature BSF can be used as a good source of proteins to human beings (Borgemeister, 2019). The use of crop residues as fodder for livestock may be cost-effective for farmers (Abate et al. 2017). The burden of buying feeds from external sources may be reduced and instead, the money allocated to feeds can go to other uses of the farm. Using manure that comes from the farm increases the production and speeds up the growth of crops through the replenishment of scarce nutrients (Tibesigwa et al. 2017), thus limiting the purchase of inorganic fertilizers. Polyculture provides environmental benefits and saves on space as different crops have different lifecycles, and there are less likely cases of crop failure, and suppression of diseases, pests and weeds (Mirera, 2011; Van et al. 2021).

2.2.2 Challenges in small-scale mixed farming

There is high possibility of animals interfering with crops while growing on the farm (Fanzo et al. 2016). Animals, even when restricted, can detach and feed on crops or stampede on them (Kosgei, 2013). This is likely to affect the yield of the crops grown. Given the small size of the land, the use of machines may be difficult due to the disparity of crops (Herrero et al. 2007). The machine may also affect delicate crops, as well as interfere with the well-being of animals.

In rural areas, farmers cannot transport their animals due to poor and inadequate infrastructure which includes marketing facilities, poor road network and poor communication (Abate et al. 2017). Farmers have no access to fertilizer or other farm inputs needed for the proper production of crops (Herrero et al. 2007). Their poor nature hampers their ability to employ measures for adopting and mitigating climate change. In most cases, they use poor farming methods and are always unable to fight pests and diseases that attach to their crops (Fanzo et al. 2016). Marginal provision of extension services has been witnessed where extension personnel are reluctant to offer services to small scale farmers given their large number. Post-harvest measures are challenging due to poor farm tools and equipment and lack of information (Tangka & Jabbar, 2005).

2.3 Significance of BSF Frass to soil, crops and environment

Most of the soils in SSA are known to contain less fertility due to continuous cultivation and leaching that is common in the tropical regions (Chikowo et al. 2014). The application of artificial fertilizer has never yielded a long-term solution to the problem (Jing-Yan et al. 2015; Shi et al. 2016). Most artificial fertilizers are meant for quick release and should be applied seasonally at any planting time (Pahalvi et al. 2021). Dependence on organic matter has been refuted by most farmers, as the materials have competed uses (Page et al. 2020). For instance, crop residues are fed to livestock as feeds. some residues are used as sources of energy in some places. Farmers who bury crop residues and other organic materials in the soils have complained of residues taking too long to decompose and become effective (Page et al. 2020). The longer they take to decompose, the longer the soils are deprived of nutrients. The best way to enhance soil fertility is through the use of frass fertilizers, which can be generated locally, at household level (Poveda, 2021; Terfa, 2021; Basri et al. 2022; Beesigamukama et al. 2022). Frass fertilizer carries all the components of organic fertilizer, since it is comprised of purely organic manure (Figure 2, section a). In addition, the frass fertilizer has numerous and elevated levels of both primary and secondary nutrients compared to any other organic fertilizer, thus enriching the soil (Chirere et al. 2021). These nutrients include nitrogen, phosphorus, potassium, calcium, magnesium and sulphur. For instance, commercial frass from the Critter Depot has an N-P-K value of 5:3:2 which translates to 5% nitrogen, 3% phosphorus pentoxide, and 2% calcium (Dempster et al. 2022). The organic matter content in frass is much higher than that in compost and other types of manure (Elissen et al. 2023). Frass contains nitrogen-fixing and nitrifying bacteria that boosts plant's nitrogen uptake, reduce atmospheric nitrogen loss and contamination of ground water (Terfa, 2021). Frass simply stores nitrogen and carbon in the soil (Elissen et al. 2023). In addition, frass contain boron, iron, zinc, manganese and copper. Frass also reduces the acidity level of the soils making the soils suitable for planting of various crops and easy accessibility of nutrients by plants (Beesigamukama et al. 2021).

BSF frass fertilizer (BSFFF) is progressively gaining momentum internationally as organic fertilizer (Čičková et al. 2015; Shumo et al. 2019; Anyega et al. 2021). However, research on its performance in crop production has not been widely done on commonly grown crops in Kenya. Research shows that maize grown with BSFFF always displays the tallest stand and highest chlorophyl compared to commercial organic and inorganic fertilizers (Beesigamukama et al. 2020; 2022; Basir et al. 2022). A study by Beesigamukama et al. (2020), showed that fields that were treated with 7.5 t ha^{-1} of BSFFF had 14% higher grain yields and 23% increased nitrogen uptake than plots treated with a similar rate of commercial organic fertilizers. Also, there was a 27% and 7% increase in grain yields and increased nitrogen uptake by 76% and 29% in fields treated with 100 kg N ha^{-1} of BSFFF compared to those applied with commercial organic fertilizer and urea fertilizers, respectively.

It is estimated that more than 70% of the waste generated in Kenya is organic, made up of agricultural, yard and food waste (Shumo et al. 2019). Nairobi county is the leading county in waste generation, estimated at 2,400 tons per day (Muiruri et al. 2020). About 50% of the waste generated in Nairobi is organic in nature. Wastes in Kenya are disposed of in informal landfills and open dumpsites deprived of proper infrastructure and management (Dianati et al. 2021). In recent years, the country, especially cities, are experiencing serious challenges in collection, disposal and recycling of wastes (Njoroge et al. 2014). The challenges have brought advanced health problems and environmental degradation. Most of the wastes emit unpleasant smell, carbon dioxide & methane gas and attracts disease carrying agents (Dianati et al. 2021). Excess methane and carbon-dioxide (greenhouse gases) in the atmosphere has resulted to climate change. Climate change's effects are more averse to the farming community and the world at large. The use of frass fertilizer will eliminate the emission of greenhouse gases and bad odors as they scavenge and reduce its volume over a short time (Zhang et al. 2021; Boakye-Yiadom et al. 2022). The BSF has an ability to remove toxic substances from organic waste with a capacity to feed on 200mg of waste a day (Attiogbe et al. 2019). The fly larvae can reduce

about 40% of biosolids in 20 days (Nana et al. 2018; Bohm et al. 2022). The feeding rate shows that BSF has a great potential of managing waste in SSA. As larvae converts carbon and nitrates into waste, they reduce the chances of the elements being lost to the atmosphere such as greenhouse gases (Pang et al. 2020).

3.0 CONCLUSION

The use of BSF has many benefits to our society. Besides being a source of proteins to livestock, it has been known to be the best organic fertilizer for crops and a better tool for managing our environment. With the rising effects of climate change, BSF can be used to cut down greenhouse gas emissions. It is surprising that many farmers have not adopted the practice besides being cheap and reliable. A lot of sensitizations through print and social media should be enhanced by the government to make the public aware of this BSF technology. Its adoption will help in improving soil fertility, plant yield and a clean environment. A projection analysis is needed to determine long-term utilization of frass fertilizer by farmers in Kenya.

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Comparative Effect of Plant Extracts and Accession Differences on the Control of A Storage Insect Pest (*Callosobruchus maculatus*)

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ABSTRACT

Insect pests are the most important constraint limiting Bambara groundnut storage in Nigeria. Consequently, this study was conducted at the Laboratory of Pest Management Technology Department of Niger State College of Agriculture, Mokwa aimed at determining the comparative effect of organic plant extracts and accession differences on a storage insect pest of Bambara groundnut *(Vigna suberrancean* L Verdc) Mokwa is located on latitude 09° 18ᴵN and longitude 05° 04ᴵE in Southern guinea savanna agro-ecological zone of Nigeria. Med at The treatments were organic materials which consisted of garlic, white onion, violent tree root powder extracts and phostoxin as check while control had no antidote application. The trial was factorially combined in a 2×4 arrangement and fitted in to complete randomized design (CRD) with three replications. Data were collected on insect mortality rate, number of life insect pests, grain weight loss and insects damage score. The application of garlic, white onion, violent tree root powder extracts and phostoxin (check) recorded a significantly higher insect mortality rate at 14 and 28 days after storage of 3.67 and 3.00 compared to the control with no application that resulted in lowest mortality rate of 1.33. The result indicated that varieties of bambara groundnut did not differ significantly on number of life insects throughout the period of the study. The application of garlic, white onion and violent tree root powders' extract are effective for the control of *Callosobruchus maculatus*. They are suggested for optimum quality protection of bambara groundnut and as alternatives to synthetic pesticides in southern guinea savanna zone of Nigeria.

Keywords: Bambara groundnut, Organic plant extracts, Quality protection, Insect damage score, Insect mortality, Nigeria.

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1. INTRODUCTION

Bambara groundnut (*Vigna subteranea* L. Verdc.) is a plant of the family Fabaceae. It is recognised for its high nutritional value, its tolerance to poor soils, drought, salt stress and its ability to produce in conditions where peanuts completely fail (Taffouo 2010 and Tsoata et al. 2017) However, it remains unfortunately, less cultivated and poorly known in tropical Africa. Bambara groundnut is native to northeastern Nigeria and northern Cameroon (Tegemne et al. 2018).

Its seeds are used as feed for pigs and poultry and their leafy stalks are also used as livestock feed (Brink. 2006). The seeds contain on average 63% carbohydrates, 19% proteins and 6.5% fats and these values are considered sufficient to make this legume a complete food (Bamishaiye, 2011). It is also rich in calcium, potassium, iron and nitrogen (Tan et al. 2020) The highly nutritious content of Bambara groundnut and its high content of essential amino acids namely methionine, Leucine, isoleucine, lysine, phenylalanine, threonine, valine and tryptophan make it an important crop to consider for food security (Yao et al. 2015 and Tan et al. 2020).

Bambara groundnut also contains vitamin E (3.18+).15mg/100g), vitamin C (1.17+0.20 mg/100g) and vitamin A (26.05+0.14 mg/100 g). It is a medicinal plant used to treat diarrhoea, anemia, abscesses, internal injuries, ulcers, infected wounds, epilepsy, cataracts, menorrhagia during pregnancy, nausea in pregnant women, kwashiorkor and venereal diseases. It also helps to prevent heart disease, eye disease and colon cancer (Jdeani and Diedericks, 2014 and Brink, 2006). It contains kaempferol, an antioxidant polyphenol, which reduces the risk of many chronic diseases such as cancer (Jideani and Diedericks, 2014; Yao, 2015).

The known distribution of Bambara groundnut extends from west to southern Africa via Central Africa. Investigations into origin of Bambara groundnut all concluded that the crop originated from the African continent (Temegne et al. 2018). The distribution of wild Bambara groundnut is now known to extend from the Jos and Yola Peateau in Nigeria, to Garoua in Cameroon, and probably beyond (Touré et al. 2013).

Touré et al. (2013) reported that Bambara groundnut is the third most widely grown legume in the plains of tropical Africa after groundnut and cowpea. The authors said that the legume is used in crop rotation to improve soil properties through its ability to fix atmospheric nitrogen and provide it to the soil. According to Anchirinah (2001) and Azam-Ali et al.(2001) the crop is mainly grown by farmers because it has several organic benefits including high nutritional value, drought tolerance and ability to thrive in poor soils compared to other preferred species such as common bean, peanut and groundnut.

The seeds and leaves of Bambara groundnut are used in traditional medicine. In Senegal, Leaf preparations are reported to be used in treating abscesses and infected wounds (Brink et al. 2006). The workers also reported that the juice extracted from the leaves is applied to the eyes to treat epilepsy and the roots are sometimes used as an aphrodisiac.

The increasingly serious problem of resistance and residue to pesticides and contamination of the biosphere associated with large-scale use of broad-spectrum synthetic pesticides have led to the need for effective bio-degradable pesticides with greater selectivity. This awareness has created a worldwide interest in the development of alternative strategies including the discovery of newer insecticides (Yallapa et al. 2012).

The present study was, therefore, aimed at determining the effect of organic plant extracts on the control of *C. maculatus* on Bambara groundnut accessions and to assess the reactions of different bambara groundnut accessions to the pest as well as the interactive effects between the organic plant extracts and the accessions. The result of the present work will enable Bambara groundnut growers especially those within the study area to indentify the most effective botanical (s) for use as safe and effective control options against *C. maculatus* in place of synthetic pesticides for increased Bambara groundnut production.

MATERIALS AND METHODS

The experiment was carried out in the Pest Management Technology Laboratory at College of Agriculture Mokwa, Niger State. Mokwa is located on latitude 09^{o} 18^{1}N and Longitude 05^{o} 04^{1}E southern guinea savanna agro ecological zone of Nigeria.

Materials used

The research materials used during the work include:

Bambara groundnut gain, Garlic, White onion, Violent tree root, Phostoxin tablet, Plastic containers, Rubber band, Sieve, Pestle and mortar, Digital weighing balance, petri dish, Knife, Moslem Cloth, and live insects (*C. maculatus*).

Samples and preparation

The garlic and white onion was bought at Mokwa market and violet tree roots were collected from a violet tree in the bush along Ja'agi Eppa road at distance of 10km and all were cut in to small pieces separately and were air dried separately for three weeks. Mortar and pestle were use to pound the garlic, white onion and violet tree root separately and were sieved and stored for use as well as phostoxin tablet as check.

Treatments and Experimental Design

The trial was laid out in a 2x5 factorially combined arrangement and fitted into a complete ramdomized design (CRD) with three replications. The main treatments were organic plant extracts which included, garlic powder (GP) White onion powder (WOP) violet tree root powder (VTRP) 40g of phostoxin tablet (PT), and the control (C) without any application. The sub-treatment was two accessions of Bambara groundnut consisting of A1 = Black Accession, A2 = Cream Accession. The 400g of Bambara groundnut were weighed into plastic containers and covered with Muslim cloth tied with rubber bands. Ten (10) live adult weevils were introduced into plastic containers to ascertain the antidote effectiveness.

Parameters Measured

- Insect mortality rate in days at 14, 28 and 42 days after storage (DAS)
- Number of life insect at 14, 28 and 42 days after storage (DAS)
- Grain weight loss at 30, 60 and 90 days after storage (DAS)
- Percentage weight loss at 30, 60 and 90 (DAS)

Insect damage score

The insect damage score was observed at 60 and 90 DAS using a scale of 1-5 by visual estimation as described by Ayala *et al*. (2013).. Where, 1 = No damage, 2 =1- 25% damage, 3 = 26-50% damage, 4 =51-75% damage and 5 = 75% and above damage.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using the statistical package GENSTAT release 12.1 (McDonald, 2014) means were partitioned where significant differences exist between the means at (P≤0.05).

RESULTS

Effect of Organic Plant Extracts and Accessions of Bambara Groundnut on Number of Life Insects at 14, 28, 42 Days after Storage (DAS)

Throughout the period of the study, insect mortality rates did not differ significantly among the different accessions of Bambara groundnut. However, the organic plant extracts consistently recorded a significant effect on insect mortality rate throughout the period of the study except at 42 DAS. The treatment applied with garlic, white onion, violent tree root powder and phostoxin (check) recorded significantly higher insects mortality rate at 14, 28, DAS of 3.67, and 3.00, compared to the control with no application which resulted in the lowest insects mortality rate of 1.33 (Table 1).

Effect of Organic Plant Materials and Accessions of Bambara Groundnut on Number of Life Insects at 14, 28, 42 (DAS)

Results presented in Table 2 show that there were no significant differences in the number of life insects among the Bambara groundnut accessions.

However, the organic plant extracts consistently recorded significant differences in the number of life insects found among the test Bambara groundnut accessions. The test accessions treated with garlic, violet tree powder extracts and phostoxin (check), recorded significantly lower numbers of life insects at 14, 28, and 42 DAS of 3.71, 2.57, 2.50 respectively compared to the control which recorded the highest number of life insects of 27.50 (Table 2).

Table 1: Effect of organic plant extracts and accessions of Bambara groundnut on Insects mortality rate at 14, 28 and 42 days after storage (DAS)

Treatments	Insect mortality rate		
Accessions of Bambara groundnut (A)	Days after storage (DAS)		
	14	28	42
Creamy accession	2.47	2.20	1.67
Black accession	2.27	2.40	1.73
S E ± (0.05)	NS	NS	NS
Organic plant extracts (0)			
Grarlic powder	3.67a	3.00a	2.17
White onion powder	3.00ab	2.00ab	1.67
Violent tree root powder	1.50c	2.50ab	1.50
Phostoxin (Check)	2.33bc	2.50ab	1.83
Control (No application)	1.33c	1.50b	1.33
S E ± (0.05)	0.51*	0.49**	NS
Interaction (AxO)	NS	NS	NS

Interaction (AxO) = Organic plant extracts (0) x Accessions of Bambara groundnut (A), NS = No Significant difference, S. E. ± = Standard error of difference of means, * = Significant difference, and ** = Highly significant and Means with same letter(s) within the columns are not significantly different at (P ≤ 0.05).

Table 2: Effect of Organic Plant Extracts and Accessions of Bambara groundnut on the Number of life Insects at 14, 28 and 42 days after storage (DAS)

Treatments	Number of Insects Alive at		
Accessions of Bambara groundnut (A)	Days after Storage (DAS)		
	14	28	42
Creamy accession	6.000	7.33	7.47
Black accession	6.067	7.40	7.47
S E ± (0.05)	NS	NS	NS
Organic plant extracts (0)			
Grarlic powder	5.500b	4.33b	3.17b
White onion powder	5.667b	4.50b	2.67b
Violent tree root powder	5.000b	3.83b	2.50b
Phostoxin (Check)	5.500b	2.17b	1.50b
Control (No application)	8.500a	22.00a	27.50a
S E ± (0.05)	0.31**	2.10**	1.94**
Interaction (A x O)	NS	NS	NS

Interaction (AxO) = Organic plant materials (0) x Accessions of Bambara groundnut (A), NS = No Significant difference, S. E. ± = Standard error of difference of means, * = Significant difference, ** = Highly significant and Means with same letter (s) within the columns are not significantly different at (P ≤ 0.05).

Effect of Organic Plant Extracts and Accessions of Bambara groundnut on Weight Loss at 30, 60, 90, days after storage (DAS)

Results presented in Table 3 show that there were no significant differences in weight loss among the varieties of Bambara groundnut throughout the period of the study.

The organic plant extracts consistently recorded significant differences in weight loss of the test accessions treated with garlic, white onion violent tree root powder extracts and phostoxin (check) recorded significantly lower weight loss at 30, 60 and 90 DAS of 227.8, 218.3, 209.7 respectively compared

to the control with no application that recorded higher weight loss of 138.7 (Table 3).

Effect of Organic Plant Extracts and Accessions of Bambara groundnut on Percentage Weight Loss at 30, 60, 90, days after storage (DAS)

Results presented in Table 4 show that the Bambara ground accessions did not differ significantly between themselves in percentage weight loss. However, the organic plant extracts consistently had a significant effect on the percentage weight loss of Bambara groundnut varieties throughout the period of study. The test Bambara groundnut varieties treated with garlic, white onion, violent tree root powder extracts and phostoxin (check) recorded significantly lower percentage weight loss at 30, 60, 90 DAS respectively of 9.13, 12.67, 6.13 compared to the control which recorded the highest percentage weight loss of 44.53 (Table 4).

Table 3: Effect of Organic Plants Extracts and Accessions of Bambara groundnut on Weight Loss at 30, 60 and 90 days after storage (DAS)

Treatments	**Weight Loss at**		
Accessions of Bambara groundnut (A)	Days after Storage (DAS)		
	30	60	90
Creamy accession	236.87	224.07	204.1
Black accession	236.67	224.60	211.2
S E ± (0.05)	NS	NS	NS
Organic plant extracts (0)			
Grarlic Powder	245.83a	236.50b	227.8b
White onion powder	238.67b	230.33c	218.3bc
Violent tree root powder	230.00c	223.00d	209.7c
Phostoxin (Check)	249.67a	247.50a	243.8a
Control (No application)	219.67d	184.33e	138.7d
S E ± (0.05)	1.88**	143.49**	6.22**
Interaction (AxO)	NS	NS	8.79*

Interaction (AxO) = Organic plant materials (0) x Accessions of Bambara groundnut (A), NS = No Significant difference, S. E. ± = Standard error of the difference of means, * = Significant difference, ** = Highly significant and Means with the same letter(s) within the columns are not significantly different at (P ≤ 0.05).

Interaction Effects between Organic Plant Extracts and Accessions of Bambara groundnut on Percentage Weight Loss at 90 (DAS)

The interaction effect of organic plant extracts and accessions of Bambara groundnut was significant at 90 (DAS). The two accessions recorded similar lower percentage weight loss under garlic, white onion, violent tree root powder extracts and phostoxin (check) while they recorded higher % weight loss with the control with no treatment (Table 5).

Effect of Organic Plant Extracts and Accessions of Bambara Groundnut on Insects Damage Score at 28 and 42 days after storage (DAS) Using Scale 1-5

Results presented in Table 6 show that the Bambara groundnut accessions under evaluation did not differ significantly among themselves on insect damage score.

However, the organic plant extracts recorded significantly different effect on insect damage score throughout the period of the study. The treatments applied with garlic, white onion, violent tree root powder extracts and phostoxin (check) recorded significantly lower insect damage score at 28 and 42 DAS of 2.56, 2.00, 2.56 respectively compared to the control treatment which recorded the highest insect damage score of 4.23 (Table 6).

Table 4: Effect of Organic Plant Extracts and Accessions of Bambara Groundnut on Percentage (%) Weight Loss of Bambara Groundnut at 30, 60, and 90 days after storage (DAS)

Treatments	**Percentage (%) Weight Loss at**		
Accessions of Bambara groundnut (V)	Days after Storage (DAS)		
	30	60	90
Creamy accession	5.72	10.37	18.91
Black accession	5.47	9.68	16.29
S E ± (0.05)	NS	NS	NS
Organic plant extracts (0)			
Grarlic powder	1.67d	5.80c	9.13cd
White onion powder	4.53c	7.73bc	12.67bc
Violent tree root powder	8.00b	9.30b	16.13b
Phostoxin (Check)	1.63d	1.00d	5.53d
Control (No application)	12.13a	26.30a	44.53a
S E ± (0.05)	0.92**	1.20**	NS
Interaction (AxO)	NS	NS	*

Interaction (AxO) = Organic plant extracts (0) x Accessions of Bambara groundnut (A), NS = Not Significant, S. E. ± = Standard error of difference of means, * = Significant difference, ** = Highly significant and Means with same letter(s) within the columns are not significantly different at (P ≤ 0.05).

Table 5: Interaction Effect between Organic Plant Extracts and Accessions of Bambara groundnut on Percentage Weight Loss of Bambara groundnut at 90 days after storage (DAS)

Organic extracts (O)	**V1**		**V2**
Garlic powder	8.53de		9.73e
White onion powder	13.07d		12.27d
Violent tree root powder	16.00c		16.27c
Phostoxin (Check)	5.74f		5.60f
Control (No application)	51.47a		37.60b
S E ± (0.05)	3.93		

Interaction (AxO) = Organic plant extracts (0) x Accessions of Bambara groundnut (A), NS = No Significant difference, S. E. ± = Standard error of difference of means, * = Significant difference and Means with same letter(s) within the columns are not significantly different at (P ≤ 0.05) and V1 = Cream Accession and V2 = Black Accession.

Table 6: Effect of Organic Plant Extracts and Accessions of Bambara Groundnut on Insects Damage Score at 28 and 42 days after storage (DAS) Using a Scale 1-5

Treatments	**Insect Damage Score at**	
Accessions of Bambara groundnut (V)	Days after Storage (DAS)	
	28	42
Creamy accession	2.58	2.64
Black accession	2.69	2.62
S E ± (0.05)	NS	NS
Organic plant extracts (0)		
Grarlic powder	2.56	2.56
White onion powder	2.61	2.00
Violent tree root powder	2.67	2.56
Phostoxin (Check)	2.67	2.56
Control (No application)	3.67	4.23
S E ± (0.05)	0.99**	1.22**
Interaction (AxO)	NS	NS Interaction

(VxO) = Organic plant materials (0) x Varieties of Bambara groundnut (V), NS = Not Significant, S.E. ± = Standard error of difference of means, * = Significant difference, ** = Highly significant and Means with same letter(s) within the columns are not significantly different at (P ≤ 0.05).

DISCUSSION

In the present report, the two different accessions of Bambara groundnut studied did not differ significantly in insect's mortality of *C. maculatus* rate throughout the periods they were stored until towards the end of the study. Furthermore, the organic plant extracts were found to be consistently and significantly effective in the control of *C. maculatus*.

The treatments with garlic, white onion and violent tree roots powder extracts were comparable to phostoxin used as check in the study. The differences in the performances of the organic plant extracts could be due to their possessing organic repellants and the toxic effects of their antidotes that prevented or reduced the activities of *C. maculatus* in causing damage to the two test bambara groundnut accessions. This is in agreement with the report by Tripathi et al.(2014) who pointed out that some organic plant extracts are effective and perform better in the management of storage insect pests of Bambara groundnut as well as being safer for consumption after using them as organic storage materials in controlling weevils especially *C. maculatus*.

This study further shows that entries not treated with either the organic plant extracts or phostoxin recorded colossal damage or losses. This agrees with the report of Colazza et al. (2017) who stated that the quality of Bambara groundnut reduces or deteriorates if storage insects are not controlled thereby causing total loss of the infested grains. The implication of the present study is that Bambara groundnut can be stored with any of the test plant extracts investigated.

CONCLUSIONS

1. Throughout the study period the creamy and black varieties tested consistently did not differ significantly in insect's mortality rate between themselves.
2. The organic plant extracts recorded significantly higher insect pest control of the stored bambara groundnut compared to the control without any application.
3. For effective insect pest control and maintenance of Bambara groundnut quality in storage it should be treated with garlic, white onion and violent tree root powder extracts.
4. Checked insect pests' infestation resulted in higher number of live insect of 27.5 at 42 DAS compared to treated samples which recorded lower number of live insects of 3.17, 2.67, 2.50 and 1.50 at 42 DAS.

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Termiticidal Potential of *Parkia biglobosa* Aqueous Seed Extract Rates and Location on Termites Infestation in Niger State, Nigeria

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ABSTRACT

Termites constitute a nuisance to both the environment and human properties anywhere they exist. Consequently, this research was conducted at Mokwa Local Government area of Niger State to evaluate the rate of bio-insecticide for their control. Mokwa is located on latitude 09˚ 18ᴵN and longitude 05˚ 14ᴵE in Southern Guinea Savanna agro ecological Zone of Nigeria. This experiment was aimed at determining the termiticidal potential of acqueous solution rates of locust bean tree *(Parkia biglobosa)* seed and location on termites". The main treatments were four *Parkia biglobosa* seed extract rates at 0, 5, 10, and 15 millilitres while the sub treatments were three termites locations at Mokwa, Muwo and Kudu. The trial was factorially combined in a 4 x 3 arrangement and fitted into a completely randomized design (CRD) with three replications. Data collection were on number of termite per meter of tunnel, length of tunnels in meter, number of life termites and the number of dead termites found after treating with the extract solution rates. The result showed that *Parkia biglobosa* seed extract rates differed significantly on termites' mortality rate irrespective of the location. Moreover, the *Parkia biglobosa* seed extract rates had significant effect on termites throughout the period of the study**.** The *P. biglobosa* seed extract rates at 10 and 15 millilitres were effective for the control of termites in all the test locations and are thus suggested for use as an alternative to synthetic termiticides in the Southern Guinea Savanna zone of Nigeria for termite control.

Keywords: Bio-insecticide, Live termites, Mortality rates, Termiticidal potential, Southern Guinea Savanna zone

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1. INTRODUCTION

The locust bean tree (*Parkia biglobosa*) is well known to be an economic tree throughout the savanna tropical countries of the world (Abdou et al. 2019). On the other hand, termites are highly destructive insect pests, which largely damage wooden portions of buildings, furniture, books, utility poles, plants and agricultural crops such as sugar cane, millet, barley, cotton, wheat and paddy (Addisu, et al. 2014; Elango et al. 2012). Termites are eurytopic as they are distributed throughout the world. They feed largely on cellulose and lingo cellulose and process 50- 100% of dead plant and decaying biomass in the tropics (Ohkuma and Brune, 2011). Damage results from the feeding activities of termites aided by the symbiotic microbes like bacteria and fungi which are capable of digesting cellulose (Ohkuma and Brune, 2011). The common genera associated with the destruction include: *Coptotremes, Rhinotermes, Marotermes, Odontotermes, Reticulitertermes, Microcerotermes, Ancistrotermes, Microtermes* (Elango et al. 2012).

Although termites are abundant worldwide, Africa seems to be the richest in number of termites species with about 38% of recognised termites (Ugbomeh and Diboyesuku, 2019). Ahmed et al. (2011) reported that the species richness is a result of the friendly climatic conditions in Africa. Termites' colonies generally affect plants either by attacking the trunks and pods or by making tunnels under the plant which eventually weaken plant stems, causing them to collapse or giving access to fungi microorganisms (Badshah et al. 2012). In the past, control of termites had relied on synthetic termiticides including DDT, aldrin, dieldrin, chlordane, heptachlor, phosphorothioate, and BHC (Dyer et al. 2012).

Synthetic insecticides have been successfully employed as soil treatment against termites (Elango et al. 2012). However, the use of synthetic termiticides for a long time poses a great hazard to the environment including toxicity to non-target organisms and residual effects. In addition, resistance development in pest populations further derives the need to search for new bioactive compounds with a wide range of new modes of action (Elango et al. 2012). Hence, the search for alternative economically viable, environmentally friendly and effective insecticides has been the concern of many researchers (Arihara et al. 2004; Elango et al. 2012).

In order to avoid environmental pollution and health problems caused by the use of synthetic pesticides, there has been increasing interest in naturally occurring toxicants from plants (Chang et al. 2001; Osbrink et al. 2001).

Many plants may be used as alternative sources of termites control agents because they are rich source of bioactive compounds mainly secondary metabolites (Osbrink et al. 2001). Plant based insecticides might be used as alternative in pest management strategies as they are generally insect specific, relatively harmless to non-target organisms, less expensive and biodegradable (Satti et al. 2004).

Manzoor et al. (2011) have reported that the ethyl acetate methanol, butanol, hexane, water and chloroform extract of *Ocimum sanctum* leaves showed termiticidal activity against *Heterotermes indicola* (Isoptera; Rhinotermitidae). Similarly, black heatwood of *Cryptomeria japonica* showed good termiticidal activity against *Coptotermes formosanus* (Taxodiaceae) (Arihara et al. 2004). Oyedokun et al. (2011) tested insecticide activity of the *Phyllanthus amarus, Acasia albida* and *Tithonia diversifolia* leaf crude extracts against the workers of *Macrotermes bellicosus* in vitro. Aqueous extracts of *P. amarus, A. albida* and *T. diversifolia* caused 40-56%, 24-60% and 42-88% mortality respectively after 140 minutes of exposure to the extracts. Similarly, ethanolic extracts of *P. amarus, A. albda and T. diversifolia* resulted in higher percentage mean mortality of 64-91%, 36.4-76% and 36-68% respectively.

In another work Elango et al. (2012) reported anti-termites activity of the crude leaf hexane ethyl acetate, acetone and methanol extract of medicinal plants of *Andrograthphis lineata, Andrographis paniculata, Argemone mexicana* L., *Aristolochia bracteolate, Datura metel* L., *Eclipta prostrate* L., *Sesbania grandifilora* and *Tagetes erecta* L. against *Coptotermes formosanus*.

Dadawa/iru is a food seasoning agent produced from the solid subtrate fermentation of cotyledons of locust bean (*P. biglobosa*). The hausa ethnic group of northern Nigeria use it to flavour soup and many other traditional dishes. Details of the kitchen process of manufacturing dawadawa /iru differ very slightly between cultures. Abdou et al. (2019) reported that basically, Africa locust bean seeds are boiled for 12-24 hour or until they are tender and the cotyledons have enlarged significantly. This is

followed by de-hulling by gently pounding in a mortar, by rubbing the seeds between palms or by use of different abrasive procedures.

The de-hulled cotyledons are washed and boiled again for 1 h then spread to a few depth in basket or calabash lined with some leaves or wrapped in jute bag and allowed to ferment for 3-4days. In some cultures, the boiled water during fermentation processes of *P. biglobosa* seeds may be effective in controlling termite's infestation. The cotyledons are molded on to small balls and wrapped in papaya or banana leaves (Aworh, 2008*),* then covered with additional banana leaves or raffia mats and allowed to ferment for 2 – 4 days and used as condiments in soups (Egwim et al. 2013).

There has been no scientific investigation on efficacy of *P. biglobosa* in controlling terminates in Niger state. Therefore, the present study was aimed at determining the termiticidal potential of *P. biglobosa* aqueous seed extract rates on termites. This was to ascertain their efficacy and to evaluate the effect of termites' location on their activities and prevalence as well as to determine the interaction effect between *P. biglobosa* seed extract concentration rates and termite's location in Mokwa Local Government Area of Niger State, Nigeria, to evaluate their rates for their control.

MATERIALS AND METHODS

The experiment was carried out in Mokwa Local Government Area at Mokwa, Muwo and Kudu in Niger State. Mokwa is located on latitude 09˚ 18^{l}N and Longitude 05˚14^{l} E Southern Guinea Savanna agro-ecological zone of Nigeria.

Experimental materials

The water used by the villagers who engage in "*dadawa*" preparation was collected in Mokwa, Muwo and Kudu in Mokwa local government area in beakers and stored at room temperature for further bioassay.

Layout and experimental design

The trial was conducted on bioassay to determine the termiticidal potential of *Parkia bigilobosa* (dawadawa) seed extracts concentration rates. The experiment was laid out in a complete randomized design (CRD) in three replications. The main treatment consisted of four *Parkia biglobos*a seed extracts concentration in solution rates of 0, 5, 10, and 15 millilitres while the sub treatments were three existing termiteria in Mokwa, Muwo, and Kudu locations. To ascertain the efficacy of *Parkia biglobos*a seed extract solution rates; 50 workers of termites were collected into four containers of different extract concentration rates and were monitored every 20 minutes for 3 hours to determine the live condition of the termites.

Parameters observed

1. Number of termites
2. Length of tunnels in metres at 2, 4, and 6 months
3. Number of live termites found at 2, 4 and 6 months
4. Number of dead termites found at 2, 4 and 6 months

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using GENSTAT 12.1 released edition and means were separated or partitioned using least significant difference (LSD) at a 5% level of probability where differences existed between the means.

RESULTS

Effect of *Parkia biglobosa* seed extract concentration rates and location on a number of termites per metre of the tunnel at Kudu, Muwo, and Mokwa at 2, 4 and 6 Months after infestation (MAI)

Throughout the period of the study, the result indicated that *Pakia biglobosa* seed extract concentration rates differed significantly on the number of termites per metre of tunnel. The treatment applied with control (0) millilitres of the seed extracts recorded a significantly higher number of termites per metre of tunnel at 2, 4, and 6 MAI of 115, 191, and 220 compared to the application of 10 and 15 millilitres that resulted in significantly lower number of termites per metre of tunnel of 11 at 6 MAI respectively (Table 1).

Effect of *Parkia biglobosa* seed extract concentration rates and location on length of termites tunnel in meters in Kudu, Muwo, and Mokwa at 2, 4 and 6 Months after infestation (MAI).

Throughout the period of the study, the result showed that *Parkia biglobosa* seed extract concentration rates differed significantly on tunnel length of termites per metre of tunnel. The treatment applied with control 0 millilitres of the seed extracts recorded significantly higher tunnel length of termites per metre of tunnel at 2, 4, and 6 MAI of 21, 25, and 30 metres respectively compared to application of 10, and 15 millilitres that resulted in significantly lower tunnel length of termites per metre of tunnel of 1 at 6 MAI metre of tunnel throughout the study period. The termiterium at Mokwa location which recorded significantly higher tunnel length of termites per metre of tunnel of 1 at 6 MAI was significant compared to the termiterium at Kudu (Table 2).

Table 1: Effect of *Parkia biglobosa* seed extract concentration rates and location on the number of termites per meter of the tunnel at Kudu, Muwo and Mokwa at 2, 4 and 6 Months after infestation (MAI).

Treatments	**Number of termites per metre of tunnel**		
Parkia biglobosa seed	Months after infestation		
extract concentration rates (P)	2	4	6
5 Mills	92b	81b	44b
10 Mills	55c	35c	21c
15 Mills	26d	15d	11d
Control (0 mills)	115a	191a	220a
LSD (0.05)	10.50 *	12.20*	10.50*
Termites location (L)			
Mokwa	75a	54a	52a
Muwo	52b	25b	21b
Kudu	31c	15c	11c
LSD (0.05)	8.50*	8.10*	10.10*
Interaction (PxL)	**	**	**

Interaction (PxL): P= *Parkia biglosa* seed Extract concentration rates x Termites Location (L), NS= No significant difference, * =significant difference, Means with the same letter (s) within the same column are not significantly different at ($P \leq 0.05$).

Table 2: Effect *Parkia biglobosa* seed extract concentration rates and location on length of termite's tunnel per metre of in Kudu, Muwo, and Mokwa at 2, 4 and 6 Months after infestation (MAI)

Treatments	**Length of termites Tunnel (m) at:-**		
Parkia biglobosa seed	Months after infestation		
extract concentration rates (P)	2	4	6
5 Mills	5b	7b	13b
10 Mills	2c	2c	3c
15 Mills	1d	1d	1d
Control (0 mills)	21a	25a	30a
LSD (0.05)	4.22*	3.10*	5.23*
Termites location (L)			
Mokwa	8a	10a	12a
Muwo	5b	6b	8b
Kudu	2c	2c	1c
LSD (0.05)	3.22*	2.24*	3.40*
Interaction (PxL)	**	**	**

Interaction (P x L) P = *Parkia biglosa* seed Extract concentration rates x Termites Location (L), NS = No significant difference * = significant difference, Means with the same letter (s) within the same column are not significantly different at ($P \leq 0.05$).

Effect *Parkia biglobosa* seed extract concentration rates and location on the number of termites found alive at 2, 4 and 6 Months after infestation (MAI)

Results presented in Table 3 showed that *Pakia biglobosa* seed extract concentration rates differed significantly on termites found alive per metre of tunnel. The treatment applied with control 0 millilitres of the seed extracts recorded a significantly higher number of live termites per metre of tunnel at 2, 4, and 6 MAI of 56, 72, and 95 respectively.

Table 3: Effect *Parkia biglobosa* seed extract concentration rates and location on number of termites found alive in Kudu, Muwo, and Mokwa at 2, 4 and 6 Months after infestation (MAI).

Treatments	**Length of termites Tunnel (m)**		
Parkia biglobosa seed extract concentration rates (P)	Months after infestation		
	2	4	6
5 Mills	48b	45b	32b
10 Mills	32c	18c	12c
15 Mills	21d	11d	8d
Control (0 mills)	56a	72a	95a
LSD (0.05)	9.21*	10.20*	12.52*
Termites location (L)			
Mokwa	49a	38a	28a
Muwo	32b	25b	13b
Kudu	21c	12c	6c
LSD (0.05)	9.34*	6.33*	7.52*
Interaction (PxL)	**	**	**

Interaction (PxL) = *Parkia biglobosa* seed extract concentration rates (P)x Termites Location (L), NS =Not significant, *= Significant difference and Means with the same letter (s) within the same column are not significantly different at P≤ 0.05.

Table 4. Effect *Parkia biglobosa* seed extract concentration rates and location on the number of termites found dead in Kudu, Muwo, and Mokwa at 2, 4 and 6 Months after infestation (MAI).

Treatments	**Number of dead termites per metre of tunnel**		
Parkia biglobosa seed extract concentration rates (P)	Months after application		
	2	4	6
5 Mills	12c	10c	9c
10 Mills	12c	12b	12b
15 Mills	34a	23a	20a
Control (0 mills)	5d	6d	7d
LSD (0.05)	4.89*	4.33*	2.11*
Termites location (L)			
Mokwa	21a	19a	15a
Muwo	13b	10b	10b
Kudu	11c	8c	6c
LSD (0.05)	2.69*	2.58*	4.20*
Interaction (PxL)	**	**	**

Interaction (PxL) P= *Parkia biglobosa* seed Extract concentration rates x L= Termites Location NS= No significant difference, *= significant difference, Means with the same letter (s) within the same column are not significantly different at P≤ 0.05.

Effect *Parkia biglobosa* seed extract concentration rates and location on a number of termites found dead in 2, 4 and 6 Months after infestation (MAI).

Results shown in Table 4 indicated that *Pakia biglobosa* seed extract concentration rates differed significantly on dead termites per metre of the tunnel. The treatment applied with 15 millilitres of the seed extracts recorded significantly higher dead termites per metre of the tunnel at 2, 4, and 6 MAI of 34, 23 and 20 when compared to application of 5, and 10 millilitres that resulted in significantly lower termites dead per meter of tunnel of 5 at 2 MAI respectively.

Furthermore, the termite's location consistently recorded significantly different effects on dead termites per metre of tunnel throughout the study period. The termiterium at the Mokwa location recorded significantly higher dead termites per metre of tunnels of 21 at 2 MAI compared to termiterium at Kudu that recorded lower dead termites per metre of tunnel of 6 at 6 MAI respectively (Table 4).

DISCUSSION

In the present, report the varied rates of *Parkia biglobosa* seed extract consistently differed significantly in termite mortality rate throughout the duration of the study. The treatments with *Parkia biglobosa* seed extract solution rates of 10 and 15 millilitres consistently and effectively controlled termites probably due to the organic repellants and toxic effect of the antidote present in them that prevented or reduced their activities in building termiteria or tunnels. This finding agrees with the report by Tripathi et al. (2014) who asserted that some organic plant materials are effective and perform better in the control of termites.

In addition, this study shows that the control treatment led to colossal damage or losses due to termites' infestation as no lethal dosage was applied. This result conforms to that of Senthilkumar et al. (2009**)** who reported that the essential oils of many plant species are known to have repellent and bio-insecticidal properties. Plant based insecticides can be used as alternatives in pest control strategies as they are generally insect-specific, relatively harmless to non-target organisms, less expensive, environmentally friendly and biodegradable as reported by Satti et al. (2004).

CONCLUSION

In the present study, treatment of *P. biglobosa* seed extracts rates on termites differed significantly in the mortality rates throughout the period of investigation. Consequently, *P. biglobosa* seed extract rates at 10 and 15 millilitres controlled termites better than other rates. Irrespective of the location the bio-insecticides of *P. biglobosa* seed extracts were effective in controlling termites and are suggested as alternative to synthetic insecticides. Uncontrolled termite's infestation treatments resulted in higher number of life termites of 56, 72, and 95 per metre respectively.

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Agricultural Price Policy in India: An Introspective Study

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ABSTRACT

Most of the agro products are available based on season. At the time of harvesting, the product prices are very low and at the time of seedling, the product prices are very high. Both producers and consumers faced problems. For overall stabilizing the economy, price policy is necessary. The study aims to explore the benefit of the farmers through the price policy in the Indian economy. This study is descriptive type by nature based on secondary sources like various Government reports, books, articles, websites and web-based journals. Need for Agricultural Price Policy and minimum support prices with findings, appraisal, its advantages and disadvantages and suggestions are discussed here. The basic motive behind the Agriculture policy of the Government of India is to save the interests of both farmers and consumers. The prices of the food grains should be decided very wisely so that neither farmers nor consumers get to suffer.

Keywords: Agro Products, Prices, Farmers, Consumers, Harvesting, Seedling, Economy

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INTRODUCTION

In recent times, India's economy has become somewhat dependent on agriculture. India was once one of the countries that relied heavily on agriculture worldwide. India offers a wide variety of agro products. Seasons determine which agricultural products are available. Product prices are extremely low during harvesting and extremely high during seedling development. There were issues for both consumers and producers. The Price policy is essential for stabilizing the economy overall. A nation's price policy is a driving force behind its economic growth. It is a crucial tool for encouraging farmers to pursue technology and investments that are focused on production by offering them incentives. Prices have an impact on farmers' income and consumption in developing nations like India, where the majority of the population works in agriculture and most farmers spend their money solely on food. The Indian government arranges purchase operations through public agencies and releases the procurement/support prices for major agricultural commodities annually.

India implemented an agricultural price policy following its independence. However, India's agricultural price policies have differed significantly between years and between crops. The prices of food grains like wheat, rice, and coarse cereals like jowar, bajra, maize, etc. were given a lot of weight under this policy. The Food Grains Policy Committee was

established in 1947, marking the inception of the price policy in India. The committee advocated for a strategy of gradual decontrol, a decrease in food grain imports, and a significant boost in food grain production. The Food Grains Procurement Committee was established once more in 1950, and this time it brought in the rationing and supply management of food grains for the nation. A clear-cut policy to give farmers an incentive price was not introduced until 1964. The Third Plan document correctly noted that food grain producers need to receive a fair return. Put differently, the farmer needs to know that the prices of the commodities he produces and food grains will never drop below a fair minimum. Consequently, in 1964, the Food Grains Price Committee was appointed. Therefore, the purpose of the study seeks to explore the benefit of the farmers through the price policy in the Indian economy.

MATERIAL AND METHODS

This study is descriptive type by nature and based on secondary sources.

Sources of Data

The data are collected from various Government reports, books, articles, websites and web-based journals published at different times.

Data Analysis

The data gathered from various sources has been examined, validated, and methodically arranged under the proper heading to support the necessary presentation and conclusion.

RESULTS AND DISCUSSION

Need for Agricultural Price Policy

There is no doubt that sharp swings in agricultural prices are detrimental to producers as well as consumers. Price fluctuation is a typical occurrence. However, abrupt, violent changes in the price of agricultural commodities have a negative impact on the nation's economy. Farmers who grow a particular crop suffer significant losses when the crop's price drops abruptly and sharply, as their income levels drop. Due to the farmers' inability to cultivate the crop the following year, there will likely be a severe shortage of that food item, which may compel the government to import the crop from overseas. On the other hand, consumers may suffer greatly from an abrupt increase in the price of a certain crop, forcing them to either discard it or significantly reduce their other spending in order to cover the crop's consumption costs. In both ways, the nation's economy will suffer greatly from the widespread fluctuations in the price of agricultural products.

In order to promote increased investment and production and to protect consumer interests by providing food supplies at fair prices, the government's price policy for agricultural produce aims to guarantee growers receive fair compensation for their produce. The nation's price policy also aims to develop an integrated, balanced price structure that satisfies the demands of the economy as a whole. To this end, the government arranges purchase operations through the Food Corporations of India (FCI), cooperatives, and other agencies designated by state governments for the purpose, as well as announces minimum support prices (MSPs) for major agricultural commodities in each season. A thorough agricultural price policy needs to be appropriately developed in order to protect the interests of both producers and consumers. Sustaining buffer stocks of agricultural commodities and a vast public distribution network are necessary to support this. These will set up the supply of these agricultural products to consumers at reasonable prices and give the producers a minimum support price. Therefore, care must be taken to set the minimum support prices and procurement prices at a level that will encourage farmers to increase their output. Consequently, one could design the agricultural price policy as a "instrument of growth."

Objectives of the Agricultural Price Policy: In order to boost agricultural output, the following goals of the Indian agricultural price policy have been taken into consideration.

1. To ensure that the prices of agricultural goods and food grains are related,
2. Monitoring Producer and Consumer Interests; 3. Crop Price Relationships;
4. Seasonal Fluctuations Management
5. Combine the Cost,
6. Maintain the Average Price,
7. Production Growth;

8. All-Round Development Facilities;
9. Infrastructure Development;
10. Cooperatives Revision and Strengthening;
11. NGOs' Involvement; and
12. Encouragement.

Advantages behind the announcement of Minimum Support Price (MSP): The minimum support price for 24 major crops has been announced by the government in order to protect both the needs of self-reliance and the interests of farmers. The following are the MSP's primary goals:

1. To stop a price decline in the event of excess production.
2. To safeguard farmers' interests in the event of a market price decline by guaranteeing them a minimum price for their crops.
3. To fulfill the obligation for domestic consumption
4. To ensure agricultural product price stability
5. To guarantee a fair correlation between the costs of manufactured goods and agricultural commodities
6.To eliminate the pricing disparity between the two areas of the nation.
7.To boost agricultural produce exports and production.
8.To supply the various industries throughout the nation with raw materials at fair prices.

Disadvantages of the Minimum Support Price:
1.It forces the nation's poorest citizens to pay more in order to boost farmers' incomes. This approach will exacerbate the nation's allocation of inefficiencies.

2. It is inefficient to support farmers by raising the price of the products they sell because this penalises the consumer. Large farmers will gain the most from it as well. Even though they have more than they require, small farmers are still having difficulties.
3. Farmers apply large amounts of fertilizer to boost output, but this causes issues for those who do not profit from the increase in output.

Currently, the Commission for Agricultural Costs and Prices (CACP) recommendations, state and central government opinions, and other pertinent factors deemed significant for fixing support prices for agricultural commodities are taken into consideration by the government when determining MSPs for various agricultural commodities shown in Table-1.

Explanation of Table-1, Fig.-1 and Fig.-2: From the above table and Fig.-1, it is seen that the prices for wheat and paddy for common variety are increasing year-wise on account of which the curve of wheat (Green Clour) and the curve of paddy (Red Colour) are upward rising from the left bottom to the right up the corner from 1980-81 to 2023-24. But the curve of wheat stands above a little more than that of paddy.

Fig.-2 is showing how the year-wise change in MSP of both wheat and paddy. Both the curves are fluctuating year-wise up and down. However, the changes in MSP of both wheat and paddy are not the same. Change in MSP between wheat and paddy is sometimes in the same direction, or one change more than another or one change but another is not change. 1980-81 is considered as origin. These curves represent from the 1980-81 to 2023-24.

Evaluation of the Price Policy

The policy has played a key role in providing farmers with a relatively stable price environment, encouraging them to adopt new production techniques and increasing the amount of food grains produced. Enhancing the affordability of food has been made possible by the subsidized distribution of food grains. Because basic staple food prices have declined relative to income, the industry and organized sector have been able to maintain low wage costs. Thus, all facets of society have benefited from price policy and input/food subsidies.

FINDINGS

Impact of Agricultural Price Policy: It's accurate to say that agricultural prices have significantly streamlined efforts to maintain price stability. A brief summary of its effects is provided below:

1. Incentive to Increase Production: Farmers have been given the necessary incentive by agricultural price policy to increase their agricultural output through the modernization of the sector. The government sets the minimum support price in an effective manner to protect farmers' interests.

2. An increase in farmers' income: By supporting agricultural prices and offering the necessary incentives and encouragement to increase output, the agricultural price policy has given farmers the

benefits they need. The standard of living for farmers has increased as a result of all of these.

3. Price Stability: A larger degree of price stability for agricultural products has been achieved through the agricultural price policy. It has been successful in containing the excessive price fluctuations of agricultural products. This has had a positive effect on the nation's producers and consumers.

4. Modification of Cropping Pattern: Due to the agricultural price policy, India's cropping pattern has to be significantly altered. With the help of the government and the adoption of contemporary techniques, wheat and rice production has significantly increased. But without such price support, the production of oilseeds and pulses could not make any meaningful progress.

5. Benefit to Consumers: By consistently providing the necessary agricultural commodities at a fair price, the policy has also had a significant positive impact on consumers.

6. Benefit to Industrials: Agro-related industries such as sugar, cotton textiles, vegetable oil, etc. have profited from the agricultural price policy. The policy has provided for an adequate supply of raw materials at a reasonable price for the nation's agro-based industries by stabilizing the prices of agricultural commodities.

Agricultural Pricing Policy's Drawbacks: The following are the main drawbacks of the agricultural pricing policy:

1. Inadequate Coverage: The pricing is no longer effective due to the procurement facility's inadequate coverage. Of the entire amount of food produced, only a small number of farmers have access to government procurement facilities.

2. Remunerative Price: The rate of cost growth has not been kept up by the remunerative price and/or subsidized inputs. It has resulted in two outcomes. The farmer is disinclined to produce at the highest possible level; instead, he attempts to strike a balance between his output and expenses, settling for a lower level of output.

3. Inefficient Public Distribution System: There hasn't been much success with public distribution. A little portion of the impoverished population is not covered by the system. Even people who are enrolled in the system may not receive the benefit or may not be eligible for it. The goal has not even been partially achieved by the system.

4. Price Difference: The significant disparity in prices between what manufacturers are paid and what consumers pay is a significant concern. In this context, it is necessary to carefully examine concerns pertaining to the regulatory network and the expenses associated with it because of factors such as increased transportation costs and distribution network fragmentation.

5. Unaccompanied by Effective Policy: A variety of other elements of the agricultural system, such as land holding patterns, income distribution, overall inequities, and cropping patterns, affect how effective the price policy is. However, it is unfortunate to report that no practical strategy for the overall growth of agriculture has been implemented in tandem with the price policy.Continuous price increases for procurement could potentially have a negative effect on agricultural productivity. Price rises that overcompensate for cost increases may dissuade farmers from taking steps to boost agricultural output because they inevitably increase their profits.

SUGGESTIONS

The current agricultural price policy is insufficient, and it needs to be reoriented in light of the top goals, which will probably influence the development plan. Concern over broad-based and sustained growth is certain to take center stage given the dire circumstances facing the country's economy right now. Such important questions about the approach required to attain such progress remain unresolved and unfocused.

National issues should take precedence above the ideologies of the nation's various political parties. The recent and ongoing debate over the Agricultural Policy Resolution, which has not yet been approved, fully reflects these larger goals.

The following suggestions may be considered on a priority basis.

1. Minimum Support Prices: Based on minimum support prices, two economic factors ought to direct the operations. Firstly, the minimum support price should only cover efficient producers, so promoting

expansion and efficiency and essentially subsidizing all farmer segments. In particular, it is critical to understand that non-viable farmers cannot be assisted by merely setting a minimum support price that is high enough; policy is not the only way to address these issues. Second, the protection needs to be limited to preventing losses for the productive producer rather than guaranteeing him profits.

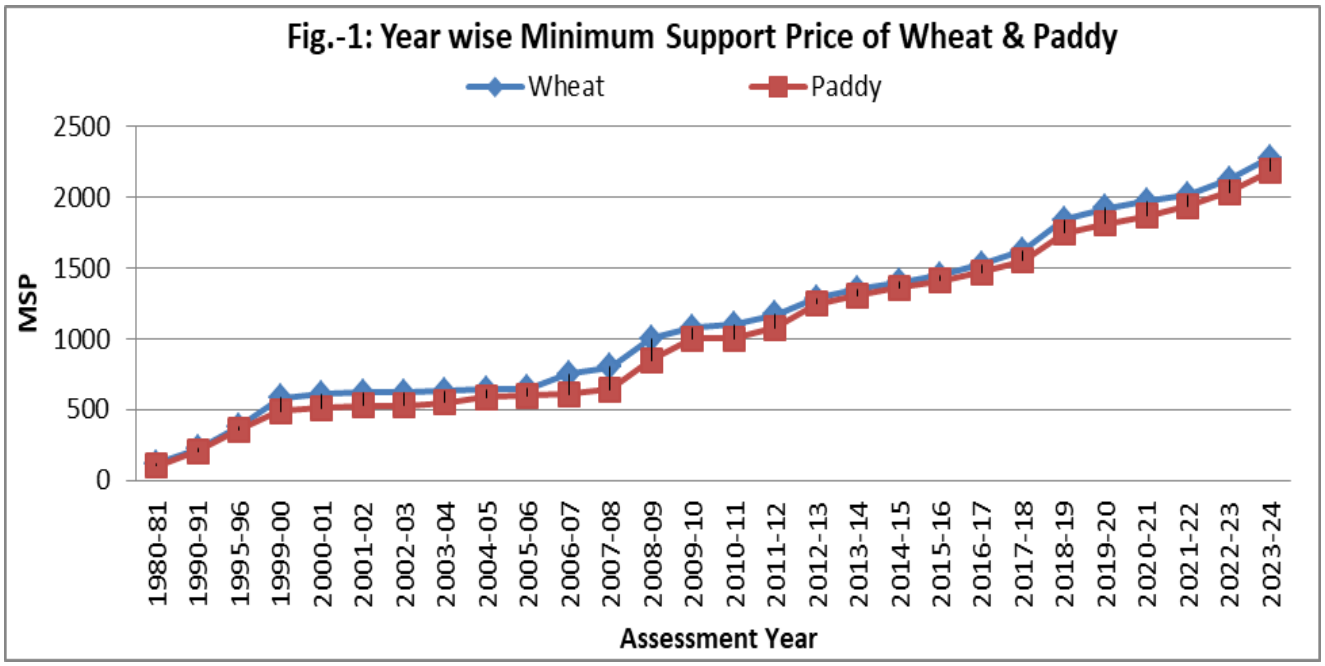
Table-1: Minimum Support Price for Wheat and Paddy since 1980-81(Rs. Per Quintal)

Crop Year	Wheat	Paddy (Common Variety)	Increase in Price between consecutive years	
Crop Year	Wheat	Paddy	Wheat*	Paddy*
1980-81	117	105	–	–
1990-91	225	205	108	100
1995-96	380	360	155	155
1999-00	580	490	200	130
2000-01	610	510	30	20
2001-02	620	530	10	20
2002-03	620	530	0	0
2003-04	630	550	10	20
2004-05	640	590	10	40
2005-06	650	600	10	10
2006-07	750	610	100	10
2007-08	800	645	50	35
2008-09	1000	850	200	205
2009-10	1080	1000	80	150
2010-11	1100	1000	20	0
2011-12	1170	1080	70	80
2012-13	1285	1250	115	170
2013-14	1350	1310	65	60
2014-15	1400	1360	50	50
2015-16	1450	1410	50	50
2016-17	1525	1470	75	60
2017-18	1625	1550	100	80
2018-19	1840	1750	215	200
2019-20	1925	1815	85	65
2020-21	1975	1868	50	53
2021-22	2015	1940	40	72
2022-23	2125	2040	110	100
2023-24	2275	2183	150	143

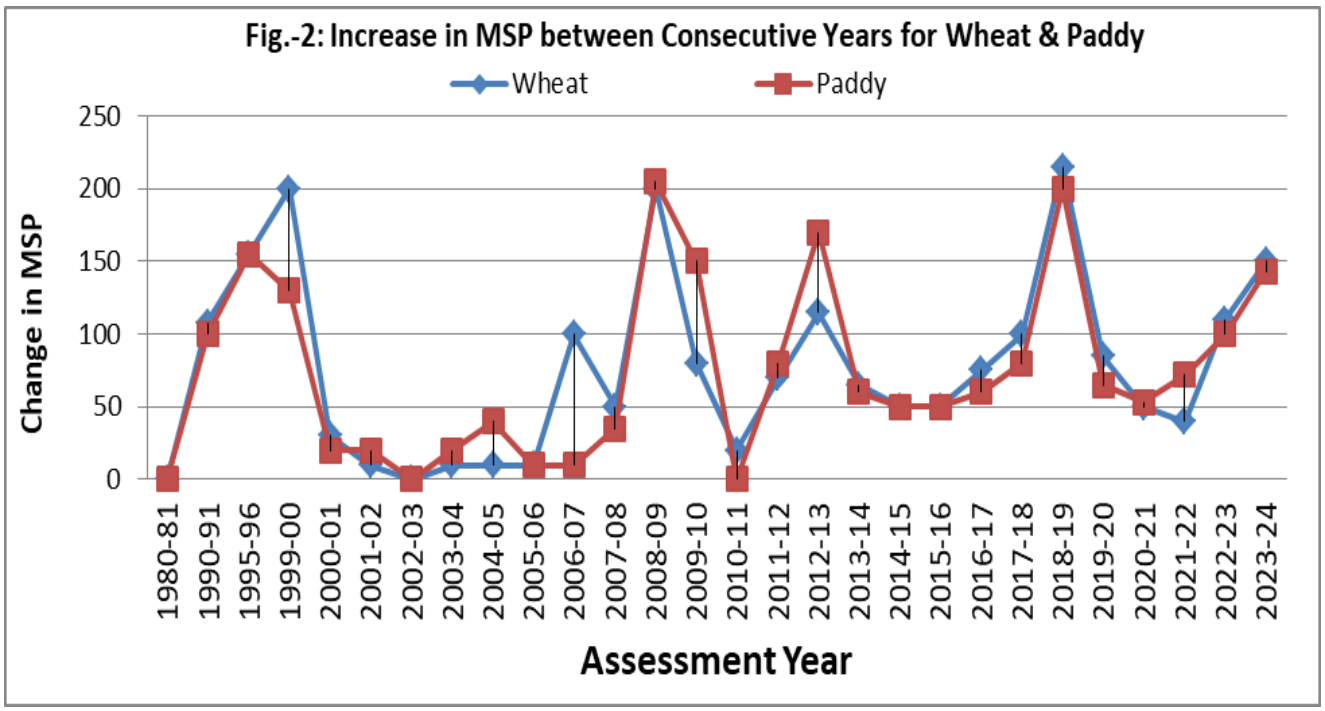
Source: Economic Surveys for 1980-2018, Ministry of Agriculture & Farmers Welfare, Government of India for 2018-24

2. Maximum Price: Setting a maximum price for a commodity does not always have simple or straightforward criteria. In terms of price level, the government's main duties are to: (a) Control the forces of inflation that cause gradual, cumulative increases in the overall price level; and (b) Get rid of collusive and manipulative tactics that cause artificial scarcity and high prices for specific commodities. It is difficult to see any need to match each minimum support price with a corresponding ceiling price if these two causes of price rise are adequately mitigated. The degree to which relative prices are allowed to fluctuate in response to shifts in the underlying supply and demand conditions determines how effective the price mechanism is while the general price level remains stable.

3. Balanced and Integrated Price Structure: It is necessary to develop criteria for a balanced and integrated price structure. This kind of pricing structure would be more beneficial for tracking changes in the variables that influence prices than for setting prices. The ability of an agricultural price policy to extrapolate, forecast, and calculate the ramifications of various actions would determine how much it would aid in the formulation of agricultural strategy and planning. Such analytical exercises in a market-based economy would require models of interconnected markets that are founded on the idea of equilibrium and are able to demonstrate how the markets respond to disruptions, policy interventions, etc.



The Fig.-1 is drawn on the basis of Table-1



The Fig.-2 is also drawn on the basis of the same Table.

When recommending pricing, the Commission on Agricultural Costs and pricing (CACP) considers a number of significant criteria, including:

1. Production costs;
2. Input price fluctuations.
3. Price parity in input and output
4. Price trends in the market
5. Price parity between crops
6. The state of supply and demand
7. Impact on the Structure of Industrial Costs;
8. Impact on the Overall Level of Prices
9. Impact on Living Expenses X. Global Market Price Conditions
10. Equiparity between the prices farmers receive and pay.

CONCLUSION

The primary goal of the Indian government's agriculture policy is to protect the interests of both farmers and consumers. It is important to carefully consider food grain pricing to ensure that neither farmers nor consumers lose out. The expansion of the volume of aggregate output and productivity is greatly aided by non-price factors including enhanced human resources, financial inputs, land reforms, and efficient technologies. The financial resources of the small state should be directed toward developing rural communities' social and economic infrastructure as opposed to giving the general public subsidized agricultural products. If the agricultural infrastructure is inadequate, the price policy will not have the desired impact of increasing agricultural productivity. A few commodities should have their agricultural prices disclosed, as it is not financially viable for the government to purchase food grains at a premium and permit offtake at a discounted rate. Additionally, the development of the infrastructure receives sufficient attention. Numerous problems with price behavior were present in the Indian market. The Indian markets are extremely volatile when it comes to commodities or agricultural items. To prevent obstacles for the growers, the authority must exercise extra caution when it comes to food products that are grown seasonally.

Conflicts of interest: There are no conflicts of interest.

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Effect of Nitrogen and Phosphorus on Growth Performance of Indian Spinach *Beta vulgaris* var. Bengalensis

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ABSTRACT

India is the world's second-largest vegetable producer, after China. Indian spinach is a leafy vegetable grown inweredia and other regions of the world. Nitrogen and Phosphorus affect the growth performance of Indian spinach *Beta vulgaris* var. Bengalensis. These can be a good alternative to organic fertilizers. Nearly all of the researchers offered suggestions for the careful application of Nitrogen (N) and Phosphorus (P) fertilizers in accordance with the state of the soil and the requirements of the crop in a particular soil and climate. The present investigation has led to the conclusion that at 30 days after sowing, plant height and leaf numbers per plant were significantly highest in treatment of 50 kg N/ha. Nitrogen could be the main component for the high growth rate of the studied species. Phosphorus was found responsible for the enhancement of the leaf in size and weight. Plant height, number of leaves, leaf length, leaf width in 15 days and 30 days, and leaf weight after 30 days of sowing were also recorded. The highest plant height (39.13 cm) was recorded 15 days after sowing in N 50 kg/ha, followed by 38.30 cm in N75 kg ha-1 with 1.58 g. Phosphorus was found responsible for the enhancement of the leaf in size and weight. Treatments had a profound effect on the growth and production of Indian spinach seeds, regardless of growing conditions. The performance of Indian spinach was found to be better during the regional season in the study site.

Keywords: Agriculture, Fertilizer, Growth performance, Indian spinach, Nitrogen, Phosphorus

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INTRODUCTION

Indian spinach (*Beta vulgaris* var. Bengalensis; 2n = 2x = 18) is a well-known leafy vegetable grown in India and other regions of the world. It is a member of the Chenopodiaceae family. Indian spinach, also known as beet leaf in English and Palak in Hindi, is a plant that comes from the Indo-Chinese region. The Indian Council of Medical Research in New Delhi recommends consuming 325 grams of vegetables each day. For nutrient-rich food, leafy vegetables contribute 50 grams, tuber plants 50 grams, and other vegetables like onions 225 grams per day. Yet, as per PJTSAU, the real utilization of 24 g verdant vegetables each day per individual in Telangana territory.

Because of its nutritious, soft, and tender leaves, beetroot is widely grown in India. It is an important part of the daily diet of people who need a lot of nutrients. Spinach beet is plentiful in nutrients, particularly vitamin A and different nutrients like Ascorbic corrosive (70 mg 100 g-1), Riboflavin, and Thiamine. Minerals like Iron and Calcium (380 mg 100 g-1), Folic corrosive and certain measures of Nicotinic corrosive, Pyridoxine, Cancer prevention agents like Carotene, Flavones, Indoles, and Isothiocyanates, fundamental amino acids and so forth. According to Thamburaj and Singh (2015), as a result, it is referred to as "Mineral Mining." India is the world's second-largest vegetable producer, after China, thanks to its diverse climate and seasons. This makes it possible to grow a wide range of vegetables. In 2018-19, the vegetable garden area was 10.1 million hectares, with a production of 185.8 million tons and 18.4 M ha-1, according to the National Horticulture Database, which was published by the National Horticulture Board. The National Horticulture Board says that the vegetable growing area in Telangana province is 140.31 thousand hectares and produced 2548.69 lakh MT in 2018-19.

Biofertilizer is an expansive term utilized in different classifications of bio-inoculants, for example, nitrogen-added substances Azotobacter, phosphate solubilizing Microorganisms, for example, Pseudomonas, Bacillus, Rhizobium, Agrobacterium, and so on., and bacteria like Bacillus, Ferredoxins, and Acidothiobacillus that can be dissolved in potassium. as *B. circulans*, *B. edaphicus* and *B. mucilagenous*. They work well, are good for the environment, are cheap, and can be made money without providing plants with the nutrients they need. Additionally, they help crop plants absorb more nutrients from the soil. Azotobacter, a free-living, aerobic, nonsymbiotic, nitrogen-fixing bacteria, is one of the bio-inoculants that can take the place of some organic fertilizers. Mohandas (1999) found that acetobacter infusion reduces nitrogen fertilizer use by 10 to 20 percent.

To meet the nutritional requirements of the developing world, Indian spinach, which is one of India's most important and popular vegetable plants, should be consumed in the form of at least 50 g of green leafy vegetables per day. During the off-season, growing these fast-growing leafy vegetables in the open under a secure structure like a net shelter in the shade can be a great opportunity. As a verdant vegetable, it has different plant-nourishing necessities, particularly Nitrogen and Phosphorous.

Mei and others (1986) detailed that the leaf count per plant expanded from 11.5 to 15.5 spinach when given NPK and given micronutrients to plant as a foliar splash. In addition, they reported a yield increase of 38% in comparison to spinach with nutrient uptake control.

Amaranthus leaf yield was studied in the field by Gogai and Rajgopal (1986) to see how blurring and nitrogen levels affected it. On the second, third, and fourth cuts, they said that shading lowers yield. Up to 40 kg ha 1, nitrogen levels increased yields.

Suryanarayana Reddy et al., (1986) investigated the impact of micronutrients and NPK in combination on sandy loam brinjal soils. Various medicines included zinc sulfate (25, 50, and 75 kg ha^{-1}) borax (5, 10, and 15 kg ha^{-1}), and copper sulfate (10, 20, and 30 kg ha^{-1}), and 120 kg N, 60 kg P_2O_5, and 60 kg K_2O ha^{-1}. NPK + 75 kg ZnSO4 ha^{-1} had the highest fruit yield (15.03 t ha^{-1}) compared to the control, which had a very low yield (4.25 t ha^{-1}).

Dixit et al. (2007) examined the efficacy of leafy vegetables like spinach, amaranthus, fenugreek, and coriander in both a protected area and an open field setting. According to the findings of the study, when compared to open-field planting, greenhouse culture results in harvests that are two to three times greater than those from outdoor planting. -2.34 kg each for spinach, amaranthus, fenugreek, and coriander) when compared to open field conditions (3.15 kg each for spinach, amaranthus, fenugreek, and coriander). Biemond (2004) found that excessive nitrogen increased leaf mass when estrogen affected

the accumulation and separation of solids and nitrogen from spinach. Re-education (NRA) of the Pusa Barathi variety of beet spinach in Uttarakhand measured growth area, dry matter yield, and nitrogen accumulation in the leaves. The recommended fertilizer dose (80:40:50 kg NPK per hectare) produced the highest quality dry matter (456,33 ka / ha), beating out all other treatments. Present study was carried out to look upon field Growth performance of Indian spinach influenced by Phosphorus and Nitrogen contents.

MATERIAL AND METHODS

Study Site

The present investigation was carried out at the Institute of Agriculture Sciences field, Bundelkhand University, Jhansi, Uttar Pradesh, India, during the rabi season of 2017-2018. The study site is at an altitude of 284 meters (935 feet), 25.43° N Latitude, and 78.58° E Longitude. It lies on the plateau of central India, an area dominated by rocky relief and minerals underneath the soil. The soil is fertile, low in available nitrogen, high in phosphorus, and high in potash with a pH of 8.5. Appropriate weather data during the growing season are presented in Table 1 and are shown in Fig. 1.

Soil of the experimental field

The climate of the study area is subtropical monsoon type, characterized by hot and dry summer (except during monsoon season) and mild winter. The average rainfall of the district is about 900 mm. The irrigated area of the district is only 38.93% to net cultivated area. This shows that the maximum cropped area of the district is rained. The soil in the district is deep black cotton soil. The soil sample of the study site was collected and analyzed. The results are presented in Table-2.

Experimental details

Present investigation was carried out with ten treatments of nitrogen and phosphorus including control. Four different concentrations of nitrogen and phosphorus were applied in the experiment. 25kg/ha, 50 kg/ha, 75 kg/ha, and 100 kg/ha amount was used for nitrogen and phosphorus both in three replications. spinach (*Beta Vulgaris var. bengalensis*) was sown in an open field in beds in 1m x 1 m apart from each replication in a randomized block design (RBD). A spacing of 40 cm was applied between rows and plant spacing was 30 cm during rabi season.

Observation of data and Statistical analysis

After sowing growth data was recorded for plant height, number of leaves, leaf length, leaf width in 15 days and 30 days, and leaf weight after 30 days of sowing was also recorded. The observation was taken from ten randomly selected competing plants in each plot for the growth characters. The average value of plants was calculated and used in statistical analysis using some mathematical formulas, JASP, WASP 2.0, and OPSTAT statistical analysis packages.

Mathematical processes

(I) Diversity analysis: The definition of each character was analyzed according to the procedure provided by Panse and Sukhatme (1989) for random block design.

(i) Standard error of mean: Standard error of mean was calculated using the following formula,

$$S.E\ (m) \pm = \sqrt{\frac{MSSer}{}}$$

Where,

S E(m) ± = Standard error of difference
MSSe = Error mean sum of squares
r= Number of replications

(ii) Standard error of difference: Standard error of difference was calculated using the following formula

$$S.Em(d) \pm = \sqrt{\frac{2\ MSSer}{}}$$

Where,

S Em(d) ± = Standard error of difference
MSSe= Error mean sum of squares
r = Number of replications

(iii) Critical difference: It was calculated as formula given below

C. D. (5%) = S E(d) x 't' value at 5% level of significance

Where,

C. D = Critical difference
S E(d) ± = Standard error difference
't'= t table value at error degree of freedom at 5% level of significance.

Table 1: Meteorological parameters recorded during the period of the investigation (8th November 2017 to 24th March 2018)

S.M. week	Duration	Temperature (^{0}C)		Relative Humidity (%)	Weekly Rainfall (mm)
		Min.	Max.		
47	18 Nov – 24 Nov	18.9	32.5	25.0	0.13
48	25 Nov – 01 Dec	18.5	30.7	28.0	-
49	02 Dec – 08 Dec	17.7	28.8	28.7	1.2
50	09 Dec – 15 Dec	15.6	27.1	32.7	-
51	16 Dec – 22 Dec	13.9	27.6	28.2	-
52	23 Dec – 30 Dec	13.7	21.5	63.2	10.5
01	31Dec – 06 Jan	12.1	24.7	50.0	-
02	07 Jan – 13 Jan	13.1	25.7	42.0	9.2
03	14 Jan – 20 Jan	11.2	25.3	36.7	-
04	21 Jan – 27 Jan	9.9	25.1	32.5	-
05	28 Jan – 03 Feb	11.9	25.3	36.0	-
06	04 Feb – 10 Feb	13.0	28.4	37.7	8.7
07	11 Feb - 17 feb	13.0	28.4	32.7	-
08	18 Feb – 24 Feb	13.6	28.7	26.7	-
09	25 Feb – 03 Mar	14.5	28.3	33.5	-
10	04 Mar – 10Mar	14.0	27.5	29.4	-
11	11 Mar – 17 Mar	17.6	32.3	21.2	-

Source: Meteorological Observatory, Dr. B.R. Ambedkar University of Social Sciences Mhow (M.P.)

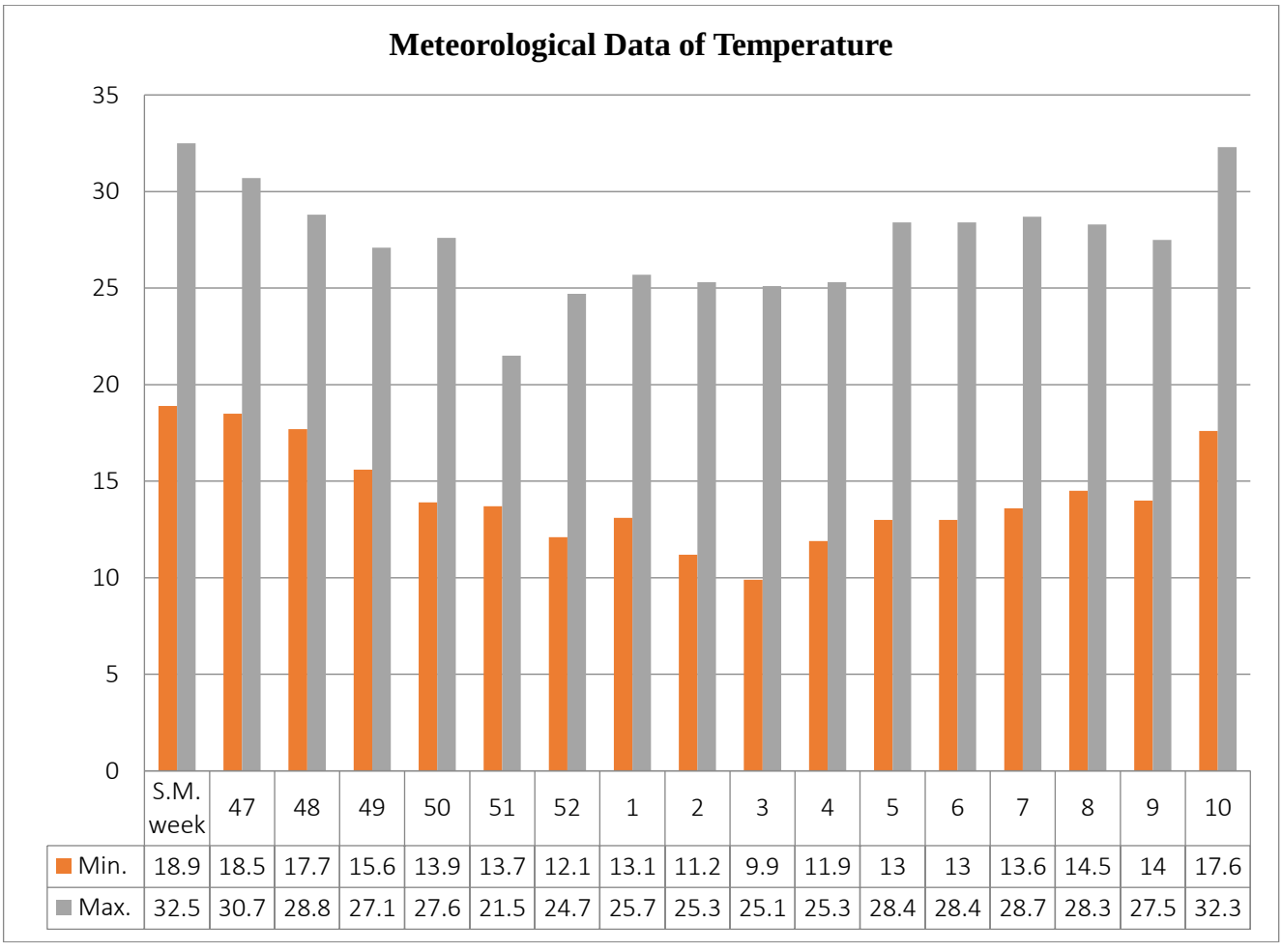


Table 2: Physical and chemical composition of the soil

SL. No.	Composition			Method adopted
	Physical	Content	Category	
1.	Organic carbon	0.28	Normal	
2.	Available nitrogen (kg/ha)	196.6	Low	Rapid titration method (Walkley and Black, 1934)
3.	Available phosphorus (kg/ha)	8.0	Medium	Olesen's extraction method (Olesen et al. 1954)
4.	Available potassium (kg/ha)	394.3	High	Flame photometer (Ghosh et al.1981)

RESULTS AND DISCUSSION

The plant height

The Analysis of Variance clearly demonstrated that the palak plant's height reacted significantly to the various levels of phosphorus-containing nitrogen and phosphorus throughout all of the current growth stages.

The highest plant height (39.13 cm) was recorded 15 days after sowing in N 50 kg/ha, followed by 38.30 cm in N75 kg/ha. The lowest level of control was observed in plant height 15 days after sowing.

When compared to the other treatments, the maximum plant height recorded 30 days after sowing was 81.18 cm in the treatment with N 50 kg/ha, followed by 79.93 cm in the treatment with P 50 kg/ha. The control's plant length, on the other hand, was only 61.75 cm. Comparable contrasts in plant level of palak species have been accounted for by Dixit et al. (2007) and Sara et al (2007). N fertilization increases the nitrate content of plant tissue due to high soil N levels (Brown and Smith, 1966, 1967; Hanway and Englehorn, 1958; Macleod, 1965; Perez and Story, 1960; Smith and Sund, 1965; Wright and Davison, 1964). Brown and Smith (1966, 1967) found that most vegetables developed nitrate accumulation when N fertilizer was applied at a rate greater than 50 pounds per acre.

Number of Leaves

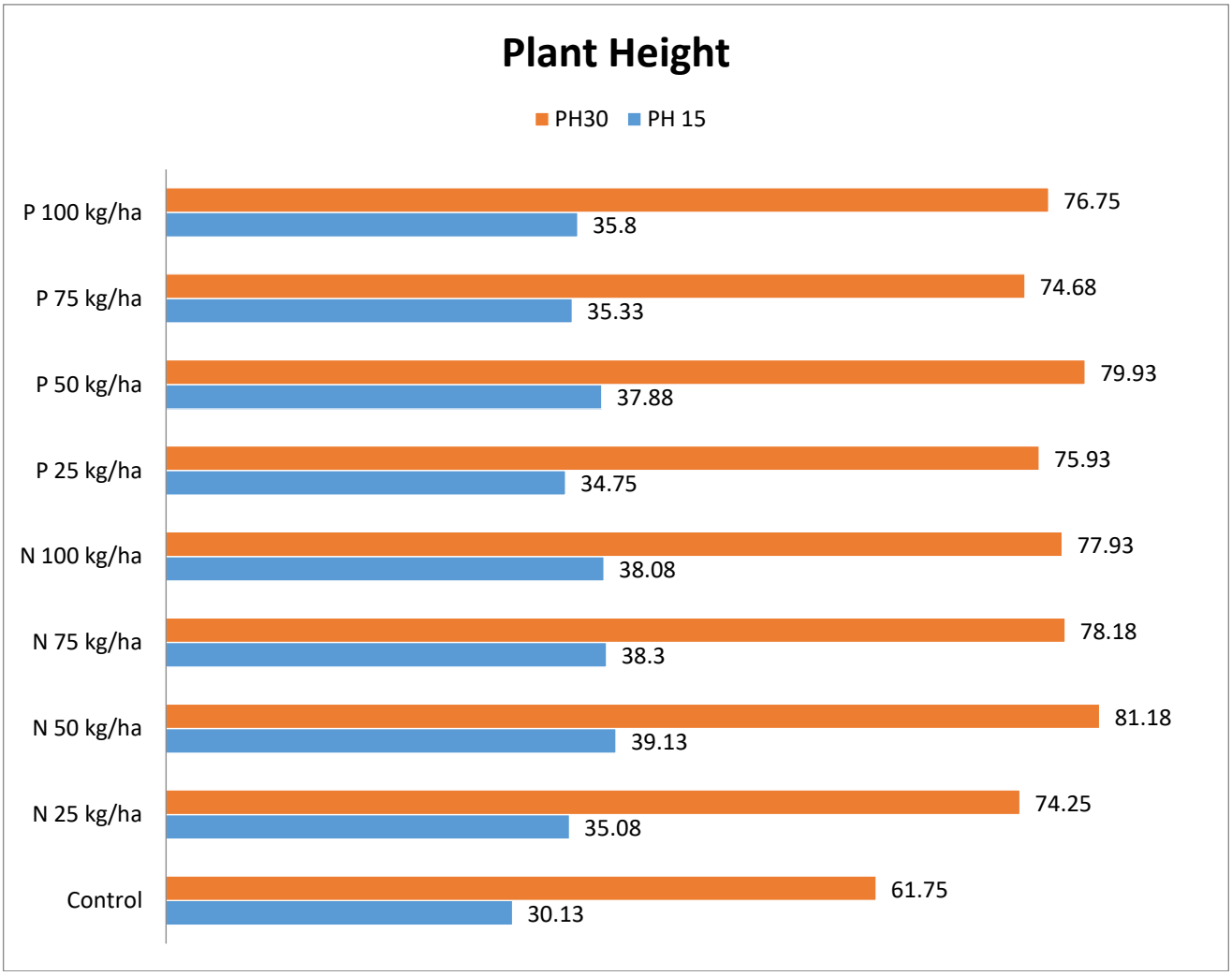
Number of leaves/plants was recorded at 15 and 30 days after sowing. At 15 days after sowing, the significant maximum of 15.80 leaves per plant was recorded in treatment N 50 kg/ha followed by N 100 kg/ha (15.70 leaves). While 6.58 leaves per plant were recorded in control.

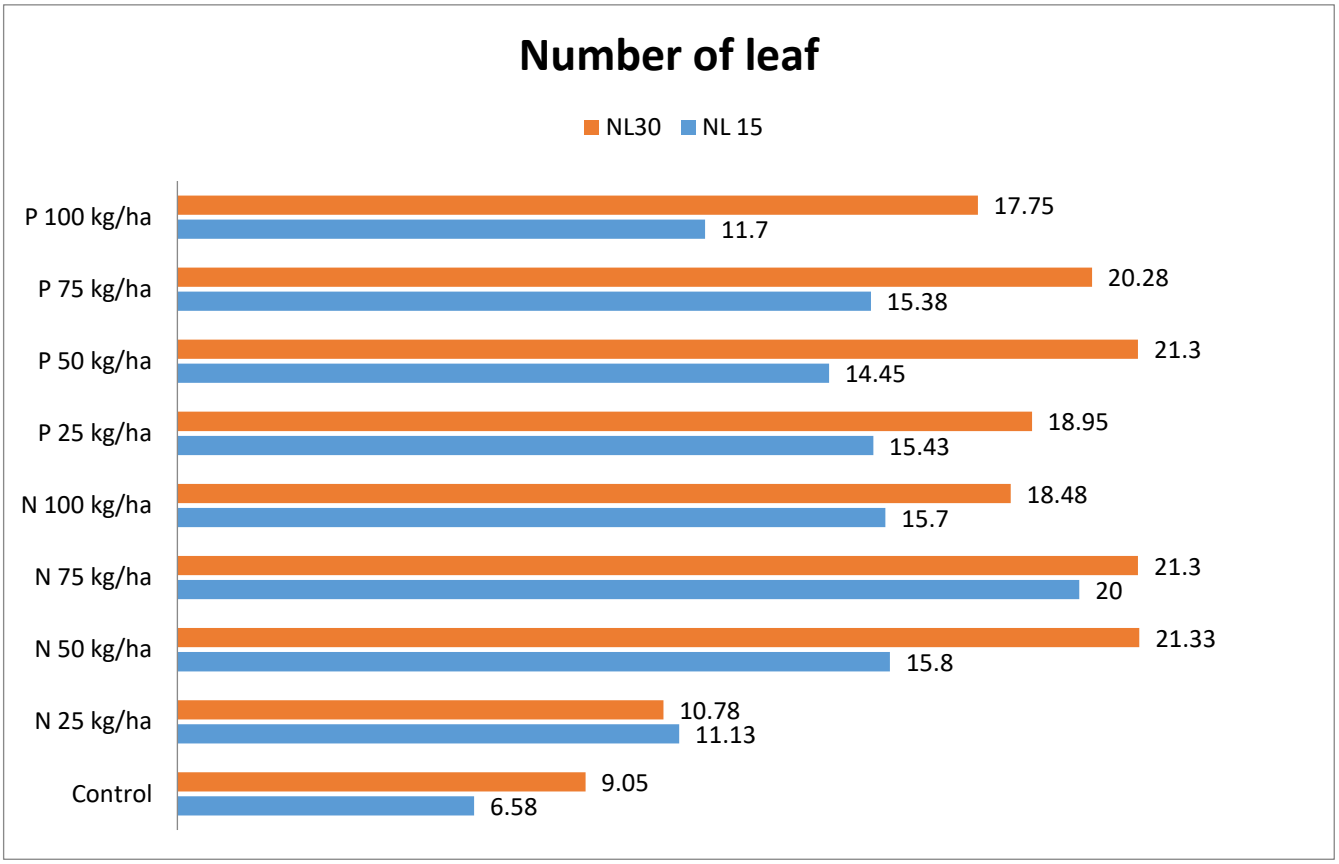
After 30 days of sowing, a maximum (21.33) leaves per plant was recorded in N 50 kg/ha followed by 21.30 leaves per plant in the treatment of N 75 kg/ha and P 50 kg/ha. While a small leaf was recorded in control by Kotadia et al. (2012) and Singh et al. (2013). Nitrogen fertilization may either increase the foraging capacity of the root system and the absorption of certain elements like phosphorus or it may decrease the concentration of other elements because of the increased growth of the plant's tops and roots (Grunes, 1964; Tserling1965). In contrast, other studies have shown that, in most cases, P fertilizer application results in a distinct yield and quality response in crops like lettuce (Alt, 1987; Sanchez et al. 1988; Johnstone et al. 2005). In a similar vein, Soundy and Smith (1992) demonstrated a significant linear correlation between the concentrations of P in lettuce head tissue and soil. The findings of Cleaver and Greenwood (1975), who reported that lettuce required more phosphorus fertilizer than the majority of other vegetables across a variety of soil types, may explain this relationship.

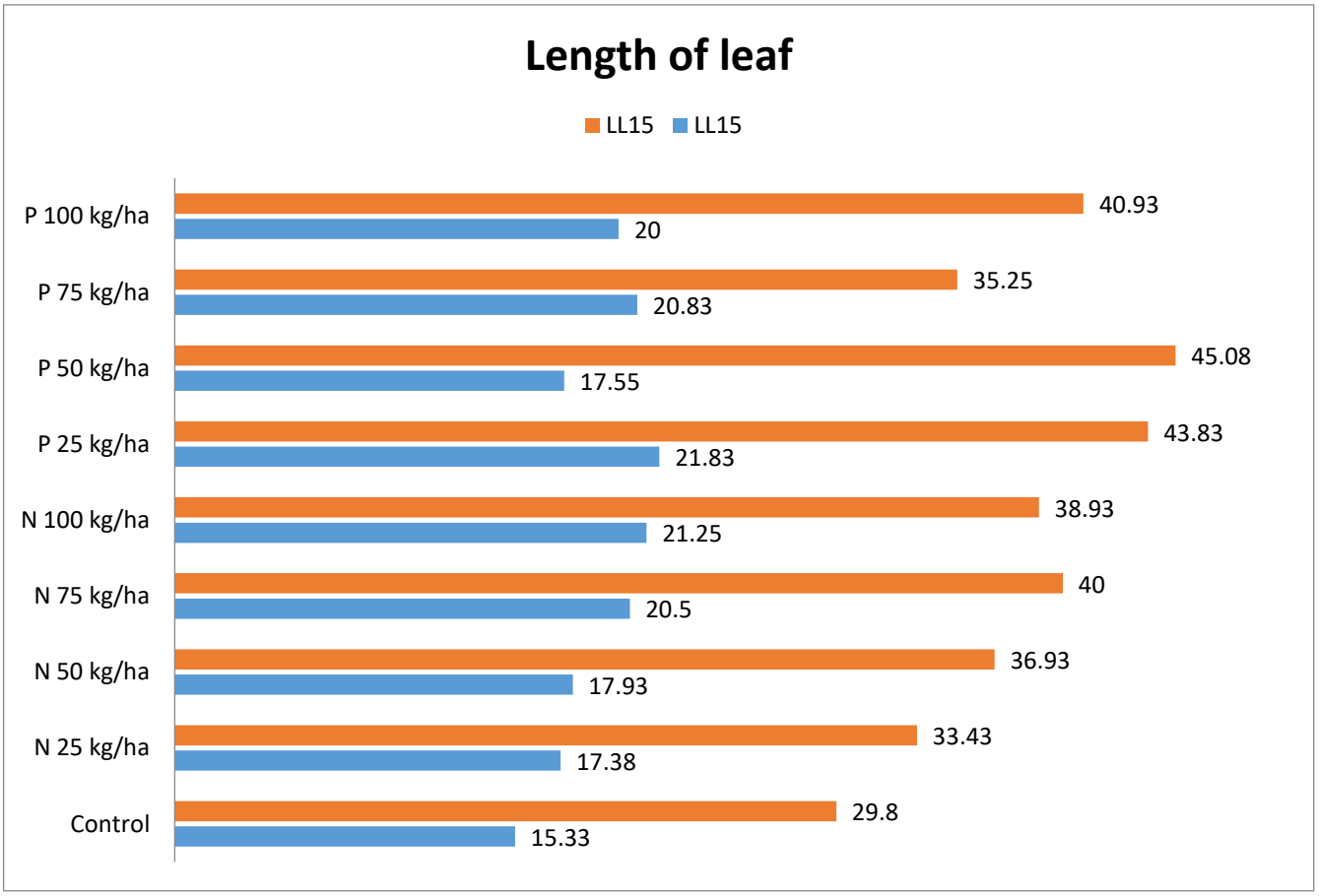
Length of leaf

The significant maximum 21.85 cm long leaf was observed in the treatment of P 25 kg/ha after 15 days of sowing followed by a 21.25 cm long leaf in N 100 kg/ha. Meanwhile, 15.33 cm length was recorded in the control. After 30 days of sowing maximum 45.08 cm long leaf was recorded in P 50 kg/ha followed by 43.83 cm in treatment of P 25 kg/ha. The same variations in the different types of palak leaves were reported by Dixit et al. (2007) and Sara et al. (2007). The improved soil's physical, chemical, and biological properties may be the reason for the increased plant growth in cow manure-treated soils. According to Kashem and Warman (2009), the increased availability of nutrients to the plants is to blame for the rise in productivity that was observed following the addition of compost. (2001, Kashem and Singh;

Warman and Zheljazkov, 2003). Regardless of amendments, the phosphorus concentration in plant parts increased linearly with rates. Higher phosphorus content in the shoot and root is logical because they immediately supply soluble P for immediate plant uptake and accumulation (Tisdale et al., 1985). According to Mengel and Kirkby (1987), nitrogen (N) is one of the most important nutrients that inhibit plant growth, as evidenced by the high demand for vegetable production. Although the application of nitrogen fertilizer can increase the yield of leafy vegetables, excessive use may result in decreased food quality, economic loss, and environmental degradation (Mozafar, 1993; Peng et al. 1996; Darwish et al. 2006; Zhang et al. 2012). Additionally, excessive use of N may increase the concentration of nitrate in spinach, which may be harmful to humans as well as animals (Citak and Sonmez, 2010), as it may cause the production of N-nitrosamines, compounds that have the potential to cause cancer (van Velzen et al. 2008). Numerous health issues, including methemoglobinaemia and gastrointestinal cancer, may result from a high nitrate intake from food and water (Bruning-Fann and Kaneene, 1993a, 1993b). According to Maynard et al. (1976) certain vegetables have a tendency to accumulate more nitrates (NO3) than others because they have an extremely effective uptake system, an ineffective reductive system, or an unfavorable combination of the two. for instance, list spinach as a nitrate accumulator Maynard et al. (1976). In addition, plant assimilation is thought to be improved by the combination of Phi and Pi ions (US patent number 6824584; Young 2004). Forster and others 1998) discovered that Phi did not perform as well as Pi fertilizer, but tomato plants treated with a mixture of Pi and Phi grew better than plants treated with Pi alone. Phosphate has been accounted for to be more dissolvable than Pi, making leaf and root take-up more effective (Lovatt and Mikkelsen, 2006; Watanabe, 2005). This demonstrates that not all plant species can effectively absorb Phi through their roots.




Number of leaf
NL30
NL 15
P 100 kg/ha
17.75
11.7
P 75 kg/ha
20.28
15.38
P 50 kg/ha
21.3
14.45
P 25 kg/ha
18.95
15.43
N 100 kg/ha
18.48
15.7
N 75 kg/ha
21.3
20
N 50 kg/ha
21.33
15.8
N 25 kg/ha
10.78
11.13
Control
9.05
6.58


Length of leaf
LL15
LL15
P 100 kg/ha
40.93
20
P 75 kg/ha
35.25
20.83
P 50 kg/ha
45.08
17.55
P 25 kg/ha
43.83
21.83
N 100 kg/ha
38.93
21.25
N 75 kg/ha
40
20.5
N 50 kg/ha
36.93
17.93
N 25 kg/ha
33.43
17.38
Control
29.8
15.33

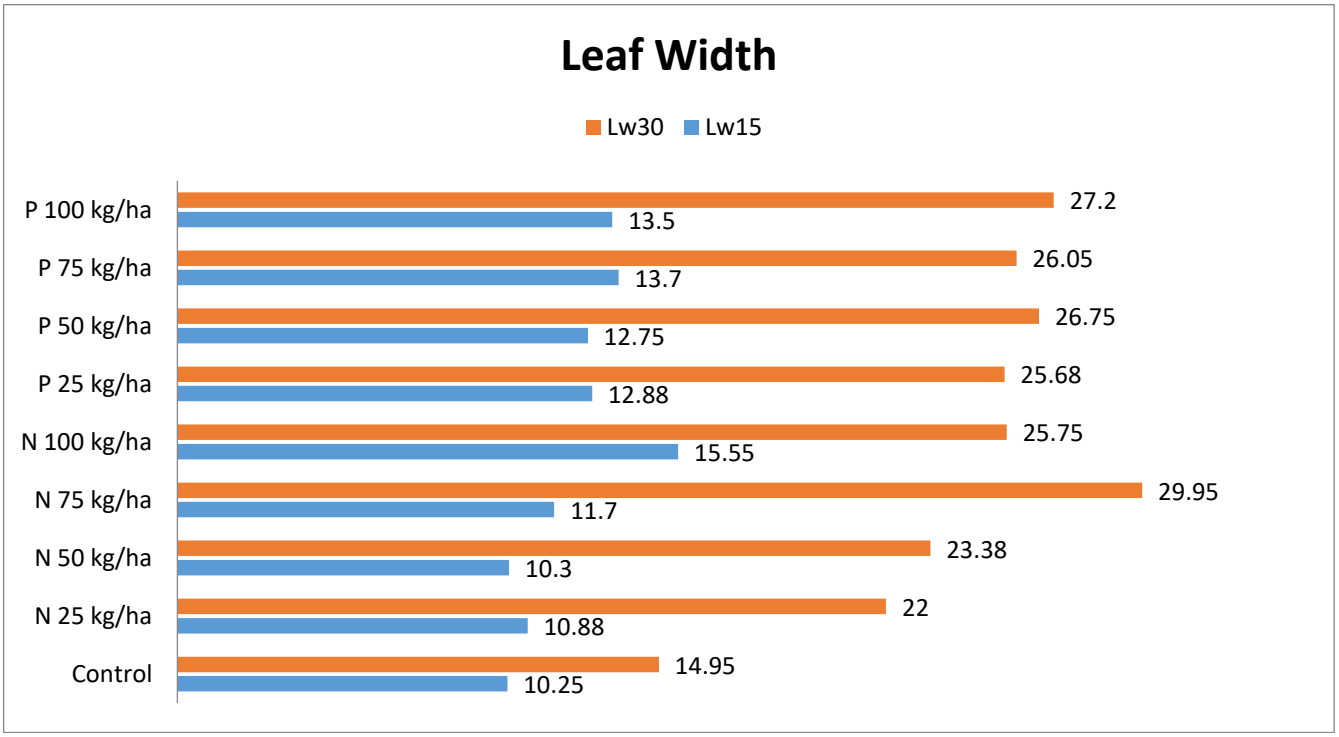


Table 4. Effects of different treatments of nitrogen and phosphorus on growth of Indian spinach after 15 of sowing

Treatment	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)
Control	30.13	6.58	15.33	10.25
N 25 kg/ha	35.08	11.13	17.38	10.88
N 50 kg/ha	39.13	15.80	17.93	10.30
N 75 kg/ha	38.30	20.00	20.50	11.70
N 100 kg/ha	38.08	15.70	21.25	15.55
P 25 kg/ha	34.75	15.43	21.83	12.88
P 50 kg/ha	37.88	14.45	17.55	12.75
P 75 kg/ha	35.33	15.38	20.83	13.70
P 100 kg/ha	35.80	11.70	20.00	13.50
LSD (at 0.05)	1.75	1.08	0.88	0.85
SE	0.60	0.37	0.30	0.29
SD	0.84	0.52	0.42	0.41
C.V. %	3.31	5.27	3.13	4.67

Leaf width

The significantly widest (15.55 cm) leaf in treatment N 100 kg/ha was noted followed by 13.70 cm in P 75 kg/ha and 10.25 cm in control after 15 days of sowing. Moreover, after 30 days of sowing maximum (29.95 cm) leaf length was recorded in N 75 kg/ha followed by 27.20 in P 100 kg/ha. It was brought about by the interaction of nitrogen and phosphorus. Phosphorus acts as a basal dose to boost plant growth and development because it delays leaf decomposition near maturity and increases leaf enlargement, especially in the early stages of growth. Mehta et al. (2010) and Anuja and Jayalaxmi (2011) serve as the foundation for these findings. As photosynthetic biomass contributes to the growth of the tuber and the nutrients collected from the leaves are transferred to the leaf, they pointed out that the growth of leaves above the ground is an indication of the yield of the tuber.

Leaf weight

Increased yields with nitrogen and phosphorus can be attributed to the corresponding increase in leaf

area, which was responsible for photosynthetic and photosynthetic growth. The weight of leaf recorded treatment-wise and the mean value are depicted in Table. The treatment of N 100 kg/ha was recorded as significantly superior and gave a maximum (1.68 g) weight of leaf followed by treatment of P25 kg/ha with 1.58 g. The regenerative effect of phosphorus on photosynthesis, phloem loading and localization, and the integration of large molecular weight components into storage organs all play a significant role in increasing leaf weight. Godara et al. (2013) and Kotadia et al. (2012) serve as the foundation for these findings.

In spinach pot experiments, applying N significantly outperformed applying K to increase leaf yield (Ehrendorfer 1964). N fertilization reduced the amount of K in grasses (MacLeod, 1964). Using the N, Kresge and Younts (1963): Orchard grass yield and nutrient content were found to be related to the P ratio of applied fertilizer, with N: Maximum yields required K ratios lower than 2.4:1.

Table 5. Effects of different treatments of nitrogen and phosphorus on the growth of Indian spinach after 30 of sowing

Treatment	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)
Control	61.75	9.05	29.80	14.95
N 25 kg/ha	74.25	10.78	33.43	22.00
N 50 kg/ha	81.18	21.33	36.93	23.38
N 75 kg/ha	78.18	21.30	40.00	29.95
N 100 kg/ha	77.93	18.48	38.93	25.75
P 25 kg/ha	75.93	18.95	43.83	25.68
P 50 kg/ha	79.93	21.30	45.08	26.75
P 75 kg/ha	74.68	20.28	35.25	26.05
P 100 kg/ha	76.75	17.75	40.93	27.20
LSD (at 0.05)	1.62	0.83	0.77	1.10
SE	0.55	0.28	0.26	0.38
SD	0.78	0.40	0.37	0.53
C.V. %	1.46	3.18	1.38	3.05

These results are in line with those of Canali et al. in 2008, they suggested that spinach needs soils with a high fertility level. Biemond (1995) expressed that manure ought to be applied in a few parts and 85 to 120 kg for each ha N would be sufficient as a side dressing. Canali and others, 2008) recommended applying up to 150 kg of nitrogen per hectare to spinach, while Patel et al., 2008 proposed incomplete utilization of ranch yard excrement at the expense of diminished N application for spinach. According to Popat et al. 2009 study, spinach leaf yields increased when NPK was applied at higher rates compared to control or at lower levels. Dua et al., 2010 suggested fertilizing spinach with 30 tons of farm yard manure, 150 kg of nitrogen, 83 kg of phosphorus, and 43.7 kg per hectare. According to Odueso (2011), NPK at rates of 20-10-10 was found to be superior for the growth and yield of spinach. Sajirani et al., 2012 suggested using 45 tons of manure per hectare in addition to 300 kilograms of urea per hectare to increase spinach yields. Nearly all of the researchers offered suggestions for the careful application of N and P fertilizers by the state of the soil and the requirements of the crop in a particular soil and climate.

CONCLUSION

The present investigation has led to the conclusion that at 30 days after sowing, plant height and leaf numbers per plant were significantly highest in treatment of 50 kg N/ha. Nitrogen could be the main component for the high growth rate of the studied species. Phosphorus was found responsible for the enhancement of the leaf in size and weight. Treatments had a profound effect on the growth and production of Indian spinach seeds, regardless of growing conditions. The performance of Indian spinach was found to be better during the regional season in the study site.

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A Comparative Nutritional Study on the Leaves of *Amaranthus spinosus* L., *Telfairia occidentalis* Hook. F and *Talinum triangulare* Jacq. Cultivated in Anambra State

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ABSTRACT

Vegetables like *A. spinosus*, *T. occidentalis* and *T. triangulare* are those vascular plants whose portions or portion are consumed as complement food or prime dish. A Comparative proximate study on *A. spinosus, T. occidentalis* and *T. triangulare* was evaluated to determine their nutritional characteristics with regards to moisture, ash contents, carbohydrate, protein, fat contents and crude fibre using standard methods and compared. This was to ascertain the one with the highest nutrient for optimum utilization and usefulness as a vegetable. Data were analyzed using analysis of variance. The result showed that the investigated nutrients were present in the leaves of the three species but in varied amounts. *T. occidentalis* had the highest ash, protein, fiber and lipid contents (12.30±0.01), (35.40±1.2), (1.60±0.08) and (13.70±0.6) respectively, while *T. triangulare* had the highest moisture and carbohydrate contents (5.24±0.14) and (56.32±0.58) respectively. The data obtained from this study showed that these vegetables contain appreciable amount of proteins, fat, fiber and carbohydrate needed for normal body functions and maintenance of the body with *T. occidentalis* being the most nutritious based on its protein and lipid contents. It can therefore, be concluded that these vegetables can contribute significantly to the nutrition of man and animals and should be used as source of nutrients to supplement other major sources of foods.

Keywords: *Amaranthus spinosus,* Nutritional Study, *Talinum Triangulare, Telfairia Occidentalis*, Supplement, Vegetable

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1. INTRODUCTION

Vegetables are esculent plants or portions of a plant consumed as complement food or prime dishes and they may be fragrant, acrid or flavourless (Mensah et al. 2008). They are greatly encouraged to be eaten because they have a proportionally extreme nutritional quality and provide daily food intake and flavor to the diet (Airaodion et al. 2019e). In botany, a leaf is a plant shoot organ specialized for the process of photosynthesis (Idris, 2011). Typically leaves are broad, flat and thin (dorsoventrally flattened), thereby maximizing the surface area directly exposed to light and enabling the light to penetrate the tissues and reach the chloroplasts, thus promoting photosynthesis.

Effective use of leafy vegetables is part of Africa's cultural heritage and they perform significant functions in the customs, traditions and food culture of the African household (Mensah et al. 2008). The nutrient composition of various types of vegetables varies greatly and they are not main sources of carbohydrates compared to the starchy foods which form the bulk of food consumed, but contain vitamins, essential amino acids, as well as minerals and antioxidants (Fasuyi, 2006). Vegetables form vital compositions of the diet, by providing nutrients and food sources that are crucial to human health. A rational diet rich in sufficient fruits and vegetables forms a healthy circulatory system (Zheng, 2017). They make up a greatly various group of crop plants that are consumed for their edible leaves, which have adequate minerals and vitamin. They are mostly short-lived herbaceous plants available during wet and dry seasons of the year. Vegetables supply some elements in which other food materials are deficient; they are sources of essential minerals elements for proper growth and development (Dhellot et al. 2006). Leafy vegetables such as *Amaranthus* species, *Celosia argentea* (amaranth), *Vernonia amygdalina* (bitter leaf), *Talinum triangulare* (water leaf), *Telfairia occidentalis* (fluted pumpkin) have large amounts of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorous (Sheela et al. 2004; Nnamani et al. 2010).

T. triangulare is a leafy vegetable of the genus *Talinum*, family portulacaceae. It is found in open places with rich top soil. Aside its usage as a vegetable, *Talinum* is also used as fodder for snails and supplement for chickens and turkeys; the carotenes make the yolk of the eggs of these birds yellow. Waterleaf is extremely nutritious, revitalizing and delicious and, as such, it is used in different cuisines for preparing a number of dishes. Aja et al. (2010) reported that the leaves contain significant amount of bioactive compounds necessary for preventing and treating various ailments.

A. spinosus usually known as prickly amaranth or spiny amaranth is a species belonging to the tropical Americas but now on most places as an introduced species. Amaranth leaves have lysine a vital amino acid required for energy production and calcium absorption. Eating amaranth leaves reduces appetite as they are high in protein. It suppresses insulin levels in the blood and makes one feeling satisfy (Okeke et al. 2020). As a vegetable, it is used in soups, stews and porridges. It is usually consumed as cooked complements to major carbohydrate staples such as yam, rice and plantain.

T. occidentalis is a perennial, dioecious herb. It is indigenous to and grows in the coastal zones of West and Central Africa. It is native to South-East Nigeria, and is widely cultivated in Nigeria, Benin and Cameroon. *T. occidentalis* is commonly grown for its palatable and nutritious leaves which are used mainly as vegetable. The tender shoots, fleshy leaves and immature seeds can also be cooked before consumption. It contains abundant calcium-containing crystals, phosphorus and sulphur, especially in its leaves; hence, its high mineral content value. Pregnant women and patients suffering from anaemia use the leaf juice as tonic and as blood booster (Okoli, 2013).

T. triangulare, A. spinosus and T. occidentalis are species of immense nutritional, agronomic and medicinal importance. A comparative nutritional study of these important vegetables has not been carried out or rather scanty, hence the need for the present study. The aim of this study was to evaluate their nutritional characteristics with regards to moisture, ash contents, carbohydrate, protein, fat contents and crude fiber and compared. This was for their optimum utilization and usefulness as vegetables.

2. MATERIALS AND METHODS

2.1. Study Area

The research was carried out in the Department of Botany, Nnamdi Azikiwe University, Awka, (6^0 12N/, 7^0 04E/).

2.2. *Procurement and identification of plant species*

Talinum triangulare, Amaranthus spinosus and *Telfairia occidentalis* were collected between the months of March-April 2022 from farmers at Awka. The species were identified and given voucher number by a taxonomist in Botany Department, Nnamdi Azikiwe University, Awka, Anambra State.

2.3. Preparation of plant samples

The leaves were examined and confirmed to be disease-free. They were manually separated and dried in the oven for 2 days. The dried samples were then crushed with the hand and ground into powdered form using an electric grinder. The samples were weighed with an analytical weighing balance.

2.4. Nutritional analysis of the plant species

The analysis was done to assess the amount of nutrient (moisture, ash, crude fat, crude protein, and crude fiber) present in the plant samples. This was carried out using the standard methods described by Association of Official Analytical Chemist (AOAC, 2005).

2.5. *Statistical Analysis*

Data collected were analyzed using analysis of variance (ANOVA) and treatment means were separated using DMRT at 5% level of probability. Results were presented in Mean ± Standard Deviation.

3. RESULTS AND DISCUSSION

The results of the study were presented in Table 1 and Plates 1-3

The result of the study showed that the investigated nutrients were present in the leaves of the three species but in varied amounts. According to Wang *et al*. (2004), the bioactive compositions of herbal extracts can differ widely with the plant variety. The result revealed that *T. occidentalis* had the highest ash, protein, fiber and lipid contents while *T. triangulare* had the highest moisture and carbohydrate contents (Table 1). Thus, *T. occidentalis* is a better source of ash, protein, fiber and lipids while *T. triangulare* is a better source of moisture and carbohydrate. Moisture content makes impactful contribution to the texture of the leaves and help in keeping the protoplasmic content of the cells. Though high moisture composition of vegetables makes them to promote the digestion of food, however high moisture content also lower the shelf life of vegetables because they facilitate bacterial and fungal action resulting into spoilage (Akinwunmi and Omotayo, 2016).The moisture content value of the leaves of the sample vegetables were relatively low. Foods with low moisture content can stay longer. The low moisture content would therefore impede the growth of spoilage microorganisms and improve shelf life (Ruberto and Baratta, 2000).

T. occidentalis has the highest fats/lipid content (1.70±0.60) among the three vegetables, *A. spinosus* and *T. triangulare* with low lipid/fat content (0.15±0.03) and (0.38±0.05) respectively. This low fat content might be an added advantage of consumption of Amaranths as high fat content is a predispository factor to cardiovascular diseases (Lovejoy, 2002). Consumption of *Telfairia occidentalis* is hereby recommended as it is of great source of fats and it benefits human health since vegetable fats and oils are known to lower blood lipids thereby reducing the occurrences of diseases associated with the damage of the coronary artery (Adenipenkun and Oyetunji, 2010). Dietary fat increases the palatability of food by absorbing and retaining flavors (Antia *et al*., 2006). The consumption of *A. spinosus* and *T. triangulare* in large amount is a good dietary habit and may be recommended to individuals suffering from overweight and obesity (Akinwunmi and Omotayo, 2016). Gordon and Kessel (2002) reported that low fat foods help to reduce cholesterol level and obesity.

The leaves of *A. spinosus* and *T. triangulare* show the highest crude fiber content (16.33±0.08) and (26.12±0.05) compared to *T. occidentalis with* (1.60±0.08).Fiber cleanses the digestive tract by removing potential carcinogens from the body and prevents the absorption of excess cholesterol. Fiber also adds bulk to the diet and prevents the intake of excess starchy food (Mensah *et al*. 2008). Fiber may therefore guard against metabolic conditions such as hypercholesterolemia and diabetes mellitus (Henry, 2004). Dietary fiber has a positive effect in the

management of diabetes by controlling post-prandial hyperglycemia. It delays gastric emptying or increase the viscosity of gastro-intestinal tract content thereby suppressing digestion of carbohydrate and delays its absorption. The substantial amount of fiber in *T. triangulare* and *A. spinosus* leaves shows that they can help in keeping the digestive system healthy and functioning properly. Fiber aids and speeds up the excretion of waste and toxins from the body, preventing them from sitting in the intestine or bowel for too long, which could cause a build-up and lead to several diseases. Adequate intake of dietary fiber can lower the serum cholesterol level, risk of coronary heart disease, hypertension, constipation, diabetes, colon and breast cancer (Rao and Newmark, 1998; Ishida et al. 2000).

Table 1: Percent Quantitative Proximate Composition of Leaves of *Amaranthus spinosus*, *Telfairia occidentalis* and *Talinum triangulare*

S/N	*Amaranthus spinosus*	*Telfairia occidentalis*	*Talinum triangulare*
Ash	3.62±0.02	12.30±0.01	4.27 ± 0.05
Moisture	4.90±0.01	4.60±0.60	5.24±0.14
Carbohydrate	48.74±0.14	33.40±2.40	56.32±0.58
Protein	26.11±0.09	35.40±1.20	8.51±0.09
Crude fiber	1.53±0.08	1.60±0.08	1.32±0.05
Crude fat	0.15±0.003	1.70±0.60	0.38±0.05

Results are in mean ± Standard deviation

Figure 1-3. *T. occidentalis, A. spinosus* and *T. triangulare* in their natural habitat respectively

The leaves of *T. occidentalis* has a high crude protein content of (35.40±1.2) followed by *A. spinosus* with (26.11±0.09) with the least value in *T. triangulare* (8.51±0.09). Plant proteins are a source of food nutrient especially for the less-privileged population in developing countries including Nigeria. Proteins are one of the macromolecules and are an alternate energy source when other energy sources are in short supply. They are building block units and food protein is needed to make vital hormones, important brain chemicals, antibodies, digestive enzymes, and necessary elements for the manufacture of DNA. Some proteins are involved in structural support, while others are involved in bodily movement, or in defense against germs (Bailey, 2008).

The result of the analysis reveals that the three vegetables have moderately high carbohydrate content and therefore contributes to great amount, the energy level in those vegetables. Carbohydrates are essential for the maintenance of life in both plants and animals and also provide raw materials for many industries (Ebun-Oluwa and Alade, 2007). Carbohydrates produced by plants are one of the three main energy sources in food, along with protein and fat. When animals eat plants, energy stored as carbohydrates is released by the process of respiration, a chemical reaction between glucose and oxygen to produce energy, carbon dioxide, and water. Glucose is also used by animal cells in the production of other substances needed for growth (Westman, 2002).

It is generally known that the ash content in a sample is indication of the amount of minerals present in it (Fagbohun et al. 2012) and as such high ash content

would mean a corresponding high mineral element in the sample. *T. occidentalis* had ash value of (12.30±0.01) compared to *A. spinosus and T. triangulare* with lesser values (3.62±0.02) and (4.27±0.05). The result therefore suggests a high deposit of mineral elements in *T. occidentalis* leaves. Generally, mineral are significantly important to cell and system functions.

4. CONCLUSION

People eat vegetables not just because they like vegetable but also for the nutritional benefits derived from them. The data obtained from this study showed that these vegetables contain appreciable amount of proteins, fat, fiber and carbohydrate needed for normal body functions and maintenance of the body with *T. occidentalis* being the most nutritious based on the protein and lipid content. It can therefore, be concluded that these vegetables can contribute significantly to the nutrition of man and animals and should be used as source of nutrients to supplement other major sources of foods.

Authors' contributions

This work was carried out in collaboration between all authors. Author CVI designed the study and all authors wrote the first draft of the manuscript and managed the literature searches. Author CVI and ONT managed the analyses of the study and Author CVI supervised the work

Competing interests

Authors have declared that no competing interests exist.

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Taxonomic Study of *Chrysophyllum albidum* Found in Awka Anambra State, Nigeria

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ABSTRACT

Taxonomic study was carried out on the stem, leaf, root, flower, and fruit of *Chrysophyllum albidum* using standard techniques. Morphological result revealed that the plant is a tree with greyish brown to dark brown stem which is glabrous and circular in shape. The leaves are green, compound (imparipinnate in arrangement), pubescent texture, and elliptical in shape. The flowers are actinomorphic, free and arranged in clusters. The fruits are depressed globose, yellow to orange when mature and have about 5 seeds arranged in a star pattern in the fruit hence the name star apple. The quantitative characters revealed the leaf length as 24.7±4.01 cm, leaf width as 8.20±0.69 cm, petiole length 1.83±0.21 cm, and stem girth 1.44 ±0.67 m. Anatomical studies revealed the presence of cortical parenchyma containing prismatic crystals in the cross-sections of some of the organs studied. The parenchyma cells have a brick wall arrangement in the radial and transverse longitudinal section of the stem. The presence of sclerenchyma and well-defined vascular bundle in the transverse section of the stem was also revealed. The overall data collected could be used as a viable tool in the identification of African star apple and retain their characters now that many plant species are genetically modified and in the delimitation of the taxa in the species level.

Keywords: Taxonomy, Morphology, Anatomy, *Chyrsophyllum albidum*

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INTRODUCTION

Chrysophyllum albidum commonly known as African star apple or white star apple is a forest fruit tree within the Sapotaceae family commonly found throughout tropical Africa. Primarily it is a forest tree species and naturally occurs in diverse Eco zones in Nigeria, Uganda, Niger Republic, Cameroon and Cote d'Ivoire (Bada, 2017). Sapotaceae family comprises of 70 genera and 800 species, 23 genera and over 300 species are found in West Africa of which the genus *Chrysophyllum* can be found. Nigeria has 7 of the species including *albidum* (Gill, 2015). In Nigeria, it is called Agbalumo in Yoruba, Udara in Igbo, and Agwaliba or Agwaluma in Hausa. *C. albidum* is an evergreen tree which often grows to a height of 25 to 37m with a girth varying from 1.5 to 2m though it may be smaller. The bole is buttressed at the base,

extending into fluting, and can be up to 2 meters in diameter. Although the branches usually start from low down on the bole, occasional specimens have cleat boles for up to 20 meters (Burkil, 2015). The fruit of the plant species is a large berry (3-4cm) containing 3-5 flattened brown shiny seeds (1-1.5 x 2cm) arranged in a star shaped pattern in the yellow pulp with a hard seed coat (Keay, 2013). Recently the species has become a crop of commercial value in Nigeria. The fleshy pulp of the fruit is eaten especially as a snack and enjoyed by both young and old (CENRAD, 2017). The fruits are also suitable for the production of fruit jams and jellies (Ureigho and Ekeke, 2010). Each of the species produces milky latex. The bark, foliage, and fruit of *C. albidum* are used in traditional medicines. Ecologically, the tree has an efficient nutrient cycling and the high rate of mineralization of the leaves improves the quality of the top soil. Amusa et al. (2014). Members of this species are often characterized by the presence of reddish –brown hairs on the abaxial leaf surfaces. The species leaves are simple, alternate or they are rarely opposite usually entire and ciriaceous. They have regular flowers, usually bisexual and actinomorphic. Morphological characters can be grouped into vegetative and floral or reproductive characters this make up the greater part of the appearance of most species which enables us to recognize them. An anatomical character consists of the transverse, radial and micro morphological characters which are of taxonomic importance. *Chrysophyllum* species has close morphological resemblance and there is apparent conceptual similarity between plant anatomy and plant morphology as a tool in plant identification hence this study on the morphological , transverse and radial anatomical characteristics of *Chrysophyllum albidum* found in Awka to ascertain the classification and identification of the species and delimitation of the taxa.

MATERIALS AND METHODS

The leaves and stems of *Chrysophyllum albidum* were collected from the wild in a farm at Amansea , Anambra State. The samples were identified and authenticated by a plant Taxonomist Mr Chisom Iroka. The voucher specimen was assigned 29D as the number and then deposited at the herbarium of the Department of Botany, Nnamdi Azikiwe University, Awka.

Study Area

The morphological studies were done in the Botany laboratory of Nnamdi Azikiwe University, Awka; while the anatomical studies were carried out at the Anatomy laboratory of the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka.

Morphological Studies

Morphological assessment was by physical observation and measurement of physiognomic features. Observations on vegetative characteristics were studied using samples collected from mature plant. For the leaves, the third and fourth fully opened leaves from the stem tip were used. Measurements were taken using a meter rule and tape rule. The meter rule was used to measure the leaf length, leaf base, and petiole length. The tape rule was used to measure the stem girth. The leaf shape, leaf texture, leaf margin, leaf arrangement, leaf type, leaf venation, and stem colour were studied by intense observation. Photographs of the prominent morphological features were taken.

Anatomical Studies

Materials used for carrying out anatomical studies

The following materials were used for the anatomical studies; petri-dishes, masking tape, camel brush, scalpel, forcep, slides, cover slip, digital camera and a compound binocular microscope (Olympus XN50V). The chemicals and reagents used include; safranin red, glycerin, 99% ethyl alcohol, absolute ethanol, formalin alcohol, acetic acid, distilled water

Procedure

Anatomical studies were carried out with the methods of Kadiri *et al*., (2007), Kadiri and Ayodele (2010), and Ajayi *et al*., (2011) with some modification. The stem and midrib samples were sectioned using a sliding Reichert microtome. The blade was well sharpened with the automatic microtome knife sharpener. The thin slices of plant parts obtained were kept in water before being transferred onto a glass slide after which few drops of 99% ethyl alcohol was added for tissue hardening and then 2 drops of safranin. Distilled water was used to wash off the excess stain and then a drop of glycerin was added afterwards. The slides were

covered with cover slips and ringed with nail varnish to prevent dehydration. The prepared sections were viewed under an Olympus light microscope at different magnifications. Photomicrographs of specimen were taken with a Nikon digitalized camera.

MORPHOLOGICAL RESULTS

Morphological features of Chyrsophyllum albidum

Table 1: Floral Morphology of *C. albidum*

Characters Inflorescences	
Floral symmetry	Actinomorphic
Pedicel length (cm)	0.5-1
Type	Cymose
Free/ Fused	Free
Arrangement	Cluster
Sex	Bisexual
Flowering period	May- June
Calyx	
Colour	Greenish yellow
Number of sepal	6
Free/ Fused	Free
Corolla	
Number of petal	6
Colour	Light greenish
Free/ Fused	Free
Androecium	
Anther shape	Bilobed
Filament Number	10-12
Gynoecium	
Ovary position	Superior
Style	1
Stigma	Lobed
Fruit	
Shape	Ovoid –subglobose
Colour when unripe Colour when ripe	Green Yellow
Type	Berry
Seed arrangement	Star Shaped
Number of seed	3-5
Seed colour	Brown
Fruit colour	July- August

Table 2: Vegetative Morphology

STEM CHARACTERS	
Habit	Evergreen
Stem type	Dichtomously branching
Stem colour	Greyish to dark brown
Height (m)	32- 36
Tree shape	Dense
Bark	Rough
Girth (m)	1.8- 2.6
Type of root system	Tap root
LEAF	CHARACTERS
Leaf colour	Green
Leaf venation	Reticulate
Leaf Margin	Entire
Leaf Apex	Obtuse
Leaf base	Cuneate
Leaf shape	Elliptic
Texture	Leathery
Type	Simple
Arrangement	Alternate
Attachment	Petiolate
Petiole length (cm)	1.83± 0.21
Leaf Length (cm)	24.7± 4.01
Leaf width (cm)	8.20 ± 0.69
Stem girth (m)	1.44 ± 0.67

Plate 1: Leaf morphology

Plate 2: Stem of *C. albidum*

ANATOMICAL RESULTS

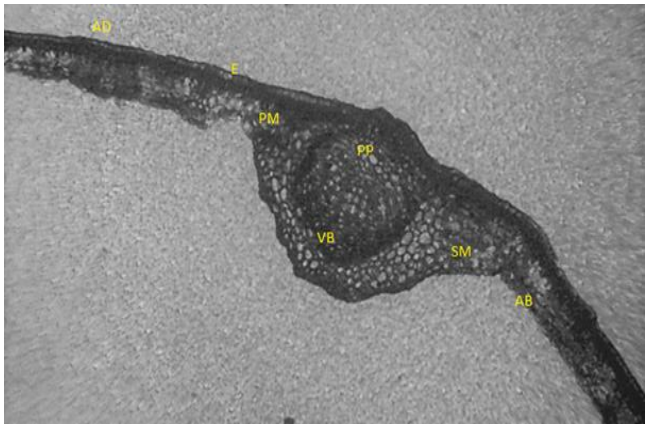
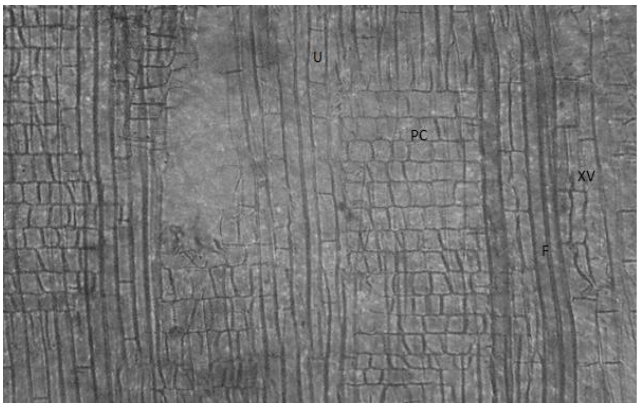


Plate 3: Transverse section of *C. albidum* Leaf

KEYS:
AB = Abaxial Surface
AD = Adaxial Surface
E = Epidermis
PM = Palisade Mesophyll
PP = Pith Parenchyma
SM = Spongy Mesophyll
VB = Vascular Bundle

Plate 4: Radial Longitudinal Section of *C. albidum* stem



KEYS:
F = Fiber
PC = Parenchyma Cell
U = Uniserate ray cell
XV = Xylem Vessel

Plate 5: Transverse Longitudinal Section of *C. albidum*

KEYS:
PC = Parenchyma Cell
PR = Prismatic crystal
R = Ray
V = Vessel

Plate 6: Transverse section of stem of *C.albidum*

KEYS:
C = Cortex
E = Epidermis
IC = Inter-Vascular Cambium
P = Pith
PC = Parenchyma Cell
PH = Phloem
S = Sclerenchyma
X = Xylem

DISCUSSION

In plants, the older and most adopted methodology that has been used to produce classification system is the observation and description of internal and external plant characters. This has been used by many authors in the taxonomic studies of plant species. Morphological characters are easily observable and obtainable thus are used most frequently in taxonomic studies. They make up the greater part of the appearance of most species which allows us to recognize them virtually. Plant anatomy deals with formed structures which are the inner structures of plants that become visible only when the plant is dissected and this enables the structures to be observed comparatively. Plant anatomy provides characters such as trichomes, stomata, curticular pattern, leaf venation, wood anatomy growth rings. The morphological and anatomical features of *C.albidum* revealed distinctive characteristics that can be used for taxonomic decisions in the identification of the plant. *C. albidum* is an evergreen and dichotomous branched tree with an average height of 25m and a low branched crown and sometimes a buttress bole. This supports the work of Bada, 2017, on the morphological characters of the plant. The result of the average stem girth observed in this study was 1.44m as opposed to the girth being between 1.5-2m according to Burkil, 2015; this may be as a result of environmental factors. The leaves are green, compound (imparipinnate in arrangement), pubescent, elliptical in shape. The leaf margin is entire with an acuminate leaf apex and a cuneate leaf base. This is in accordance with Besong et al. 2006 observation on the characters of the leaf length and petiole length. Leaves are one of the most diverse plant organs in terms of morphology and anatomy and such morphological and anatomical characters can vary drastically according to environmental conditions. This may attribute to some variations in the morphological and anatomical characters observed in this study as regards its environment. However studies has revealed that analysis of certain external and internal leaf structures could be of substantial information to aid species classification; Bibian et al. (2016) and Chinelo et al. (2013). The morphological character of the flower showed that the flowers are small, actinomorphic cluster at the axil leaves, bisexual and cyme; this is a good taxonomic attribute. The sepals are greenish – yellow also a good character for differentiating the plant species from other species of *Chyrsopyllum* species and delimiting the taxa at species level. The fruits of African star apple are depressed globose with a yellow to orange colour when ripe; the inside is fleshy and red to orange in colour with laterally compressed shiny brown ellipsoid seeds arranged in a star shaped pattern within the fruit. The stem is circular, glabrous, and greyish brown to dark brown in colour, and the roots are adventitious, this conforms to Burkil, 2015. Anatomy has been of great help in learning the differences and similarities between various plant species which has helped in plant identification. In the radial anatomy, two plants may appear very similar on the surface but when sectioned they are different. The anatomical studies showed sections of the leaf and stem. There were prismatic crystals in their cortex, pith and vascular bundles (mostly xylem tissues). The mesophyll is characterized by palisade parenchyma and spongy parenchyma. The vascular bundles are embedded mainly in the spongy mesophyll extending to the adaxial epidermis. The radial longitudinal section of the stem revealed a brick wall arrangement of the parenchyma cells, the xylem fiber in its longitudinal line, uniserate ray and vessel, while there was presence of prismatic crystals in the parenchyma cells of the transverse longitudinal section of the stem. This also is in line with the study of Ekeke and Agogbua (2019). Presence of intervascular cambium in the vascular bundle of the stem signifies secondary growth and a wide pith for food storage which is located at the center of the stem, the cortex which is located to the outside of the vascular bundles. There were also sclerenchyma cells present on the epidermis of the stem.

CONCLUSION

Based on the findings of this study, morphology of *C. albidum* investigated conforms to the already morphological characters described by some authors. The differences that may be seen in the quantitative characters may be as a result of environmental factors. Morphological characters are easily observable and obtainable, hence frequently used in the taxonomic studies. Anatomical study has revealed that it can be used in addition to morphology in the identification, and delimitation of the taxa at species level.

COMPETING INTEREST

Authors have agreed no competing interest exist.

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Analyzing the Relationship between Soil Properties and Crop Productivity Using Geophysics and Statistical Models

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ABSTRACT

Agronomists and researchers have demonstrated persistent interest in examining the relationship between soil properties and crop productivity with the objective of improving agricultural practices. The application of geophysics and statistical models offers valuable techniques for analyzing the complex nature of this relationship. This article investigated the application of geophysical techniques and statistical models to understand the impact of soil properties on agricultural productivity. It thoroughly examined the main factors that influence this relationship through an extensive analysis of existing literature. The results showed that there was correlation between crop yield and soil nutrient level, soil texture, pH level and increased electrical conductivity. The study further recorded that electrical resistivity increased with greater depth due to further dryness in the soil. The study's findings and analyses made valuable contributions to improving agricultural methodologies and increasing crop productivity, while also prioritizing the preservation of sustainable soil management techniques.

Keywords: Agricultural practices, Crop productivity, Electrical resistivity, Geophysics, Statistical models, Sustainable soil management.

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INTRODUCTION

The productivity of agricultural systems is intricately linked to the soil's quality in which crops are cultivated. To effectively implement sustainable and efficient agricultural practices, it is crucial to have a comprehensive understanding of the intricate interplay between soil properties and crop productivity. In the past, analyzing soil properties, such as its appearance, nutrient content, pH level, and water retention, necessitated a substantial

amount of labor and time, as well as the inclusion of specific values (Rabot et al. 2018). It alters the manner in which we scrutinize these specific relationships. Geophysics provides non-invasive techniques for assessing soil properties, while statistical models allow for the examination and forecasting of the impact of these properties on agricultural yield. This article examines the utilization of geophysics and statistical models to comprehend the complex correlation between soil characteristics and agricultural productivity. The foundation of human civilization is primarily rooted in the implementation of agriculture, where the crucial factor for agricultural prosperity lies in the interaction between soil attributes and crop productivity. The historical literature acknowledges the significance of comprehending the inherent characteristics of the land where agricultural workers opt to cultivate crops. The role of soil goes beyond its function as a factor for plant growth. The intricate interaction among the physical, chemical, and biological characteristics of soil directly affects the quality, strength, and ultimately the overall potential yield of agricultural crops (Fageria, 2002).

The increasing need for food, fiber, and biofuels due to the expanding global population has exerted unparalleled pressure on agricultural systems (Westcott and Trostle, 2012; Fedoroff et al. 2010; Balakuntala et al., 2018). Ensuring food security and promoting sustainable development heavily relies on optimizing the utilization of cultivated lands (Chen et al., 2021).To achieve this goal, it is crucial to have a thorough understanding of the factors that determine agricultural production. It is at this point that the combination of geophysics and statistical models emerges as a powerful catalyst for change.

Historically, the assessment of soil properties required the use of laborious and time-consuming methods. Soil samples were obtained from various locations in a specific field, then carefully analyzed in the laboratory, and the results were extended to cover the entire area. The heterogeneity of soil properties within a field can be significant, making the conventional approach insufficient for capturing this spatial variability (Piotrowska-Długosz et al. 2018). Moreover, the reliance on empirical correlations often showed a lack of accuracy in predicting and guiding immediate management decisions.

Geophysics comprises a range of non-intrusive techniques that allow for the examination of underground soil properties without compromising its structural integrity (Khan et al. 2021). These methodologies provide a significant quantity of data regarding soil texture, moisture levels, compaction, and the distribution of roots. By understanding the spatial distribution of these characteristics, farmers and researchers gain knowledge about the variability within a specific agricultural area. This knowledge enables them to make more precise and targeted decisions regarding field management.

The amalgamation of geophysics and statistical models has expedited the investigation of the intricate interdependencies between soil attributes and agricultural productivity. The application of statistical models, made possible by the advent of advanced computing technology, enables the effective examination of large datasets and the detection of meaningful patterns (Aditama et al. 2017).

This article conducts a thorough examination of the incorporation of geophysics and statistical models to understand the intricate relationship between soil properties and crop productivity. Through a thorough examination of existing academic literature, we investigate the core factors that impact this connection. The concrete advantages of this approach are emphasized by the exposition of the study's results and analyses (Tan and Shibasaki, 2003), which were carried out in a representative agricultural field. Our discussions analyzed the abilities and limitations of these techniques, thus enabling informed recommendations that could potentially transform modern agriculture.

A multitude of scholarly studies have examined the impact of soil composition on agricultural yield. Soil physical properties, including texture, structure, root permeability, water retention, and nutrient availability, greatly influence soil water retention and drainage (Panagea et al. 2021). The soil's texture is determined by the proportions of sand, silt, and clay present. This phenomenon arises and consequently impacts the plants' capacity to acquire vital nutrients and water. The chemical composition of soil, which includes the nutrient content and pH levels, significantly influences and supports plant growth (Cekstere and Osvalde, 2013). The presence of vital nutrients, such as nitrogen, phosphorus, and potassium, significantly influences the growth and

development of crops. The pH of soil is influenced by soluble nutrients and the activities of microorganisms, which in turn impact the quality of soil and plant ecosystems. Geophysical methods such as electromagnetic induction (EMI), ground penetrating radar (GPR), and electrical resistivity tomography (ERT) play a crucial role in studying soil properties through electrical measurements (Liu et al. 2011). EMI, in particular, is commonly used to assess geothermal lightning energy features as well as to determine water content and salinity. GPR is an efficient method for observing the terrain and distinguishing distinct layers with varying properties. Electrical Resistivity Tomography (ERT) provides valuable information about subsurface resistivity, a parameter closely linked to soil texture and water content.

The integration of geophysics into statistical models has expanded the scope of understanding concerning these relationships. Narayan (2021) introduced the application of machine learning techniques to predict crop yield. The forecast was derived from a combination of factors, including soil characteristics, meteorological data, and historical crop productivity data (Narayan, 2021). The aforementioned methodology provided a thorough understanding of the complex dynamics that affect crop productivity, enabling the identification of previously overlooked factors. Geostatistical techniques, like kriging, have been used to interpolate soil property data spatially. This application facilitates the creation of intricate maps that provide valuable guidance for making precise agricultural management decisions.

The fusion of geophysics and statistical modeling holds great potential for the future of agricultural practices. The studies mentioned above collectively highlight the importance of implementing an interdisciplinary approach. By employing geophysical techniques to assess soil properties and utilizing advanced statistical models for data analysis, significant advancements can be made in improving crop productivity, conserving resources, and promoting sustainable agricultural practices.

Statistical models, such as regression analysis, machine learning, and geostatistics, enable the combination of soil data and crop yield data (Chowdary et al. 2022; Lekakis et al. 2022). These models have the ability to identify significant correlations between different soil properties and crop performance. By analyzing past data and taking into account various environmental factors, statistical models can accurately predict how changes in soil characteristics will affect crop yield. Significant research has been carried out in the fields of agronomy, soil science, and geophysics to examine the relationship between soil characteristics and crop yield. Over time, numerous research studies have revealed key factors that influence this relationship. The use of geophysical methods and statistical models has brought new perspectives to this important area of agricultural research.

The studies have established the fundamental significance of soil texture in determining crop productivity (Doe, 2018). The researchers discovered that soil with a loamy texture has improved water retention abilities and allows roots to penetrate easily, leading to better plant growth. The discovery sparked an interest in exploring the capabilities of geophysical methods, particularly EMI and GPR, to map variations in soil texture within agricultural fields Freeland et al. (1998). Lesch et al. (2005) conducted a study where they used electromagnetic induction (EMI) to assess soil electrical conductivity as a measure of soil texture. This method enabled the real-time monitoring of spatial fluctuations and offered valuable support for precision agriculture initiatives.

A comprehensive study has been conducted to examine the impact of nutrient availability on crop productivity. Grzebisz et al. (2020) highlighted the significance of soil nutrient availability, particularly nitrogen (N), phosphorus (P), and potassium (K), in influencing plant growth and the sensitivity of crop yield.

Alamry et al. (2017) showcased the merging of geophysics and soil nutrient evaluation by employing ERT to map out the spatial diversity of nutrient dispersion. The application of this technique enabled accurate fertilization, thereby reducing inefficiency and mitigating the ecological repercussions linked to excessive nutrient consumption.

The pH of the soil, which is an essential soil attribute, significantly affects the accessibility of nutrients and the functioning of microorganisms. The research conducted by Msimbira et al. (2022) emphasized the importance of maintaining appropriate pH levels to achieve the best possible crop performance. Geophysical techniques, particularly EMI, have been studied to indirectly estimate soil pH by examining its

relationship with electrical conductivity (EC). Uchida et al. (2019) proposed a non-invasive method to assess pH variations in agricultural fields. This technique aids in identifying precise regions that could be improved through soil management interventions to optimize pH levels.

MATERIALS AND METHOD

Research Design and Data Collection: 15 locations were selected from the Agricultural Farmlands of Abavo in the Ika South Local Government Area of Delta State. The selected areas represent the typical range of soil properties and crop types in the region. Secondly, soil data was collected on texture, nutrient content, and electrical conductivity using geophysical techniques such as electromagnetic induction (EMI) and electrical resistivity tomography (ERT). Also, crop yield data was gathered across multiple agricultural cycles, taking into account various crops and planting seasons.

1.Data Preprocessing

The data that were collected were carefully cleaned and validated to remove any inconsistencies or outliers, and then integrated by combing the soil and crop yield data to create a comprehensive dataset for analysis.

2. Analysis of Soil Properties

2.a). Soil texture analysis

Soil texture analysis was also carried out using geophysical methods like EMI and GPR to assess soil texture and categorize areas into sandy, loamy, or clayey soil types.

2.b). Nutrient Content

Analyze soil samples for nutrient content, with a focus on nitrogen (N), phosphorus (P), and potassium (K). Finally, electrical conductivity was measured using EMI to evaluate soil moisture levels.

3. Statistical Graphs

Graphs were employed to show the relationship between soil properties (texture, nutrient content, and electrical conductivity) and crop yield.

RESULTS

The results of the study are presented in Tables 1-8 and interpreted in Figures 1-6.

Soil Texture and Crop Yield

Figure I showed that the data points clustered around certain soil types, indicating a correlation between soil texture and crop yield. Loamy soil appeared to result in the highest crop yield.

Nutrient Content and Crop Yield

The bar chart displayed in Table 2, Figure 2 showed the average crop yield at different nutrient content levels (Low, Medium, and High). It shows that there was a significant difference in crop yield associated with varying nutrient content. Higher nutrient levels, particularly "High," were linked to higher crop yields.

Electrical Conductivity vs. Crop Yield

Crop yield varied with changes in electrical conductivity (soil moisture levels) as shown in Table 3. It shows that as electrical conductivity (indicative of soil moisture) increased, crop yield also tended to increase. This suggests that higher soil moisture levels positively affected crop yield.

Soil pH and Plant Growth

Figure 4 presents the influence of different soil pH levels on plant growth. It demonstrated that plants generally thrived at a soil pH of 7.0. At this neutral pH, the plant growth score reached its peak value of 10. As soil pH deviated from 7.0, the plant growth score tended to decrease. For instance, at a pH of 5.5, the growth score was 7, and as pH increased to 9.2, the score declined to 7 as well. This suggests that soil pH significantly affected plant growth, with optimal growth occurring at a near-neutral pH.

Soil Moisture Content and Electrical Resistivity

In the scatter plot (Figure 5), the relationship between soil moisture content and electrical resistivity was examined at different depths. As depth increased, soil moisture content generally decreased. For instance, at the surface (0 cm), the soil moisture content was around 20%, and it gradually decreased to about 10% at a depth of 30 cm. On the other hand, electrical resistivity

demonstrated an opposite trend. It tended to increase with greater depth, indicating a higher resistance to electrical flow as the soil got drier. This suggests that moisture content and electrical resistivity had a discernible inverse relationship as we moved deeper into the soil.

Table 1: Soil Properties and Their Importance in Crop Productivity

Soil Property	Importance in Crop Productivity
Soil Texture (1)	Influences root penetration, water-holding capacity, and draage
Nutrient Content (2)	Critical for plant growth, especially nitrogen, phosphorus, and potassium
Soil pH (3)	Affects nutrient availability and microbial activity
Electrical Conductivity (EC)	Indicates soil moisture and salinity, related to nutrient availability
Compaction	Influences root growth and water movement
Organic Matter	Enhances soil structure, water retention, and nutrient cycling

Table 2: Geophysical Techniques and Their Applications in Soil Assessment

Geophysical Technique	**Application in Soil Assessment**
Electromagnetic Induction (EMI)	Mapping soil electrical conductivity and indirectly inferring soil texture
Ground-Penetrating Radar (GPR)	Imaging soil profiles, detecting layers with different properties
Electrical Resistivity Tomography (ERT)	Mapping subsurface resistivity, related to soil texture and water content
Magnetic Susceptibility (MS)	Indicating soil mineral content and potential nutrient availability

Table 3: Soil Texture Analysis

Soil Location	**Soil Type**	**Crop Yield (kg/ha)**
Location 1	Sandy	300
Location 2	Loamy	450
Location 3	Clayey	250
Location 4	Sandy	320
Location 5	Loamy	500
Location 6	Sandy	280
Location 7	Loamy	460
Location 8	Clayey	240
Location 9	Loamy	470
Location 10	Clayey	260
Location 11	Sandy	330
Location 12	Loamy	490
Location 13	Sandy	310
Location 14	Clayey	270
Location 15	Loamy	480

Machine Learning Results

Figure 6 showed the relationship between soil texture and nitrogen content on crop yield. Darker lines represented higher crop yields, indicating that specific combinations of soil texture and nitrogen content led to better results in the past. This information can inform future agricultural decisions and practices.

DISCUSSION

The study's results offer significant insights into the intricate relationship between soil properties and

crop productivity, shedding light on key factors that influence agricultural outcomes. The correlation observed between soil texture and crop yield, as illustrated in Figure 1, underscores the importance of understanding the physical composition of soil in agricultural productivity. The preference for loamy soil aligns with previous research, emphasizing its positive impact on water retention, drainage, and root penetration (Buccigrossi, et al. (2009). This finding has practical implications for farmers, guiding decisions on crop selection and soil management practices.

Table 5: Nutrient Content Analysis

Soil Location	Nitrogen (ppm)	Phosphorus (ppm)	Potassium (ppm)	Crop Yield (kg/ha)
Location 1	25	12	40	380
Location 2	30	15	45	420
Location 3	20	10	35	350
Location 4	28	14	38	400
Location 5	32	16	42	440
Location 6	24	11	36	360
Location 7	31	15	41	410
Location 8	22	12	37	370
Location 9	33	17	43	450
Location 10	26	13	39	390
Location 11	29	14	44	430
Location 12	34	18	46	460
Location 13	27	12	40	380
Location 14	23	10	34	340
Location 15	35	19	47	470

Table 6: Electrical Conductivity Analysis

Soil Location	Electrical Conductivity (mS/m)	Crop Yield (kg/ha)
Location 1	1.2	360
Location 2	1.5	420
Location 3	1.0	330
Location 4	1.4	400
Location 5	1.6	440
Location 6	1.1	350
Location 7	1.5	420
Location 8	1.0	330
Location 9	1.7	460
Location 10	1.3	390
Location 11	1.6	440
Location 12	1.8	480
Location 13	1.2	360
Location 14	1.0	330
Location 15	1.9	490

Table 7: Machine Learning Results

Soil Location	Soil Texture	Nitrogen (ppm)	Phosphorus (ppm)	Potassium (ppm)	Electrical Conductivity (mS/m)	Crop Yield (kg/ha)
Location 1	Sandy	25	12	40	1.2	370
Location 2	Loamy	30	15	45	1.5	420
Location 3	Clayey	20	10	35	1.0	330
Location 4	Sandy	28	14	38	1.4	400
Location 5	Loamy	32	16	42	1.6	440
Location 6	Sandy	24	11	36	1.1	350
Location 7	Loamy	31	15	41	1.5	420
Location 8	Clayey	22	12	37	1.0	330
Location 9	Loamy	33	17	43	1.7	460
Location 10	Clayey	26	13	39	1.3	390
Location 11	Sandy	29	14	44	1.6	440
Location 12	Loamy	34	18	46	1.8	480
Location 13	Sandy	27	12	40	1.2	370
Location 14	Clayey	23	10	34	1.0	330
Location 15	Loamy	35	19	47	1.9	490

Table 8: Soil Moisture Content and Electrical Resistivity

Depth (cm)	Soil Moisture (%)	Electrical Resistivity (Ωm)
0	20	300
10	15	400
20	12	500
30	10	600
40	18	350
50	25	250
60	30	200
70	28	220
80	22	320
90	17	420
100	10	550
110	8	620
120	14	410
130	19	330
140	23	280

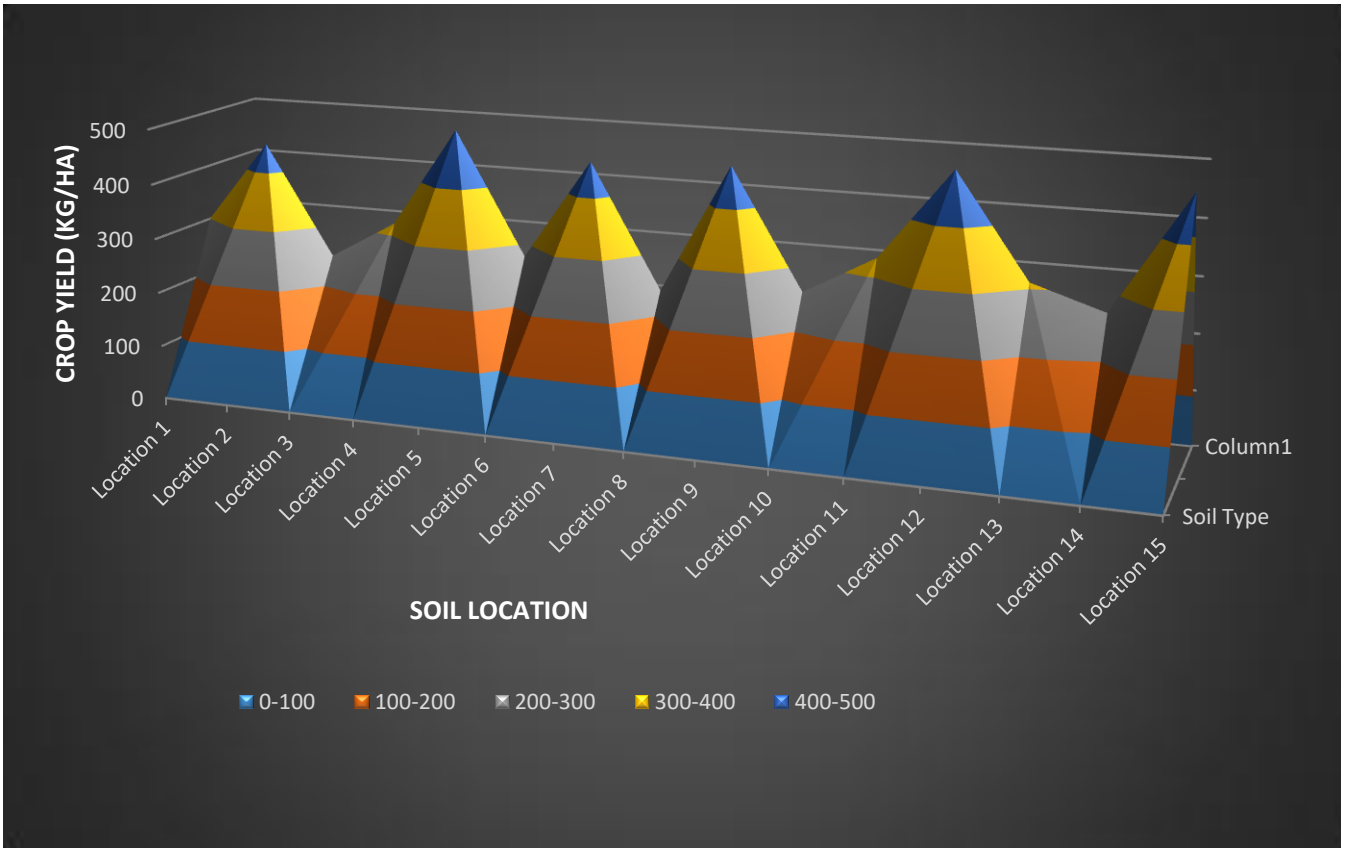

Figure 1: Soil Texture vs. Crop Yield

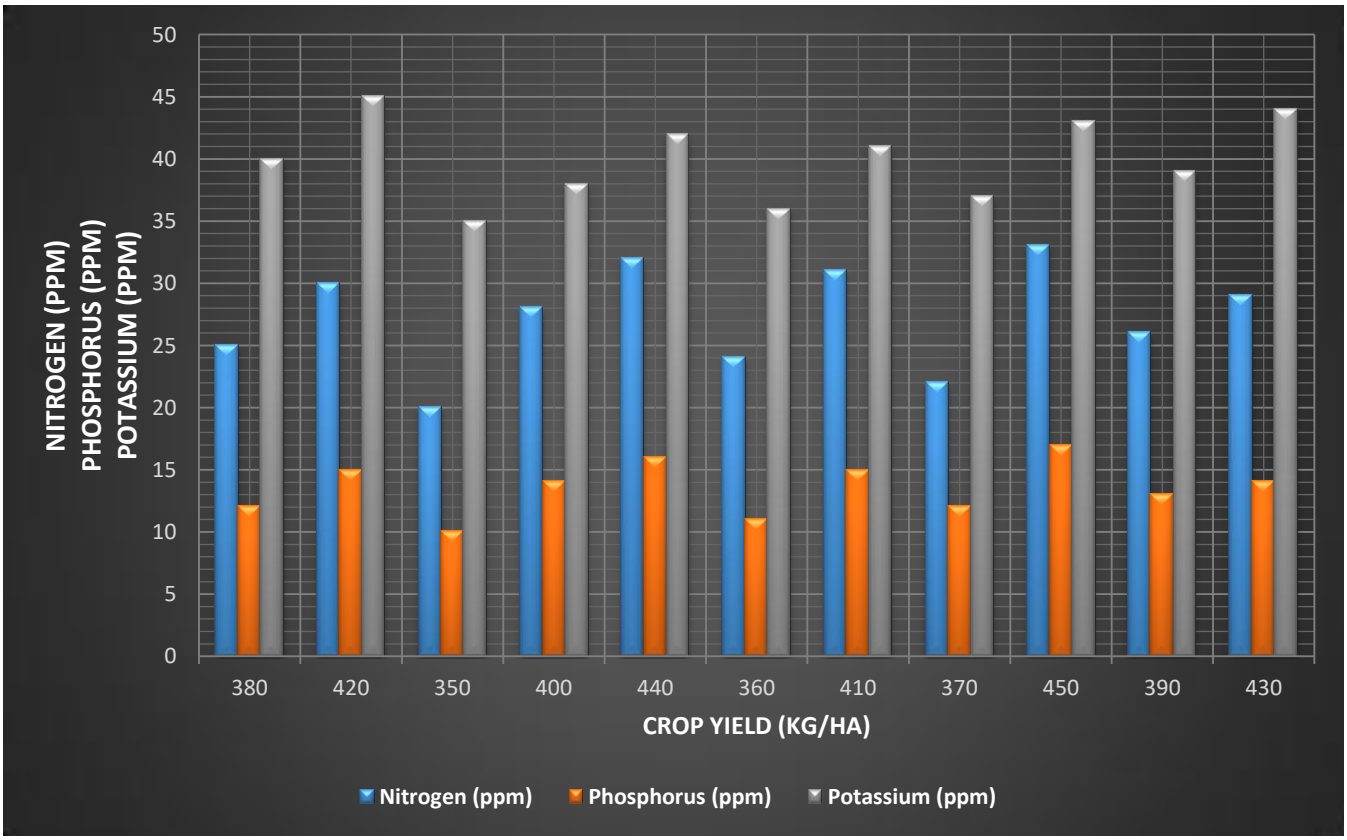

Figure 2: Nutrient Content vs. Crop Yield

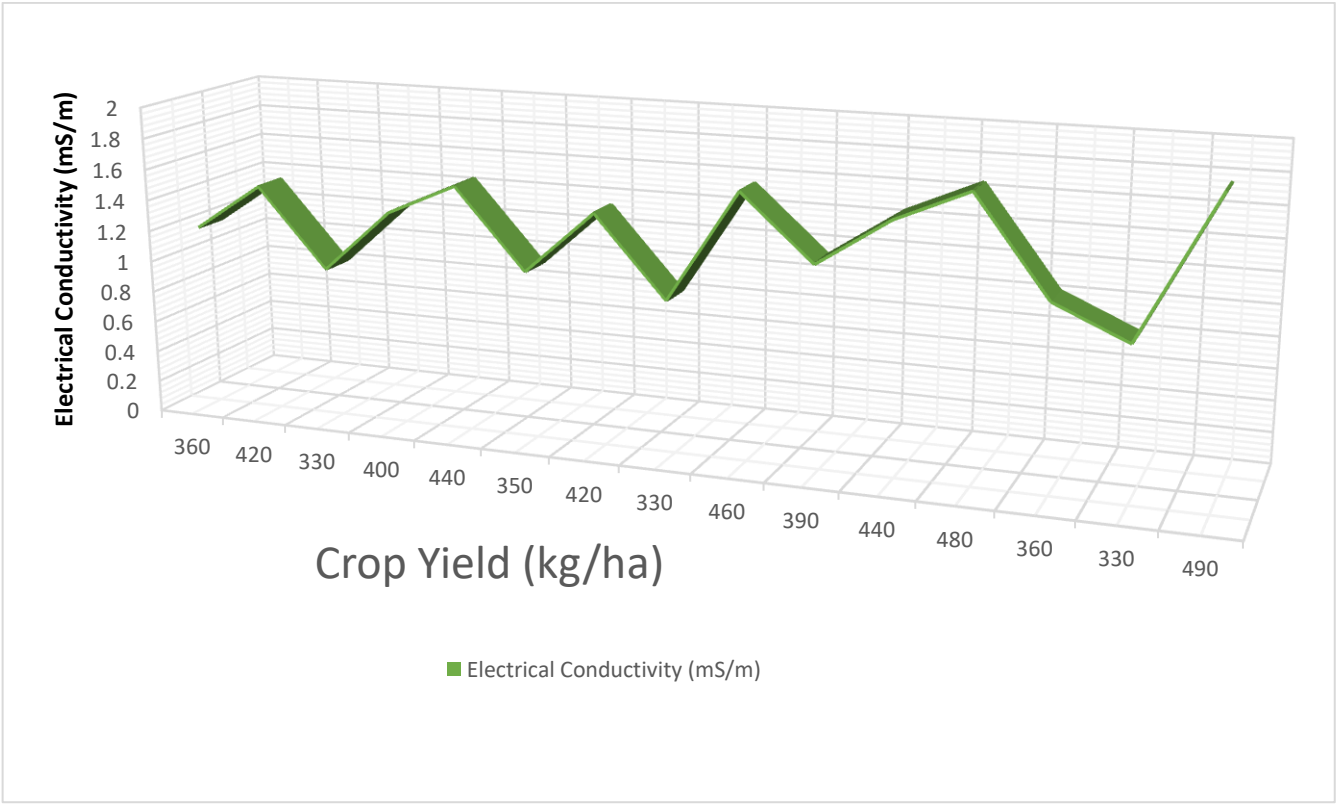

Figure 3: Electrical Conductivity vs. Crop Yield

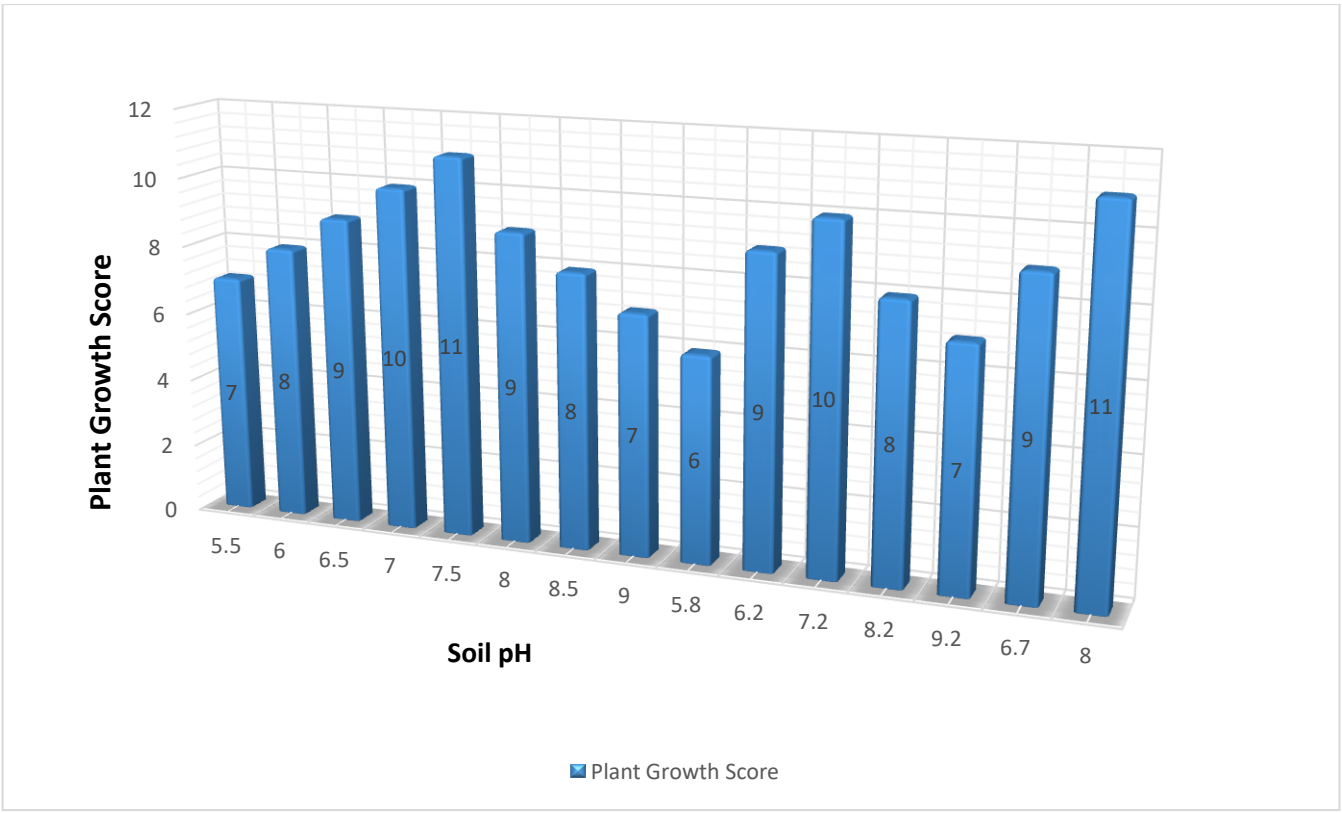

Figure 4: Soil pH and Plant Growth

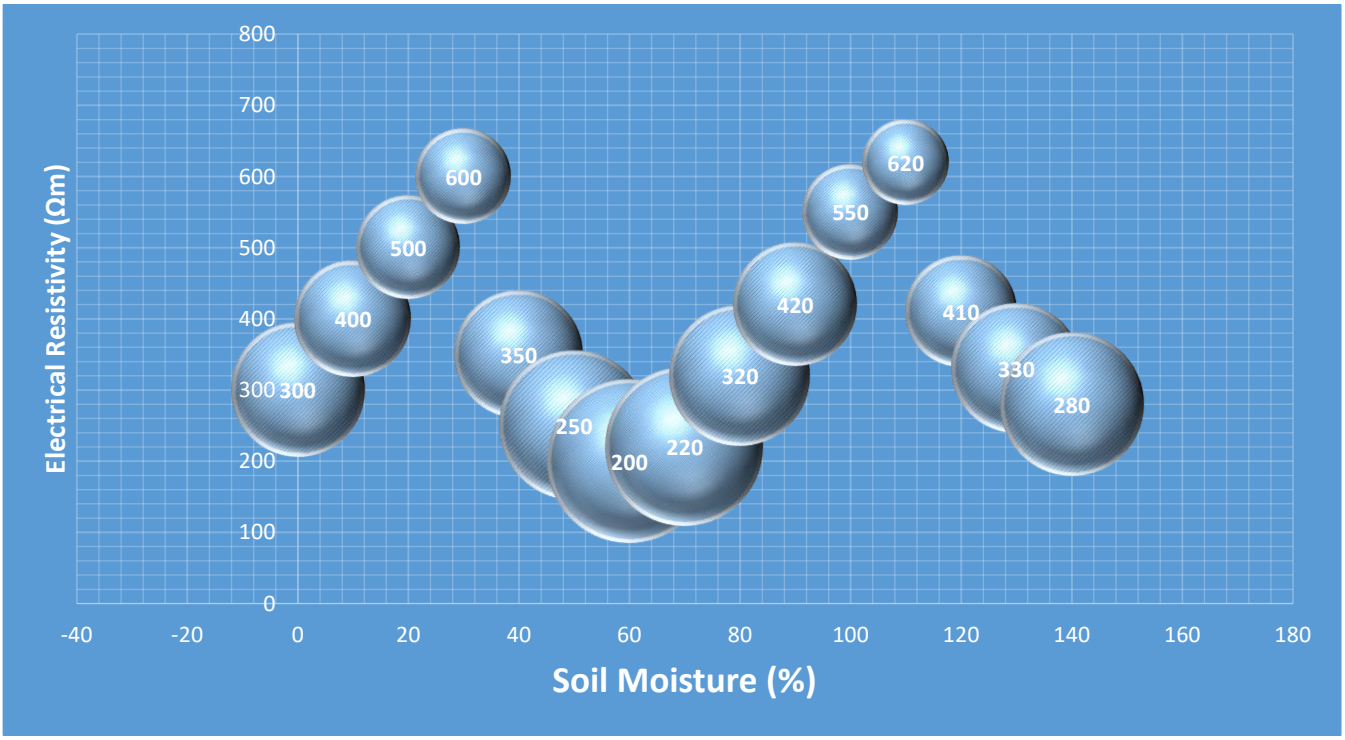

Figure 5: Soil Moisture Content and Electrical Resistivity

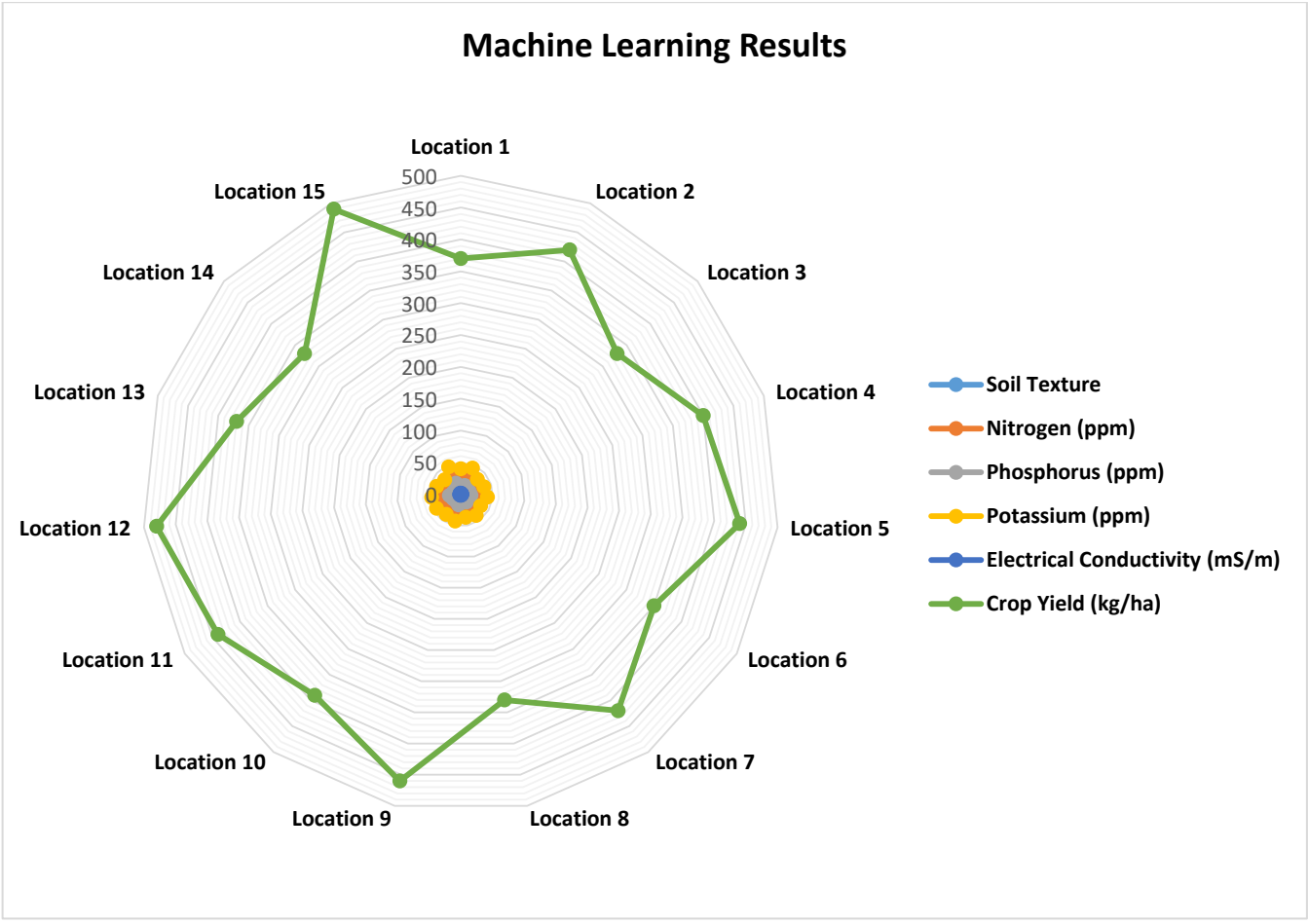

Figure 6: Machine Learning Results

Soil nutrients were reported to impact crop yield as well. Higher levels of nitrogen, phosphorus, and potassium correlate with increased crop productivity, validating the critical role of soil nutrient availability in supporting plant growth. The integration of geophysics for nutrient mapping, as showcased by Alamry, et al. (2017), offers a practical approach to optimize fertilization practices and enhance overall crop yields.

Electrical Conductivity and Soil Moisture

The positive relationship between electrical conductivity and crop yield, depicted in Figure 3, reinforces the importance of adequate soil moisture for optimal plant growth. Higher electrical conductivity, indicative of increased soil moisture, is linked to improved crop yields. This aligns with conventional wisdom in agriculture and provides a quantitative validation of the relationship between soil moisture and crop productivity.

Furthermore, the influence of soil pH on plant growth, revealing an optimal pH level for peak plant performance was highlighted. Deviations from neutral pH levels impact plant growth, emphasizing the need for precise pH management in agricultural practices Lee, et al. 2019). This finding underscores the significance of understanding and maintaining appropriate soil pH to maximize crop yields.

The study has shown a comprehensive view of the relationship between soil moisture content and electrical resistivity at different depths. The observed inverse relationship suggests that as soil moisture decreases with depth, electrical resistivity increases. This understanding can guide decisions related to irrigation and soil moisture management, particularly in different soil layers.

The machine learning results offer a visual representation of historical relationships between soil texture, nutrient content, and crop yield. Darker lines highlight combinations associated with higher crop yields, providing actionable insights for farmers. This integration of machine learning techniques contributes to the advancement of precision agriculture, allowing for more informed decision-making.

Limitations and Considerations

While the results provide valuable insights, it's essential to acknowledge the limitations of geophysical methods and statistical models. Calibration with traditional soil sampling may be necessary for precise interpretation of geophysical data. Additionally, the effectiveness of statistical models is contingent on the quality and quantity of available data, emphasizing the importance of robust data collection and analysis.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the study's findings contribute significantly to the understanding of the complex interdependencies between soil properties and crop productivity. The practical implications extend to on-the-ground decisions for farmers and agronomists, informing choices related to soil management practices, crop selection, and resource optimization. The recommendations for further investigations into integrating geophysical data with other environmental variables reflect a commitment to continuous refinement and improvement in predictive models for enhanced agricultural precision. Ultimately, the integration of geophysics and statistical models holds transformative potential for sustainable agricultural practices, ensuring both food security and environmental stewardship.

The amalgamation of geophysics and statistical models holds the potential to fundamentally transform agricultural practices. Through precise evaluation of soil characteristics and anticipation of their influence on agricultural output, farmers can make well-informed choices regarding fertilization, irrigation, and crop choice. This approach not only enhances crop production but also encourages the practice of sustainable soil management.

Nevertheless, it is crucial to acknowledge the constraints of these methods. Geophysical methods yield valuable spatial data but may necessitate calibration with conventional soil sampling for precise interpretation. Statistical models depend on the caliber and quantity of accessible data, underscoring the significance of resilient data gathering and examination.

Ultimately, the correlation between soil characteristics and crop yield is a pivotal aspect in contemporary farming. The combination of geophysics and statistical models provides effective tools for

comprehending this correlation, offering valuable insights that can direct sustainable agricultural practices. The study highlights the importance of soil texture, nutrient composition, and moisture levels in influencing crop productivity. We suggest conducting additional investigations into the integration of geophysical data with other environmental variables, such as climate and topography, in order to improve the precision of predictive models.

It is advisable for farmers and agronomists to contemplate implementing these techniques in order to enhance the efficiency of their operations. Utilizing geophysical methods for regular soil assessments can effectively detect areas within the field that exhibit diverse soil properties, thus facilitating focused interventions. Furthermore, the utilization of statistical models for yield prediction enables the implementation of proactive management strategies, resulting in enhanced productivity while simultaneously reducing environmental consequences.

By incorporating the knowledge and analysis offered by geophysics and statistical models, the agricultural community can work towards a future in which effective crop production and environmentally responsible soil management are closely linked, guaranteeing both food security and the protection of the environment.

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Qualitative and Quantitative Ethnobotanical Study of Arrang Valley of District Bajaur, Khyber Pakhtunkhwa Pakistan

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ABSTRACT

The findings of the ethnobotanical field work in the Arrang valley of Bajaur are presented. Arrang is a closed valley, 18 kilometers long and gifted with some of the most important plant species which are on the verge of extinction. How this traditional knowledge can contribute to modern scientific human plant diachronic interactions, is emphasized in the current research. Totally 180 persons were properly interviewed in Arrang, ranging from specialists in traditional ethnobotanical knowledge to common persons. Although the valley and its adjacent area about of 300 species. During current research only 163 species were documented. Only two species of gymnosperm were found worth consideration and 118 species belonging to 80 families of Angiosperms were documented. One species belong to Pteridophytes. These plants have been in active use up to the present time as food, medicine, tools, materials for construction, resources for rituals, for the sake of naming, fodder, timber, fuel, honey bee attractants, aromatic, broom making, toothbrush, ornamental, cage making, rope making, staple food, vegetable, fruit, flavoring and soil binders etc. According to the accumulated ethnobotanical information most of the plants served multiple functions. The most abundant species belonged to families Brassicaceae, Asteraceae, Rosaceae, Euphorbiaceae, Lamiaceae and Solanaceae. Due to over exploitation and over grazing about 12 species are on the verge of extinction in the area such as *Xanthium stromonium, Ammivisnaga, Foeniculum vulgare, Trigonella foenum-graecum, Melia azedarach, Ailanthus altissima, Berberis lycium, Quercus baloot, Rumex hastatus, Tecrium stocksianum.*

Keywords: Ethnobotany, Local communities, 118 species of Angiosperms, 80 families of Angiosperms, 2 species of gymnosperm, One species of Pteridophytes.

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1. INTRODUCTION

District Bajaur present in the north East Latitude 34° 30' to 34°58' North as well as Longitude 71◦11' to 71◦48' East occupying an area of 1290 square km at present time. The district is also divided in to seven tehsil 1. Khar (142sq)[2]. Salarzai 253, Mamund 216, Nawagai150, Chamarkand 009, Uthman Khel 150 and Barang tehsil 370 sq.km area respectively (Ullah et al. 2018). Bajaur has 46.55 km long common border line with Afghanistan's province, Kunar; with lower Dir's region Jandool, the boundary line is 56.75 km; with Mohmand its length is 68.19 km and Malakand Agency shares 23.68 km long boundary line with Bajaur (Ajaib et al. 2021). The total population according to the recent census exceeds 1.5 million persons. Bajaur lies amid Latitude 34◦ 30'to 34◦58' North as well as Longitude 71◦11' to 71◦48' East. Occupying an area 1290 Km square at present time (Ullah et al. 2023). Arrang is the dwelling place mainly of Uthman Khel tribe, particularly of the Shamozai branch of Uthman khels (Ullah et al. 2018). Uthman Khel belongs to Karlani stock of Pashtun tribes, but they had put in their lot with Khakhi Khel and particularly Yousafzai tribe. They helped one another in different battles and usually migrated jointly from one place to another. Uthman Khel had their abodes in the vicinity of Kabul along with Yousafzai (Farooq *et al.,* 2010; Ullah et al. 2018). Later on, they migrated to Nangahar and then to Tank and Gomel valley. From there the whole family shifted to Peshawar, but the atmosphere was not conducive for this tribe's nomadic habits there, and as a consequence went to Teerah and after the battle of Katlang the whole tribe shifted to the present locality, Arrang. And since that time, they have been residing there and have trickled down and moved side by side, occupying much larger space for their residence (Ahmad et al. 2006). The total population of Arrang valley is 60,000 individuals. As the area is landlocked and fertile land is very scanty due to lack of abundance of water, a lot of families migrate to other parts of Bajaur or elsewhere. Although most of the people of this area are attached to agriculture (Lubna et al. 2023). A climatic condition of district Bajaur is severe in together winter as well as summer. The winter is very moist as well as cold while summer is very hot and June July is the hottest month which mean the high temperature is 33°C and 24°C correspondingly (Ajaib et al. 2021). The coldest months as January and December which mean high temperature of 7°C in December 9°C but in January which are wrote in the (Yaseen et al. 2019). Ethnobotany is the learning of alliance as well as association among people along with plants in place with time (Ullah et al. 2018). Every learning that describes involvement amongst the plants and local people are related to ethnobotany (Murad et al. 2013). It is the branch of science which deals with relationship between plants and people (Khan et al. 2018). Since olden days human has been in close association with plants for the sake of food, shelter and medicine. Indigenous communities of the world have been since long dependent on plants for their objects of ritual and common use. Land with environment has been of tremendous import for flowering and growth of the cultural, religious and social systems (Ullah et al.2018). Plants acting as safeguard and steward of their domain and environments, they have been entrusted by their ancestral characters to take care of these during several succeeding generations (Ullah et al. 2023). Local people have great potential and capability to develop practices and products from their environments. No sooner Pakistan came in to being than the documentation of indigenous knowledge about the usefulness of plants and its myriad of uses was started in earnest (Irfan et al.2018). Different researchers devoted their lives solely for this pursuit. "Botanical survey of medicinal plants" was an ambitious project of 1951, launched by Pakistan Ministry of Food and Agriculture (Ullah et al. 2021). These days almost all parts of the country have been rummaged for ethnobotanical purposes and thousands plant species have been identified with their particular indigenous uses. It is true that ethnobotany is still in embryonic stage in Pakistan (Hussain, 2021). The objective of the present study (1) to explore medicinal plants of research area (2) to study the biodiversity of angiosperms (3) to documents the ethnobotanical use of the area.

2. MATERIALS AND METHODS

The ethnobotanical information of the valuable plants of Arrang valley Bajaur was collected from April 2019 to March 2020. The research area was visited regularly, local people were interviewed, and data on ethnobotanically and medicinally valuable plants was collected. A modified questionnaire was also used in the collection of information from the people. The collected information was also cross-checked during these study trips. Mostly aged people were selected for interview, with only fifty (50) people were contacted from the research area. The

plant samples were gathered from all parts of the study region. The collected flora was recognized with the assist of obtainable literature as well as the latest principles of Plant Taxonomy, particularly those of Flora of Pakistan Tropics Project (Farooq et al. 2010). The time-tested and herbarium cards were correctly stacked for identification after the collected plants were properly pressed and dried (Khan et al. 2009; Ullah et al. 2023). The collected plant was properly preserved by treating with Naphthalene and moth balls. The plant specimen was deposited in the herbarium of the Botany Department at Bacha Khan University in Charsadda.

2.1 Quantitative study

Quantitative indices were calculated for the collected data to make the information more authentic and accurate. These indices were these i.e., Relative Frequency Citation, Relative Importance as well as Use Value (Hussain et al. 2022).

2.2 Relative Importance

It is intended as RI= NUC+NT Where NUC indicate numeral of exploit classes as well as NT indicate numeral of utilize aspects. Which value is NUC is intended as NUC=NUCS/NUCVS where NUCS show numeral of exploit categories with the meticulous taxa in the NUCVS indicate numeral of exploit groups with most versatile taxa which value is NT is intended as NT= NTS/NT.MIT, where NTS indicates numeral of total utilized of every category credited the species. The MIT shown numeral of whole exploited of all categories of mainly adaptable species in their latest research study (Shuaib et al. 2019).

2.3 Relative Frequency Citation

Relative Frequency Citation was calculated by the following formula as Rfc=FC/N), Where the Fc = Frequency Citation in the N is the entire numeral of interviewees. The FC characterized the numeral of utilize cited through the kind of correct species. Class of RFC deceit amid 0 and 1:0 show that the flower is not mention through even a solitary being, also 1 shows that all candidates mentioned the meticulous plant to be helpful (Ullah et al. 2023).

2.4 Use Value (UV)

The values were intended through the follow formula, UV = ∑U/N in the Ui indicates that the entire numeral of a correct sp. affirmed through one informant to N is the whole numeral of interviewees. Similarly, ∑Ui suggest the total numeral of exploited the flora by the citizens (Abbasi et al. 2013).

3. RESULT AND DISCUSSION

The people of Arrang valley are still dependent on plants in their daily lives. Because people are poor and cannot afford the modern allopathic medicine. In the current research work a total of plants cannot be separated from their lives and this reciprocal interdependence is accountable for the preservation of plant variety. Plants are either used singly or in mixture. Medicinal plants such as *Mentha longifolia, Acacia modesta, Podophyllum headroom, ajuga bracteosa, Prunus domestica* etc. are some of the medicinal plants which are in active use in Arrang. Some of the most valuable therapeutic vegetations on the verge of extermination due to over exploitation. Among these are *Periploca aphylla, Calotropis procera, Funiculum vulgare, Ammi visnaga, Ziziphus mauritiana, Withania somnifera* etc. So far know how about the use and identification of useful ethnomedicinal use of plants is concerned; elderly people beyond 60 years of age have almost 40 percent of the required knowledge. Plants are utilized for treating various ailments, accounting for 6% of the overall diseases prevalent among them. Pathetically the young generation below 50 years of age have very low level of knowledge about medicinal plants ranging from 10 to 12 %. Their use of medicinal plants was very less just falling in the ratio of 0.78 %. Children of Arrang are almost ignorant about medicinal plants but during illness they are at first treated with these medicinal plants. Due to steel and cement the trends of using timber in the constructions has been reduced considerable but still the use is visible. Furniture has retained the wood as in old days and people prefer it in comparison with steel. Complete detailed of the ethno botanical valuable plants are as below.

The research area consists of 53% shrubs, 27% trees, and 20% other vegetation. The dominant presence of shrubs provides essential cover and nesting sites for small mammals and birds, while the towering trees offer food and shelter for larger species. The remaining 20% of other vegetation, including grasses and herbs, contributes to the overall biodiversity by providing food sources and habitats for various organisms.

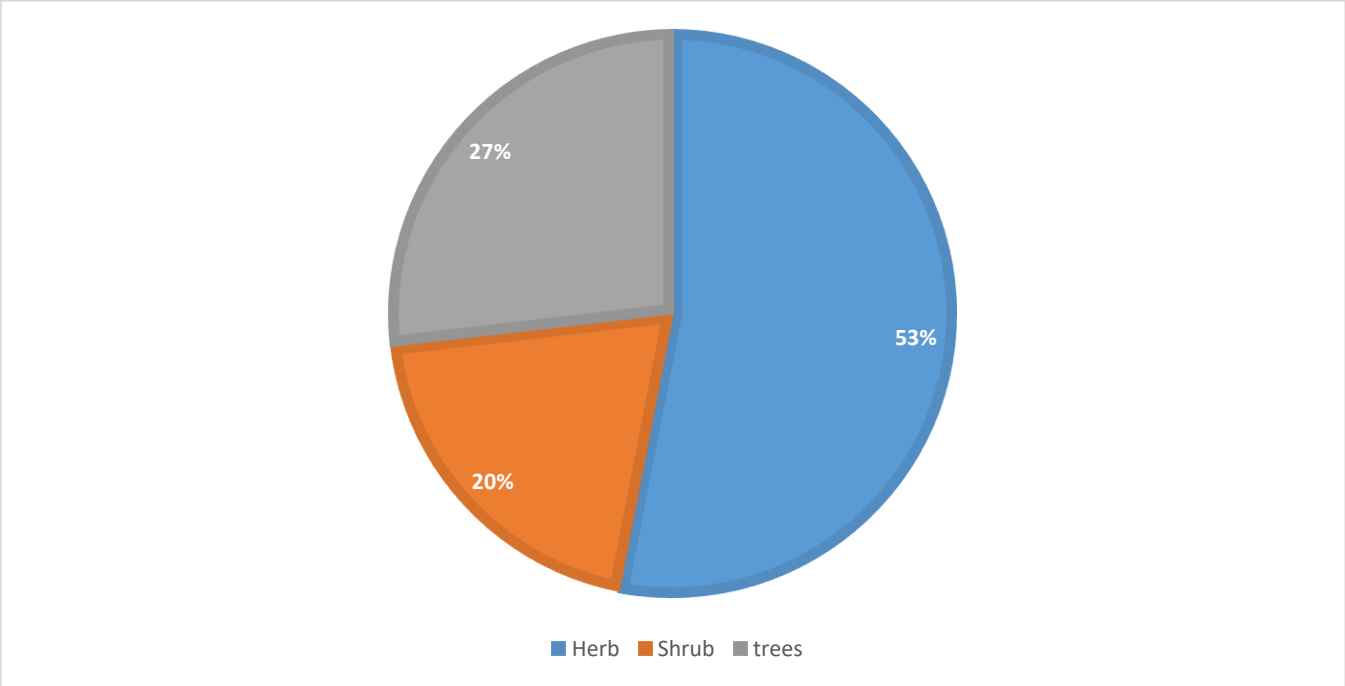

Figure No: 1 Habit wise representation of plant species of research area.

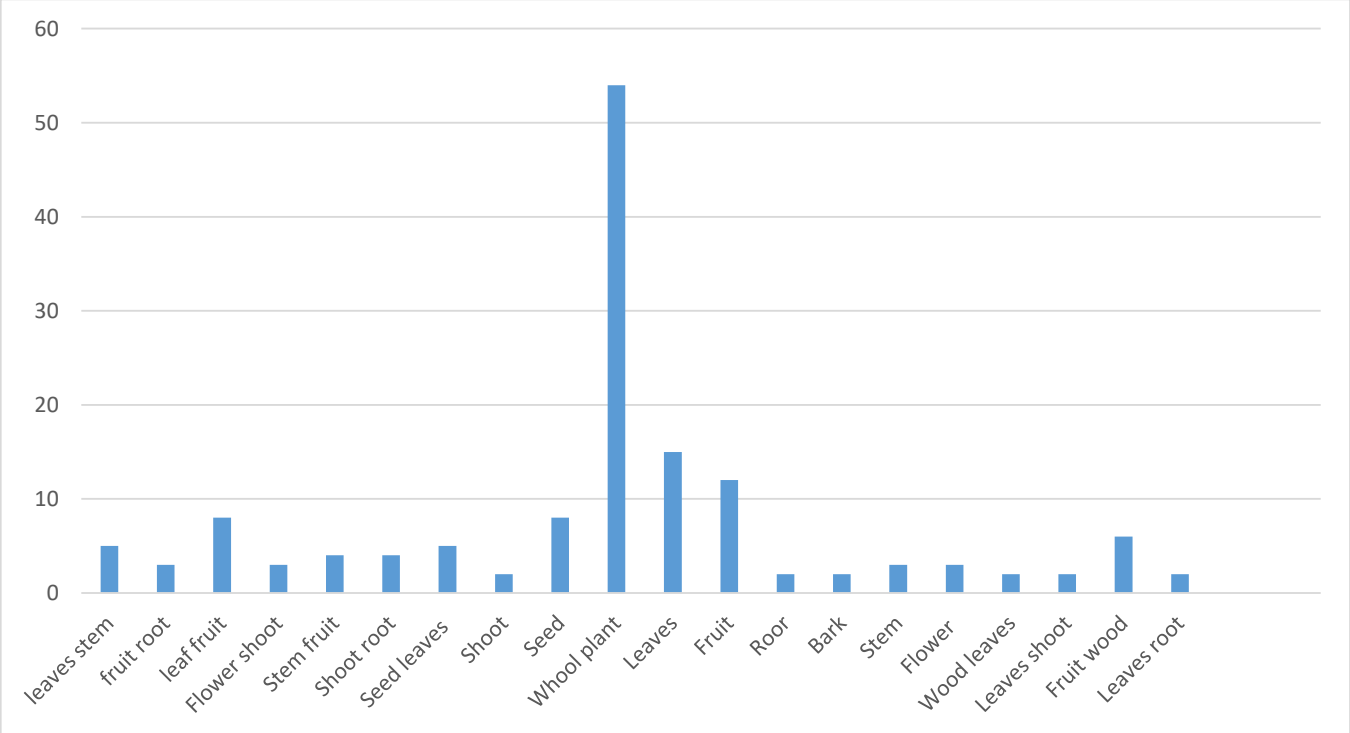

Figure No: 2 showing plant parts using in research area.

Based on the data, 163 plants were used in various ways, with the majority being utilized as an entire plant (59.56%), followed by leaves (9.83%), seeds (2.73%), fruits (9.83%), roots (1.63%), seeds and leaves (0.54%), root, leaves, and seed (0.54%), root and leaves (1.63%), fruit and leaves (7.10%), leaves, flowers, and latex (0.054%), fruit and seed (0.54%), leaves and flower (1.09%), root and bark (0.54%), wood and fruit (1.09%), flowers (1.09%), seed and latex (0.54%), root and fruit (0.54%), and leaves and stems (0.54%). Based on the data, it is evident that a wide variety of plants were utilized in different ways,

with the majority being used as an entire plant. Leaves, fruits, roots, seeds, and other plant parts were also utilized in varying proportions, highlighting the diverse range of uses for these botanical resources.

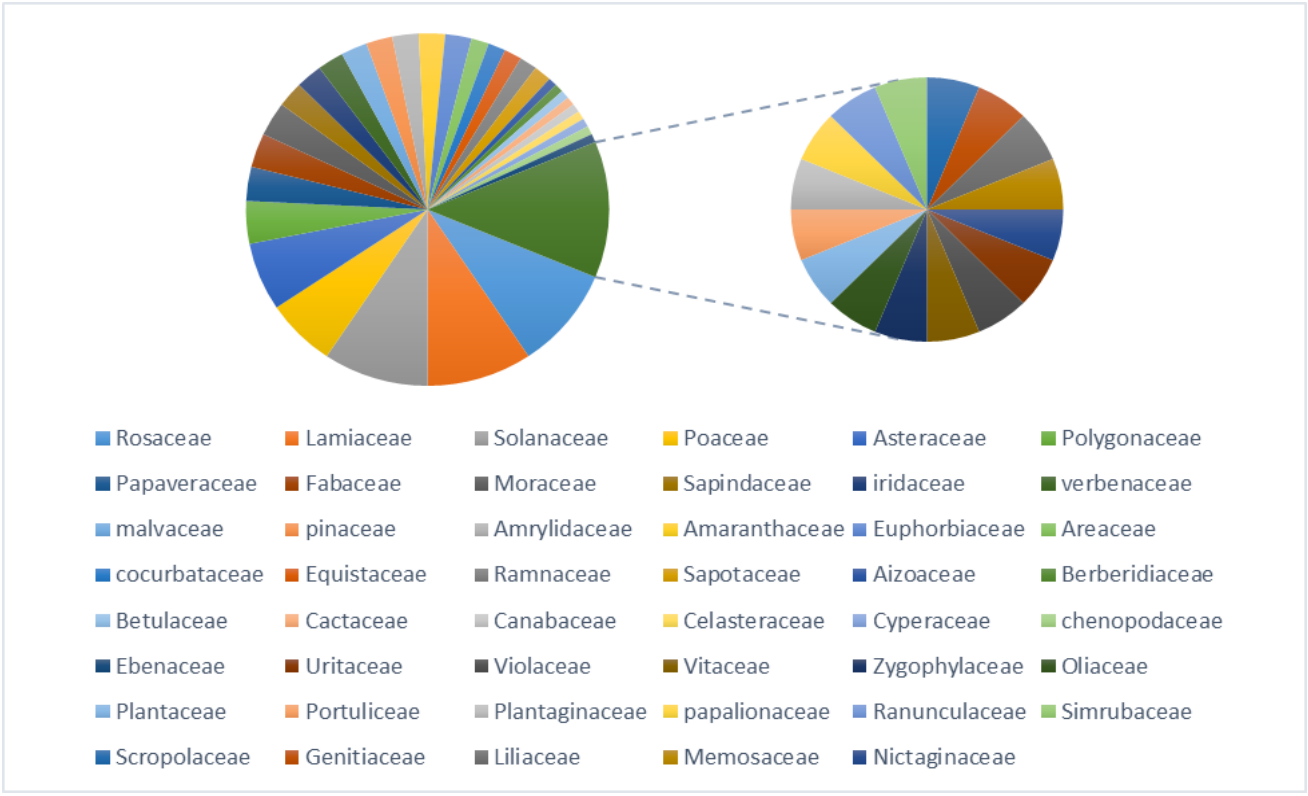

Fig: 3 Show family wise representation of plant present in the research area.

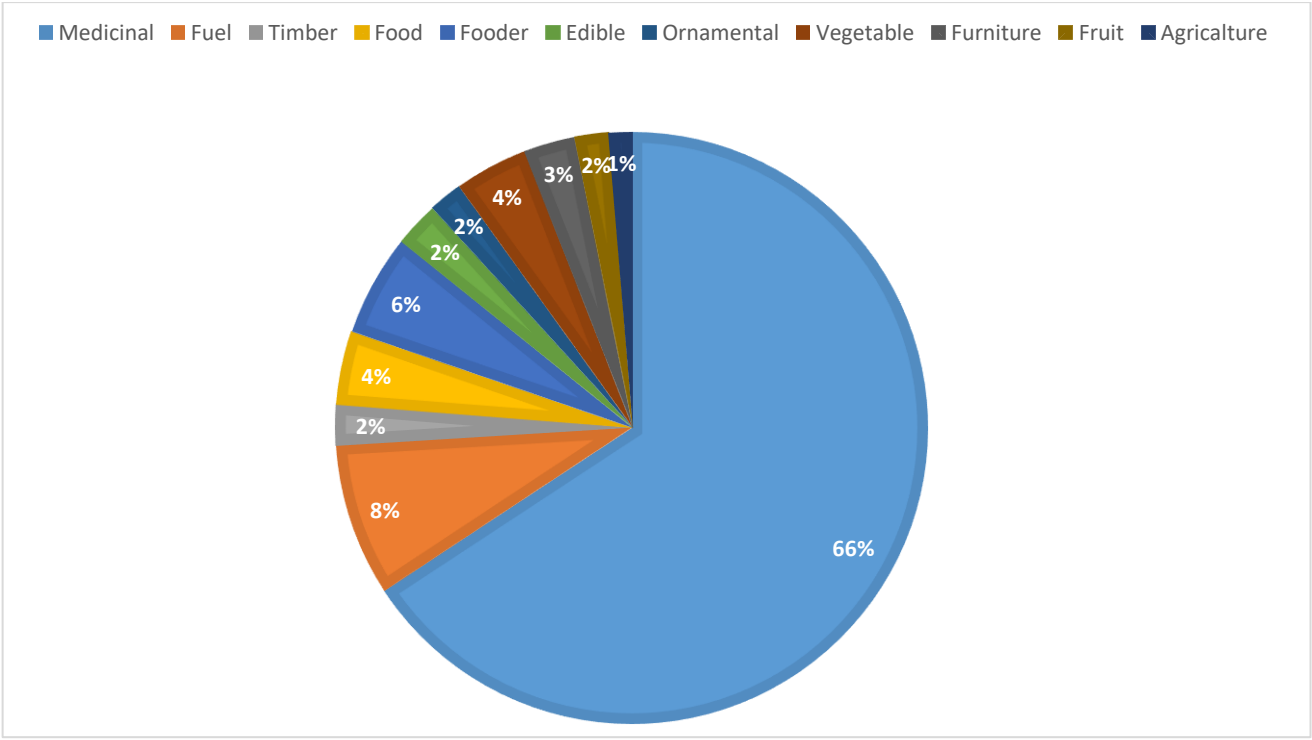

Fig No: 4 represent plant species used for various purpose.

The Rosaceae, Lamiaceae, and Solanaceae groups were the largest, with 12 plant species each. Poaceae and Asteraceae had 8 species. Polygonaceae had five species. Papaveraceae, Fabaceae, and Moraceae each had four species. Sapindaceae, Iridaceae, Verbenaceae, Malvaceae, Pinaceae, Amrylidaceae, Amaranthaceae, and Euphorbiaceae each had three species. Areaceae, Cucurbitaceae, Equistaceae, Rhamaceae, and Sapotaceae each had two plant species. Aizoaceae, Berberidiaceae, Betulaceae, Cactaceae, Canabaceae, Celasteraceae, Cyperaceae, Characeae, Chenopodiaceae, Ebenaceae, Uritiaceae, Violaceae, Vitaceae, Zygophylaceae, Oleaceae, Plantaceae, Portuliceae, Plantaginaceae and Papilonaceae, Ranunculaceae, Simrubaceae, Scropolaceae, Gentianaceae, Liliaceae, Mimosaceae, and Nictaginaceae each had one plant species. Among these plants, herbs were the most commonly used by the local population, followed by shrubs.

Based on research data, the majority of the area is covered by medicinal plants, making up 66% of all the data. 8% of the plants are used for fuel, 2% for timber, 4% for food, 6% for animals' fodder, and 2% of the plants are edible. 2% of them are ornamental plants, 4% are used as vegetables, 3% are used for furniture, 2% are fruits, and 1% are used for agriculture. Based on this rich diversity, it is clear that the region's flora plays a crucial role in supporting both traditional and modern livelihoods. The extensive use of medicinal plants reflects the deep-rooted knowledge of natural remedies within the local communities.

From the Arrang valley 163 valuable plants are collected between these 52 (31.90%) plants are in used for medicinal purpose. Amongst the medicinal plant *Accia niltica, Acaia moesta, Donea vicosa, Metha longiolia, Fagonia indica, Plantago major, Justicia adhatoda, Allium sativa*, *Coriandrum sativum, Funiculum vulgar, Phoenix dactylifera, Calotropis procera, Psidium guajava, Teucrium stocksianum, Solanum surrattense, Withania coagulants* as well as Punica granatum was also highly valued for its medicinal properties and was used to treat various ailments such as digestive issues and inflammation. Additionally, its vibrant red color made it a symbol of fertility and abundance, often depicted in art and religious rituals. From Swat 93 medicinal plants were also collected which were used for the treatment of different type of disease. (Shah et al. 2021; Kamran et al. 2020). A total of 13 (7.97%) of the plants were used as food. Among these plants *Precarious fistulas, Luffa acutanula, Cucumis sativus, Cucumis melo, Lagenaria siceraria, Vigna unguiculata, Diospyros kaki, Cymbopogon citrates, Pyrus communis, Pyrus persica* are most important to the local's people (Kayani et al. 2014; Ullah et al. 2019). Work on the medical plants as well as their conventional utilization in Village Thana, District Malakand, KpK, Pakistan and reported various plants species which are used as food. A total of 18 (11.65%) plants used as fodder for various animals (Khan et al. 2003). A total of 63 (3.68%) plants species were employed for ornamental intention. Among these plants *Narcissism Poeticus, Plumeria rumba, Tagetes minut Ipomoea hederaca, Thuja orientalis, Salvia moorcroftana, Callistmon cuminatus (*Ullah et al.2023)*, Mirabilus Jalapa, Pteris ceritica,* are mostly planted the locals (Ullah et al. 2023) Work on the ethnobotany of Ranyal hills, District Shangala, Pakistan and recorded 7 ornamental species. *Poplus Aba, Platanus orientalis* are the most important plant species which were utilized through the local peoples for ornamental. A total of 9 (5.52%) plants are used by the local people for furniture. Among these plant *Quercus incana, Ficus carica, Olea ferrognea. Platanus orientalis, Populus alba* used by the local people. Work on the ethno botany of Thana Village, Distract Malakand and Khyber Pakhtunkhwa, Pakistan for furniture purposes. Consequently, the area needs suitable organization of these precious plants as well as particularly the remedial plant require conservation.

4. CONCLUSION

The aims of present investigation were to provide an ethnobotanical profile of Arrang valley. The ethnobotanical evaluation of plants of selected area was determined the uses of plants by local inhabitants. The main purpose of this study was determined the medicinal uses of plants for different disease. The present study of plants was documented the economic values of the plants of research area.

5. ACKNOWLEDGMENT

I am thankful to my supervisor Dr. Fazli Rahim, Department of Botany, Department of Botany, Bacha Khan University Charsadda Khyber Pakhtoon Khwa, Pakistan for providing necessary facilities and cooperation during this research work.

Table no: 1 provides a comprehensive overview of plant botanical names, family, local names, ethnobotanical uses, important values, and frequencies of their use in this research.

SL. No	Plant name	Family	Local name	Ethnobotanical uses	Important value	Relative frequency	Use value
1	*Pinus longifolia*	*Pinaceae*	Nakhtar	Used for fuel, Timber and Medicinal	1.16	0.7	0.7
2	*Acacia modesta*	Fabaceae	Palosa	Wood is used as fuel and traditionally used for the treatment of backache, dysentery and bacterial infection etc.	0.83	0.7	1.0
3	*Zanthoxylum armatum*	Rutaceae	Dambara	Used as a Medicinal as well as Vegetable	1.58	0.9	0.6
4	*Teucrium leucocladum*	Lamiaceae	Yakandaaz	It is used for the treatment of fever, hepatitis and stomach problems	0.41	0.7	0.5
5	*Quercus incana.*	Fagaceae	Sirai	Used as Fodder, Medicinal, Fuel and Fruit.	0.75	0.9	0.5
6	*Nannorrhops ritchiana*	Arecaeceae	Maizaray	Used as a rope and food.	0.41	0.9	0.5
7	*Platanus orientalis*	Plantaceae	Chinar	Furniture, and fuel purposes	1.16	0.9	0.7
8	*Olea ferrognea*	Oleaceae	Khona	Used for constipation and	0.83	0.7	0.6
9	*Ficus carica.*	Moraceae	Inzar	It is used for fuel. Its fruit is also used for constipation	0.58	0.7	0.6
10	Indigofera *amblyantha* Craib	Papilionacea	Ghoreja	Young shoots are used for the manufacturing of baskets.	1.91	0.9	1.0
11	Cynodon dactylon	Poaceae	Kabal	Grown in lawns and as fodder for grazing cattle	0.75	0.7	1.0
12	*Desmostachya bipinnata*	Poaceae	Drab	Fuel and Packing	1.41	0.9	0.6
13	*Saccharum spontaneum*	Poaceae	Saccharumspontaneum	Used for making baskets and also used for brooms	0.41	0.9	1.1
14	*Opuntia dillenii*	Cactaceae	Zaqoom	Generally used by diabetic patients and also used an ornamental plant	0.83	0.9	1.0
15	*Artemisia absinthium*	Asteraceae	ZangliTarkha	Usually grown on graveyards traditionally. It is use as a fuel.	0.58	0.7	1.0
16	*Osmium bacilicum*	Lameaceae	Lameaceae	Leaves Used for external wounds, leaves are also used as expectorant.	0.58	0.7	0.7
17	Equisetum arvense	Equisteaceae	Bandakay	It is use as a fodder for animals and used to remove stones from the kidney	0.75	0.9	1.0
18	Cannabis sativum.	Cannabaceae	Bhung	Commonly utilized as for narcotic purposes and pain leaving agent.	0.58	0.7	0.7
19	*Maytenus royleanus*	Celastraceae	Spin Azghay	Medicinal, Fuel, and Vegetable.	0.83	0.9	0.9
20	*Tulipa orphanidea*	Liliaceae	Ghantol	Used as a medicinal.	0.41	0.9	0.9
21	*Punica granatum*	Lythraceae	Anungoray	Used as a Medicinal, Fuel and Agriculture.	0.41	0.9	1.2
22	*Ranunculus muricatus*	Asteraceae	Zergulay	Use as a fodder for animal and utilized in diaphoretic.	0.83		0.7
23	*Ranunculus saleratus*	Ranunculaceae	Jashagay	Used as a Fruit, Medicinal and Fuel.	0.58	0.7	1.1
24	Ziziphus mauritiana	Rhamnaceae	Markhanai	Used as a food, Medicinal and Agriculture.	0.58	0.7	0.9
25	*Eriobotrya japonica*	Rosaceae	Lowkat	Used as a timber and Medicinal.	0.75	0.9	0.6

26	*Prunus domestica*	Rosaceae	Aloocha	Food, Medicinal and Timber.	0.58	0.7	0.7
27	*Prunus armeniaca*	Rosaceae	Khoobanai	Used as a food, Medicinal and Timber.	0.83	0.9	2.0
28	*Prunus persica*	Rosaceae	Shaftaloo	Used as a food, Medicinal and Timber.	0.41	0.9	0.8
29	*Prunus communis*	Rosaceae	Nashfati	Used as a food, Medicinal and Timber	0.41	0.9	1.0
30	*Rosa indica.*	Rosaceae	SoorGulab	Used as a fragmented and Agriculture	0.83	0.7	1.8
31	*Rubus ulmifolius*	Rosaceae	Karwara	Used as a Food and Agriculture	0.58	0.7	0.8
32	*Citrus sinensis.*	Rutaceae	Malta	Medicinal, Fuel and Fruit.	0.58	0.9	1.6
33	*Zanthoxylum armatum*	Rutaceae	Dambara	Used as a Food and Medicinal**.**	0.75	0.7	1.7
34	*Populus alba.*	Salicaceae	WataniSperdar	Used as a food, Medicinal, Fuel and Fencing	0.58	0.9	0.7
35	*Populus nigra*	Salicaceae	Sufaidad	Furniture and timber.	0.83	0.9	0.9
36	*Salix babylonica*	Salicaceae	Asleewala	Furniture and timber.	0.41	0.9	0.8
37	*Salix tetrasperma.*	Salicaceae	wala	Furniture and timber.	0.41		0.7
38	*Dodonaea viscosa*	Sapindaceae	Ghoraskai	Used as a Food and Fuel.	0.83	0.8	0.9
39	*Monotheca buxifolia*	Sapotaceae	Gorgowara	Medicinal, Food, Fuel and Fruit**.**	0.58	0.8	1.8
40	*Ailanthus altissima*	Solanaceae	Sapenna Shundai	It is used for toothache, fever, hyperlipidemia, poor blood circulation as well as heart illness avoidance	0.58	0.8	0.9
41	*Verbascum thapsus*	Solanaceae	Har ghwag	Extract of leaf used for to thatched, headache and epilepsy. Outside leaf are used to harsh limbs. Seeds are antipyretic and narcotic. Dry leaf and flower are used for antispasmodic and also use for fuel.	0.75	0.7	0.8
42	*Capsicum Annuum*	Solanaceae	Marchakay	Toothache, headache and epilepsy.	0.58	0.8	0.6
43	*Cestrum nocturnum*	Solanaceae	Rat ki Rani	Its leaf is use in cooked form as a vegetable. Fruit is used for the treatment of inflammation and liver problems.	0.83	0.6	0.6
44	*Datura stramonium*	Solanaceae	Batoora	Extract of leaves is used for toothache, headache and epilepsy	0.41	0.8	0.5
45	*Solanum nigrum*	Solanaceae	Kacmachoo	Use in cooked form as a vegetable	0.41	0.6	0.7
46	Solanum surratense	Verbenaceae	Maraghoonay	It is used for the treatment of digestive disorders, exhaustion, jaundice, spasms, nervous conditions, gallbladder and liver infections	0.83	0.7	0.8
47	*Withania somniferum*	Solanaceae	Kotilal	Use for fertility purposes in sterile women	0.58	0.9	0.7
48	*Verbena officinalis*	Verbenaceae	Shoomakay	It is used for the treatment of digestive disorders, exhaustion, jaundice, spasms, nervous conditions, gallbladder and liver infections	0.58	0.8	0.6
49	*Polygonum barbatum*	Polygonaceae	Palpulak	It is used for the treatment of fever, pain as well as a diuretic agent.	0.75	0.9	0.9
50	*Rumex dentatus*	Polygonaceae	Shalkhay	It is use as antitumor, bactericidal, anti-helminthic, anti-inflammatory, anti-dermatitis as well as astringent. Its roots used in folk medicine for the treatment of eczema, diarrhea,	0.58	0.9	0.7

				acariasis, as well as constipation			
51	*Rumex hastatus*	Polygonaceae	Tarookay	Generally, use for fuel purposes	0.83	0.5	0.8
52	*Equisetum arvense*	Equisetaceae	Bandakay	It is used commonly for the treatment of kidney troubles and tuberculosis, to stop bleeding, heal wounds as well as ulcer	0.41	0.5	0.8
53	*Cedrus deodara*	Pinaceae	Diyar Ranzra	The wood is medicinally used for the treatment of flatulence, fevers**,** urinary and pulmonary disorder, piles, insomnia, kidney stones, rheumatism, and diabetes etc. It is also used for furniture and fuels	1.41	0.6	1.3
54	*Allium cepa*	Amaryllidaceae	Piyaz	It is used for curing of, asthma as well as bronchitis, gastro intestinal disorder. It is also used as a vegetable	0.58	0.4	0.9
55	*Allium sativum*	Amaryllidaceae	Aooga	Used for the cardiac problem and it cloves are directly used for the lower the blood pressure	1.58	0.6	1.1
56	*Cyprus rotundus*	Cyperaceae	Della	It is used for the treatment of malaria diabetes, diarrhea, stomach as well as bowel disorders	0.41	0.6	1.4
57	*Tulipa clusiana*	Poaceae	Ghantol	The plant is also use and can be as a fuel	0.83	0.6	1.5
58	*Avena fatua*	Cunvovalaceae	Jawdar	Increase the milk in animal	0.83	0.7	1.0
59	*Hordeum vulgare*	Poaceae	Wabashay	It is used commonly in soups, breads, as well as health products and also use as a fodder for cattle's and an alcoholic beverage	0.58	0.9	0.8
60	*Hedera nepalensis*	Araliaceae	Parwatai	It is used for the treatment of diabetes and also important food for animal	0.75	0.7	0.8
61	*Tribulus terrestris*	Zygophyllaceae	Markondai	It is commonly used to increase libido, maintain the urinary tract strong as well as decrease swelling	0.41	0.7	1.2
62	*amaranthus viridis*	Amranthaceae		Leaves are cooked as vegetable	0.83	0.8	0.7
63	*Visnaga daucoides*	Apiaceae	Sperkai	It is used for the treatment of angina, atherosclerosis, colic, coughs, asthma and diabetes	0.83	0.9	0.7
64	*Funiculum vulgare.*	Apiaceae		It is used as digestive, carminative, diuretic galactagogue also used for treatment of gastrointestinal as well as respiratory disorder	0.83	0.5	2.0
65	*Coriandrum sativum*	Apiaceae	Dhaniya	It is used for treatment of digestion troubles, nausea, hernia spasms, diarrhea, bowel as well as intestinal gas. It is also used to treat toothaches, hemorrhoids, worms, measles as well as joint pain etc.	1.33	0.6	2.1
66	*Nerium oleander*	Apocynaceae	Ganderay	**:** It used for asthma, cancer, leprosy, painful menstrual periods, ringworm, epilepsy, indigestion, as well as venereal disease	1	0.8	0.5
67	*Calotropis procera*	Apposynaceae	Spalamai	Used animals for external parasites (Kone) in cows and	0.41	0.8	1.8

				buffalo			
68	*Periploca aphylla*	Aizoaceae	Barara	Use as ornamental purposes and use as ornamental purposes	2	0.8	0.7
69	*Achillea millefolium*	Asteraceae	Karkara	People masticate the clean foliage to reduce toothache and the ground part is use in medicine.	1.41	0.8	1.6
70	*Artemisia vulgare*	Polygonaceae	Tarkha	It is used to motivate bile secretion as well as gastric juice. It is also used for the treatment of epilepsy as well as hysteria in broods	0.58	0.7	0.6
71	*Portulaca umbraticola*	Portulaceae	Warkharay	Use as vermifuge, antiseptic, antioxidant, anti-inflammatory, antiulcerogenic as well as wound-healing	1.58	0.8	2.7
72	*Zizania palustris*	Lamiaceae	Karkanda	Use as a source of fodder for animals	0.41	0.6	1.7
73.	*Malus Pumila*	Rosaceae	Manra	The fruit is said to dispel gas, dissolve mucous, cure flux also be a stimulant for anemia, bilious disarrays as well as colic	0.83	0.8	1.9
74.	*Monotheca buxifolia*	Sapotaceae	Gwargwara	**:** It is used for the treatment of laxative, hematinic, antipyretic and anti-helminthic	0.83	0.6	1.4
75.	*Sonchus asper*	Asteraceae	Shodapai	The extraction is used for the cure of skin and other disease.	0.58	0.7	1.3
76.	*Argemone mexicana*	Papaveraceae	RediGul	It is use as a diuretic, painkiller as well as anti-inflammatory. The seed oils are also used pomade and purgative. The leaf infusion drunk to relieve cough	0.75	0.9	1.4
77.	*Astragalus graveolens*	Fabaceae	Azghay	It is use as a natural dietary supplement and also used to treat diabetes**,** fibromyalgia and common cold	0.41	0.8	1.8
78	*Malus pumila*	Rosaceae	Manra	The fruit is said to dispel gas, dissolve mucous, cure flux also be a stimulant for anemia, bilious disarrays as well as colic	0.83	0.9	1.4
79	*Dodonea viscosa*	Spindaceae	Ghwaraskay	Used for fuel and treatment of fungal infections	0.83	0.9	1.5
80	*Brassica campestris*	Brasicaceae	Sharsham	Used fodder for animals	0.83	0.5	0.9
81	*Urtica dioica*	Urticaceae	Seezonkay	**:** It is used for the treatment of back pain well as arthritis.	1.33	0.5	1.4
82	*Mentha arvensis*	Lamiaceae	Podina	Used in salat and also for stomach problems	1.0	0.6	0.7
83	*Melia azedarach*	Meliaceae	Hindustani Shandai	Used for making furniture, timber	0.41	0.4	1.2
84	*Carthamus oxyacanthus*	Asteraceae	Kareza	It is used to treat biliousness	2.0	0.6	1.1
85	*Berberis vulgaris*	Berberidaceae	Kwaray	It is used to cure cough, fever, depression, hyperglycemia, bleeding and hyperlipidemia	1.41	0.6	0.7
86	Alnus nitida	Betulaceae	Geeray	It is used for tanning as well as dyeing purposes	0.58	0.6	0.7
87	*Nasturtium microphyllum*	Brassicaceae	Tarmeera	Use as a food and fodder for animals. It is also used as an expectorant, diuretic, stimulant and purgative etc.	1.58	0.7	1.0
88	*Luffa cylindrica*	Eupharbiaceae	Toorai	Locally its Latex are poisonous and cause swelling on skin	0.41	0.9	0.6
89	*Momordica charantia*	Characeae	Karila	It is used for the treatment of fever, diabetes and infections. It is also used as food	0.83	0.7	0.5
90	*diospyros lotus*	Ebenaceae	Tore Amlook	It is used as an anti-diabetic, astringent, antiseptic, nutritive,	0.83	0.7	0.5

				sedative, antitumor, antipyretic, laxative as well as nutritive.			
91.	*Euphorbia helioscpia*	*Euphorbiaceae*	Mandaroo	It is used for breathing disarray containing bronchitis, asthma as well as chest jamming.	0.58	0.8	0.5
92.	*Quercus baloot*	Fagaceae	Sirai	used as a tea for colds, diarrhea, cough, fever as well as bronchitis	0.75	0.9	0.7
93.	*Ailanthus altissima*	Simaroubaceae	Bakanra	is used for the treatment of fast heart rate, asthma, cramps, diarrhea, epilepsy	0.41	0.5	0.6
94.	*Juglan regia*	Juglandaceae	Ghooz	Used in quality furniture and carving	0.83	0.6	0.6
95.	*Rumix dentatus*	Lamiaceae	Shalkhay	Leaves are useful for treating digestive problems in both animal and human	0.83	0.8	1.0
96.	*Viola canescens*	Violaceae	Guli Binafsha	Use for the treatment of flu, fever, cough, cold as well as malaria. It is also use as anti-cancerous drug	0.83	0.8	1.0
97.	*Rosa webbiana*	Rosaceae	Jangli Gulab	It is use as a food and also use for the treatment of stomach aches as well as jaundice.	1.33	0.8	0.6
98.	*Verbasum thapsus*	Scrophulariaceae	Khar Ghwag	It is used for the treatment of asthma, inflammatory diseases, pulmonary problems, diarrhea, spasmodic, coughs as well as migraine headaches	1.0	0.8	1.1
99.	*Rumex hastatus*	Polygonaceae	Aranda	used as a fuel and fodder for animals	0.41	0.7	1.0
100.	*Swertia cherayita*	Gentianaceae	Swertiacherayita	It is traditionally use for the treatment of malaria, liver disorders as well as diabetes.	2.0	0.8	1.0
101.	*Withania somnifera.*	Solanaceae	Marwandai	It is use as a medicine traditionally	1.41	0.6	0.7
102.	*Iris germanica.*	Iridaceae	Qabar Gulay	It is use in medicine and perfume	0.58	0.8	1.0
103.	*Iris sisyrinchium.*	Iridaceae	Gandechar.	Use as ornamentally and root tea used for diarrhea,	1.58	0.6	0.7
104.	*Xanthium strumariem*	Asteraceae	Geeshkay	It is used in Chinese remedy to cure respiratory allergies, chronic nasal obstructions, sinus congestion as well as nasal discharges.	0.41	0.7	0.9
105.	*Teucrium stocksianum*	Lamiaceae	Yakhandaz	Use as ornamental plants	0.83	0.9	0.9
106.	*Punica granatum*	Lythraceae	Anar	*People use pomegranate* for diabetes, athletic performance, high blood pressure and heart disease.	0.83	0.8	1.2
107.	*Iris germanica*	Iridaceae	Guli Zambaq	Root was mostly utilized in Macedonia and perfumery. Flowers are also used for color as well as flavor	0.58	0.9	0.7
108.	*Ajuga bracteosa*	Lamiaceae	Gooti	It is used in the curing of agues. The root juice is utilized in the treatment of dysentery as well as diarrhea.	0.75	0.9	1.1
109.	*Ajuga parviflora*	Lamiaceae	Gooti	It is used in the curing of agues. The root juice is utilized in the treatment of dysentery as well as diarrhea	0.41	0.5	0.9
110.	*Abelmoschus esculentus*	Malvaceae	Bhindi	Itis use as a food and seed is used as cordial, antispasmodic as well as stimulant	0.83	0.5	0.6

111.	*Allium griffithianum*	Amaryllidaceae	Ogakai	It is used to treat hyperlipidemia, hypertension as well as for avoiding cardiovascular disease	0.83	0.6	0.7
112.	*Broussonetia papyrifera*	Moraceae	Gul Toot	Fruits are edible and also use to treat diuretic, vulnerary, tonic and Astringent.	0.83	0.4	2.0
113.	*Eucalyptus globules*	Myrtaceae	Lachi	Its wood is used for fuels	1.33	0.6	0.8
114.	*Veronica ciboria*	Verbenaceae	Shumakay	Its leaves boil in water ten use for the treatment of fever and acne	1.0	0.6	1.0
115.	*Narcissus tazetta*	Amaryllidaceae	Guli Gangas	It is use as a food and also use for curing of disarray of the, cardiovascular system, respiratory tract, nervous system as well as metabolism	0.41	0.6	1.8
116.	*Origanum vulgare*	Lamiaceae)	GharKashmaly	It used as a food as well as a remedial plant	2.0	0.7	0.8
117.	*Lathyrus aphaca*	Fabaceae	Koorkaman	It is use as a food and also use to treat toothache and wound.	1.41	0.9	1.6
118.	*Cedrella serrata*	Meliaceae	Shenai	It is used for antimicrobial purposes also against infection as well as liver diseases	0.58	0.7	1.7
119.	*Funiculum vulgare*	Apiaceae	Kagelanay	It is used as digestive, carminative diuretic and lacteous also in curing of gastrointestinal as well as respiratory disorders	1.58	0.7	0.7
120.	*Cucurbita maxima*	Cucurbitaceae	Kadoo	Use as a vegetable	0.41	0.8	0.9
121.	*Papaver pavoninum*	Papaveraceae	Raiday	It is used for the treatment of diarrhea and seed use to cure infliammation.	0.83	0.9	0.8
122.	*Caralluma edulis*	Apocyna	Pamankay	Use as vegetables and traditional medicine	0.83	0.5	0.7
123.	*Pinus roxburghii*	Pinaceae	Nakhtar	The wood is used for fuels, furniture and shelter	0.58	0.6	0.9
124.	*Myrtus communis*	Myrtaceae	Manrho	Leaves are used for cold as well as for stomach disorders.	0.75	0.8	1.8
125.	*Mentha longifolia*	Lamiaceae	Enaly	Leaf extract used against vomiting and dysentery	0.41	0.8	0.9
126.	*Acacia nilotica*	Mimosaceae	Kikar	Used for house construction, agricultural tools and fuel	0.83	0.8	0.8
127.	*Juglans regia*	Juglandaceae	Ghuz	use for the cleaning teeth infection. Nuts is edible and nutritive	0.83	0.8	0.6
128.	*Chenopodium album*	Amaranthaceae	Sarmay	used as vegetables.	0.83	0.7	0.6
129	*Lycopersicum esculentum*	Solanaceae	Tamater	Food	1.33	0.8	0.5
130.	*Nasturtium oficinale.*	Brassicaceae	Tarmera	Cooked as vegetable. Cooked herb is used in tetanus	1.0	0.6	0.7
131.	*Osmium bacilicum*	Lamiaceae	Kashmalay	Used for external wounds, leaves are also used as expectorant	0.41	0.8	0.8
132.	*Morus alba* L	Moraceae	Thooth	Fodder for cattle	2.o	0.6	0.7
133.	*Vitis vinifera*	Vitaceae	Kwar	Join pain	1.41	0.7	0.6
134.	*Avena sativa*	Poaceae	Jawder	Fodder and fuel	0.58	0.9	0.9
135.	*Cupressus sempervirens*	Cupressaceae	Sarwa	Anthelmintic and astringent	1.58	0.8	0.7
136.	*Morus nigra*	Moraceae	Tor thooth	Wood	0.41	0.9	0.8

137.	*Rumex dentatus*	Polygonaceae	Shalkhay	Cook as vegetables as well as used to treat constipation	0.83	0.9	0.8
138.	*Sorghum halepense*	Poaceae	Dadam	Fodder for cattle,	0.83	0.5	1.3
139.	*Mirabilus jalapa*	Nyctaginaceae	Gulabasi	wounds to get heal. Use as an ornamental.	0.58	0.5	0.9
140.	Spinacia oleracea	Chenopodiaceae	Palak	Leaves are edible and are used for vegetables	0.75	0.6	1.1
141.	*Abelmoschus esculentus*	Malvaceae	Bindy	vegetable and fuel	0.41	0.4	1.4
142.	*Dalbergia sissoo*	Fabaceae	Shawa	Its wood is use as a source of furniture and fuel	0.83	0.6	1.5
143.	*Dichanthium annulatum*	Poaceae	Shamogha	It is used as fodder for various animals.	0.83	0.6	1.0
144.	*Digera arvensis*	Amaranthaceae	Surgulay	Vegetable and fodder	0.83	0.6	0.8
145.	*Cucumis sativus*	Cucurbitaceae	Badrang	Fruits are edible	1.33	0.7	0.8
146.	*Capsicum annum*	Solanaceae	Marchaky	Anti-helminthic	1.0	0.9	1.2
147.	*Zea mays*	Poaceae	Jewar	fodder	0.41	0.7	0.7
148.	*Helianthus annus*	Asteraceae	Anwerfarasat	Oil	2.0	0.7	0.7
149.	*Tagetes erecta*	Asteraceae	Dambergulay	It is grown in lawns for ornaments	1.41	0.8	2.0
150.	*Broussonetia papyrifera*	Moraceae	Gul tooth.	Fodder	0.58	0.9	2.1
151.	*Citrus limon*	Rutaceae	Nembo	Use as fuel. Its leaves are used for treating vomiting	1.58	0.5	0.5
152.	*Salvia moorcrofiana*	Lamaiaceae	Khardug	The boiled root extract is used for internal injuries of cattle	0.41	0.6	1.8
153.	*Sisymbrium irio*	Brassicaceae	Genger	use as a source of fuel when dried	0.83	0.8	0.7
154.	*Ricinus communis*	Euphorbiaceae	Randa	Generally, its wood is used as a fuel	0.83	0.7	1.6
155.	*Triticum aestivum*	Fabacea	Ghanam	Use for food and fodder.	0.58	0.7	0.6
156.	*Fumaria parviflora*	Papaveraceae	Shatara	use as a fodder for animals	0.75	0.7	2.7
157.	*Plantago lanceolata*	Plantaginaceae	Ghawajabai	use for the treatment of dysentery, constipation and expectorant	0.41	0.9	1.7
158.	*Prunus amygdalus*	Rosaceae	Badam	use as a fuel and enhance memory of people	0.83	0.7	1.9
159.	*Malva neglecta*	Malvacae	Panderak	They can be added in quantity to salads, and make an excellent lettuce substitute, they can also be cooked as greens. People find this mucilaginous texture unpleasant,	0.83	0.6	1.4
160.	*Papaver somniferum*	Papaveraceae	Koknar	use for headache, dysentery and tonic	0.83	0.5	1.3
161	*Alternanthera pungens*	Amarantheaceae	Insut	Fodder	1.33	0.7	1.4
162.	*Rosa moschata*	Rosaceae	Zangligulab	Dysentery, sexual problem	1.0	0.5	1.8
163.	*Ziziphus oxyphylla*	Rhamnaceae	Elani	Antibiotic	0.41	0.5	1.4

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