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Preface

We would like to present, with great pleasure, the inaugural volume-9, Issue-12, December 2023, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development*, and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas.

Environmental Research:

Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.

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Influence of Endophytic Mycoflora of Xerophytes on Drought Resistance of Pepper (*Capsicum Annum* L.)

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Abstract**—** *Because of significant increase of temperature, decrease in seasonal precipitations and hard and frequent droughts on the background of climate global change the attenuation of the yield of many agricultural crops is expected. Different approaches are used to raise plant's drought resistance. Applying plants endophytes is one of the modern ways of problem solwing. The purpose of the presented work was to study the effect of spraying the pepper plant (Capsicum annum L.) with consortia of endophytic microscopic fungi of wild xerophytes on experimental plant's drought resistance and productivity. Ten different species of xerophytes served as a source of endophytic fungi: Artemisia lerchiana Weber ex Stechm., Artemisia scoparia Waldst. &Kit., Erigeron canadensis L. (Conyza canadensis), Lactuca serriola L., Setaria viridis (L.) P. Beauv., Ballota nigra L., Polygonum aviculare L., Tribulus terrestris L., Zygophillum fabago L., and Chenopodium album L. Isolation of microscopic fungi was performed following the standard scheme, i.e. the primary sowings and later – the pure cultures were obtained. The efficiency of the fungal biopreparation was evaluated by the biometrical and biochemical indices of plants. For this purpose the habitus of both control and sptayed plants was observed and the height was measured; as well as the content of plastid pigments and ascorbic acid in leaves was studied. According to experimental results is clear that microscopic fungi alleviated the stress effect on experimental plants and enhanced the drought resistance of photosynthetic apparatus. Biopreparations stimulated the growth and development of test-plants as well, and accelerated the flowering onset.*

Keywords**—** *Drought Resistance, Endophytic Fungi, Pepper, Xerophytes.*

I. INTRODUCTION

Significant increase of temperature, decrease in seasonal precipitations and hard and frequent droughts are expectable on the background of climate change in nearest decades. Probability of plants dying out because of hard stresses caused by such conditions is very high. Attenuation of the yield of many agricultural crops is expected as well (Rezaei et al, 2023).

Different approaches are used by scientists to raise plant's drought resistance (Yasha et al., 2017). One of the modern ways of the problem solwing is applying of plant endophytes (Kim et al., 2012).

It is well known that a big part of the plant's microbiome is occupied by endophytic fungi, which perform their life cycle inside the plant without any apparent damage to the host (Grabka et al., 2022). Applying the biopotential of endophytic fungi to increase plant drought resistance and productivity is very popular today. Many-sided and intensive investigations of the abilities of endophytic mycobiota have been done during the last peiod (Kour et al., 2019).

To study the effect of the consortium created from the endophytic microscopic fungi, isolated from wild xerophytes, on the drought resistance and productivity of pepper plant (*Capsicum annum* L.) was the purpose of the presented work.

II. MATERIALS AND METHODS

2.1 Biological material and place of collection:

Ten different species of wild drought resistant plants were collected on a dry habitat, situated at the suborb of Tbilisi (end of the Mindeli st.), as a source of endophytic fungi: *Artemisia lerchiana* Weber ex Stechm., *Artemisia scoparia* Waldst. &Kit., *Erigeron canadensis* L. (Conyza canadensis), *Lactuca serriola* L., *Setaria viridis* (L.) P. Beauv., *Ballota nigra* L., *Polygonum aviculare* L., *Tribulus terrestris* L., *Zygophillum fabago* L., and *Chenopodium album* L.

Plant samples were collected following standards, maintaining maximum sterility. Leaves and stems of plants were placed in a streile container with reference of species name and location.

2.2 Isolation of endophytic microscopic fungi from xerophytes:

Isolation of microscopic fungi was performed following the standard scheme, i.e. the primary sowings and later – the pure cultures were obtained. The samples were preliminary treated according the standard method (Vujanovic et al., 2000). Later the preliminary treated piece of the sample was placed on a Petri dish maintaining the sterility, on the the following universal agarised nutrient medium (per liter): must – 0.5lml, tap water – 0,5lml, agar – 21g; pH of the nutrient medium – 5,5-5,8; sterilization regimen – 121ºC, 15min. The primary sowings were obtaind by the sample dilution method as well, on the above mentioned agarized universal nutrient medium (Waksman, 1916). The primary sowings of the microscopic fungi were incubated on Petri dishes at 28º-30ºC, in thermostat for 10days.

2.3 Obtaining pure cultures of microscopic fungi:

After the primary sowings were grown a small part of their micelium was looped on a Petri dish containing a sterile agarized nutrient medium. Microbiological inoculums were incubated in a thermostat at 25-28°C. This procedure was repeated several times, until a pure culture was obtained on a separate plate. Pure cultures were stored in test tubes, on universal agarized, slanted nutrient medium, in a refrigerator at 4°C.

2.4 Identification of the microscopic fungi isolated from drought resistant plants:

The primary identification of microscopic fungi was based on macromorphological and microscopic research methods, comprising visual characterization of the cultural-morphological properties (growth rate, diameter, size, color, etc.) of colonies developed on Petri dishes. Colonies were observed directly on a Petri dish under a microscope, at low magnification.

Morphological description of colonies was started from the fifth day of incubation and continued until the end of culture growth. At the same time preparations for microscopy were prepared.

The study of the finished preparation was based on the use of a dry optical system. For the identification of microscopic fungi guides were used (Bilayi and Koval, 1988; Malloch, 1981).

2.5 Biopreparation of endophytic microscopic fungi isolated from drought resistant plants:

Cultivation of selected endophytic microscopic fungi, isolated from xerophytes, was performed stationary, in thermostat at 30°C during 10 days, in 250ml volume conical vessels, in 50ml nutrient medium of the following composition (g/l): $NaNO_3$ - 9.0; KH_2PO_4 – 1.0; $MgSO_4 \times 7H_2O$ – 0.5; KCl – 0.5; $FeSO_4 \times H_2O$ – 0.02; glucose – 29; malt sprouts - 1,0; pH of the nutrient medium 5,5- 5,8; sterilization regimen - 121 °C, 15min.

After the cultivation was over, the content of each vessel was filtered through the glass filter and the supernatant was used as a liquid biopreparation.

2.6 Evaluation of the efficiency of biopreparation under the laboratory conditions

Pepper (*Capsicum annum* L.). - the annual agricultural plant was used to test the efficiency of the biopreparation under the laboratory conditions.

Free of chemical treatment seeds of the pepper were sowed in deep pots with sandy loam (one seed in one pot). On the 20th day of cultivation, at the three-leaf stage, plants were sprayed with biopreparation (2-3ml on each plant). Untreated plants served as control. There were 50 plants in each experimental variant.

To mimic the drought conditions watering of plants was ceased on the 40th day of cultivation, and water deficiency conditions were created; which continued for several days since the full drying of the soil.

The efficiency of the biopreparation was evaluated by the biometrical and biochemical indices of plants. For this purpose the habitus of both control and sptayed plants was observed and the height was measured; as well as the content of plastid pigments and ascorbic acid in leaves was studied.

2.7 Biochemical characteristics of experimental plants

Content of chlorophylls and carotenoids in leaves of studied plants was measured in 96% ethanol extract, spectrophotometrically. The optical density of the filtrate was measured on a corresponding vawelength on a spectrophotometer (SPEKOL 11, KARL ZEISS, Germany) and the concentration of pigments was calculated by the Vintermanns formula (Gavrilenko et al., 1975).

Ascorbic acid was determined in mg% by the titration method, with 0.0001N dichlorphenolindophenole solution (Ermakov et al., 1987). All analyses were performed with 3-fold repetition.

2.8 Statistical processing of data

Both, results of biometric and biochemical observations were processed statistically. One way ANOVA and Tukey's multiple comparison tests were used to test differences between means. All calculations were performed using statistical software Sigma Plot 12.5.

III. RESULTS AND DISCUSSION

3.1 Isolation of endophytic fungi from xerophytes

The composition of endophytic mycroflora significantly depends on plant species and is characteristic for the particular habitat where the given plant grows. The relations between plants and their endophytes are so symbiotic that the idea of their coevolution has been supposed (Hubbard et al., 2012). Accordingly, the possibility of the adaptation of xerophytes' mycobiota to extreme environment is very high. Based on this information it seemed advisable to isolate adapted to high temperature and water deficiency endophytes from xerophytes. For this reason a dry ecosystem at the suburb of Tbilisi, inhabited mainly with xerophytes was selected. 27 strains of microscopic fungi were isolated from above mentioned plant species and their pure cultures were received.

The first step in the identification of microscopic fungi was determination of the big-scale taxonomic unit, based on the structure and peculiarities of reproductive organs of a particular strain. Identification till the genus was performed according to morpho-cultural characteristics of a particular strain, following the guides (http://www.indexfungorum.org/, http://www.speciesfungorum.org/ https://www.mycobank.org).

TABLE 1
THE ENDOPHYTIC MYCOFLORA OF DROUGHT RESISTANT PLANTS

Plant species	Microscopic fungi
Artemisia lerchiana	*1. Penicillium* sp. GB 1-1 *2. Alternaria* sp.GB -1-2 *3. Aspergillus* niger GB 1—3
Erigeron canadensis	*4. Mucor* sp. GB 2-1 5. sp. GB 2-2 6. *Fusarium* sp. GB 2-3 7. *Alternaria* sp. GB 2-4 8. *Cladosporium* sp. GB 3-1 9. *Fusarium* sp. GB sp. 3-2 10. *Alternaria* sp. GB 3-3
Lactuca serriola	11.*Epicoccum* sp. GB 4-1 12.*Alternaria* sp. GB 4-2 *13.Fusarium* sp. GB 4-3 *14.Mucor* sp. GB 5-1 *15.Penicillium* sp. GB 5-2 16.sp. GB 5-3
Ballota nugra	17. sp. GB 6-3 *18. Alternaria* sp. GB 6-4
Polygonum aviculare	*19. Fusarium* sp. GB 7-1 20. sp. GB 7-2
Tribulus terrestris	*21. Alternaria* sp.GB 8-1 *22. Fusarium* sp.. GB 8-2
Zygophillum fabago	23. sp. GB 9-1 *24. Alternaria* sp.GB 9-2 25.sp. GB 9-3
Chenopodium album	26. sp. GB10-2-1 27. *Fusarium* sp. GB10-2

Isolated from grasses microscopic fungi belong to genera: *Alternaria, Aspergillus, Fusarium, Cladosporium, Mucor, Penicillium* and *Epicoccum* (Table1). The occurrence of these genera of microscopic fungi in the endophytic mycoflora of plants has been mentioned by other authors as well (Rashmi et al., 2019). Two strains of microscopic fungi were identified to the species, and 19 - to the genus as a result of the analysis. Seven cultures require additional molecular studies for identification (Table 1).

The mycoflora isolated from individual herbaceous plant was not distinguished by great diversity. Carroll (1988) pointed out the paucity of grass mycobiota even in the last century. According to his results one or two endophytes prevailed in the mycoflora isolated from a specific host, while other isolates were very rare. Later this fact was confirmed by other scientists (Arnold et al. 2003). Hyde and Soytong (2009) explained the small number of endophytic mycoflora by the fact that when endophytes are isolated by traditional methods on agarized food areas, fast-growing, "aggressive" cultures are isolated with a higher frequency, and the probability of "loss" of relatively slow-growing endophytes is very high (Hayd and Soitong, 2008).

3.2 Creation of consortia of endophytic fungi isolated from drought resistant herbaceous plants

To create a consortia of endophytic fungi of drought-resistant plants, adapted to high temperature and water deficiency was the main goal of the presented research. In order to select potential members of a consortium, selection of typical for the majority of tested plants cultures among endophytic mycoflora was decided; that is, the microscopic fungi reported as fast-growing "aggressive" cultures were to be revealed (Hayd and Soytong, 2008). Based on the calculation of the frequency of the individual genus of microscopic fungi in the endophytic mycoflora (Fig. 1), the dominant endophytes from the genera *Alternaria* and *Fusarium* were identified. It is significant to mention that these genera include many pathogens; but here following must be considered: generally fungi establish three types of relationships with the host plants: mutualistic (beneficial endophyte), commensalistic (latent pathogen) and pathogenic (virulent pathogen). The type of relationship depends on the physiological status of the host, or the characteristic environment in which it is located. Depending on these three types of relationship, the fungus can enhance or reduce the life potential of the host, or remain neutral towards it (Alam et al., 2021). According to some scientists, there is no neutral relationship between the endophyte and its host, but rather a balanced antagonism. There is always a threat of aggression from the fungus, but the immunity of the host plant ties it up (Schulz and Boyle, 2005). This opinion is confirmed by the latest studies. It has long been known that *Alternaria alternata* is a ubiquitous species found in plants as an endophytic pathogen. Previously, it was believed that there were pathogenic and non-pathogenic endophytic forms of *Alternaria*. However, with modern molecular analysis methods, it has been determined that this is a single species that can be in a variety of nutritional relationships with the host plant (DeMers, 2022).

One microscopic fungus was also isolated from most of tested plants, which could not be identified at this stage of the study.

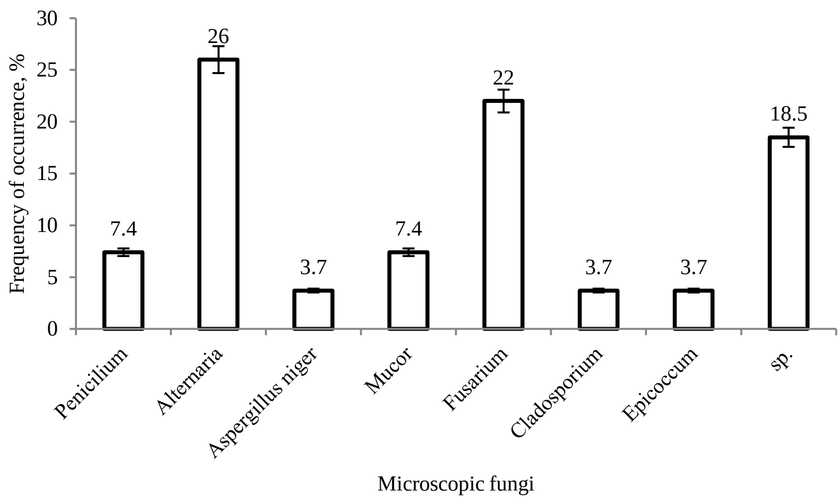

FIGURE 1: The frequency of occurrence of microscopic fungi spread among xerophytes

We assumed that mentioned dominant cultures were the fast-growing endophytes of the herbaceous plants of the selected location. To create a consortium, we focused on the dominant culture isolated from one specific species; in particular, into one consortium were grouped strains sp. GB 6-3 and *Alternaria* sp. GB 6-4, isolated from *Ballota nigra*; and in the second one we combined strains *Alternaria* sp. GB 8-1 and *Fusarium* sp. GB 8-2 isolated from *Tribulus terrestris*.

3.3 Testing the biopreparation of endophytic consortium on pepper plant in laboratory conditions

The suspension obtained by the submerged cultivation of a single strain of the consortium was used as a biopreparation. Three different biopreparations were prepared: 1) a mixture of suspensions of the cultural solutions of *Alternaria* sp. GB 6-4 and sp. GB 6-3; 2) a mixture of suspensions of the cultural solutions of *Alternaria* sp. GB 8-1 and *Fusarium* sp. GB 8-2; 3) the suspension of the culture solution of *Trichoderma viride* 12-1-1 - strain of the collection of microscopic fungi of the Faculty of Agricultural Sciences and Biosystems Engineering of the Technical University of Georgia.

Application of *Tr. viride* 12-1-1 (the strain which did not belong to the mycobiota of experimental xerophytes) was due to the fact that from the literature this microcopic fungus is known as a stimulator of plant growth and productivity and at the same time it stimulates plant drought resistance (Mona et al., 2017). Thus, it was interesting to test this endophytic fungus as well, in order to compare its effect with that of other experimental consortia.

3.4 Plastid pigments and ascorbic acid

The functional state of the photosynthetic apparatus is evaluated according to the content of photosynthetic pigments - chlorophylls and carotenoids (Lichtenthaller, Buschmann, 2001). It is known that water deficit, which is usually associated with intense illumination and high temperature, inhibits photosynthesis. One of the reasons for this is chloroplasts damage and chlorophyll destruction; which is even considered a kind of protective reaction to stress (Herbinger et al., 2002). Thus, the reduction of chlorophylls is a common phenomenon under drought conditions, which may be caused by the inhibition of pigment biosynthesis due to stress, or the degradation of pigments (Ma et al., 2020).

Carotenoids are the auxiliary pigments of photosynthesis with protective and structural function. Their photoprotective function is expressed by the effective neutralization of chlorophyll and oxygen excited molecules (Maoka, 2020). According to literary data by the carotenoids content one can discuss the stress intensity affecting plant, as well as the stress resistance of the latter (Strzalka et al., 2003).

Ascorbate is widely distributed low molecular antioxidant and important protective substance in plant. One of its principal roles is the protection of photosynthetic appatatus against oxidative stress (Venkatesh and Park. 2014). Increase of the content of ascorbate is one of the plant's primary responses to drought and intensive irradiation stresses (Yang et al., 2008).

According to all above mentioned we followed the changes in the content of carotenoids and chlorophylls in leaves of experimental plants under the drought stress, and studied the effect of the artificial inoculation with endophytic fungi on these indices. Investigation of ascorbate content as one of the key protective antioxidants of the photosynthetic apparatus was also interesting. The latter would give some information on the role of applied endophyts in stress-protection.

In pre-flowering phase the content of plastid pigments in experimental leaves was determined after three weeks of inoculation with endophytes. During this period experimental plants were subjected to artificial water deficiency for two times (pots were not watered until the turgor of leaves dropped significantly due to the lack of water, and the plants became "bored").

In flowering phase plastid pigments were determined in plants subjected to five–fold drought stress. In both phases of development, the content of chlorophylls and carotenoids in leaves was determined after the removal of stress (the plants were watered and the turgor of the leaves restored).

From the obtained results, it is clear that the content of chlorophylls in pre-flowering phase was statistically similar ($p>0.05$) in both experimental and control variants (Fig. 2). In the flowering phase, the difference between the test-variants appeared. In particular, the content of chlorophylls in leaves of the control variant was found to be lower than that of all test variants ($p<0.05$). Results were 1.6 times lower, compared to plants treated with the first consortium and 1.4 times less - compared to the variants treated with *Trichoderma* and the second consortium (Fig. 2). Between the test variants themselves a statistical difference was also revealed; in particular, the results of the first consortium-treated variant prevailed over the data with *Trichoderma*- and the second consortium- treated variants. It is interesting to note that the chlorophyll content in the first consortium-treated variant and *Trichoderm*a was statistically the same in pre-flowering and flowering phases, while in control and the second consortium-sprayed variant- decreased during the flowering phase (1.6 times and 1.2 times, respectively) (Fig. 2).

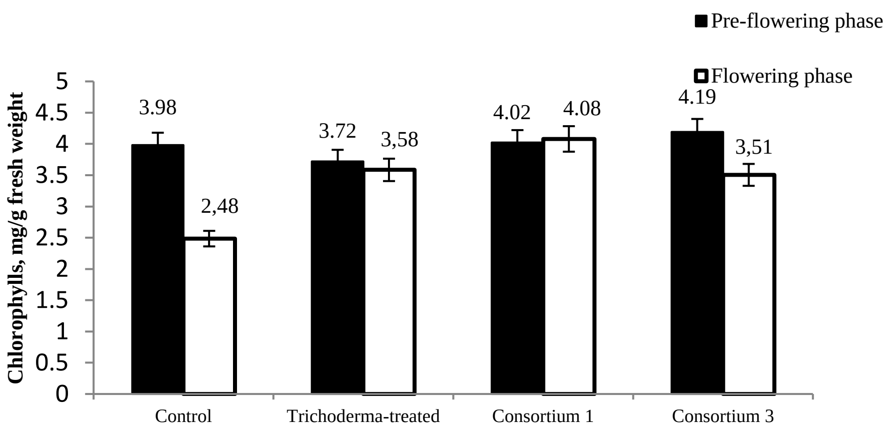

FIGURE 2: Content of chlorophylls in pepper leaves

As for carotenoids content, in pre-flowering phase a statistical similarity was observed between the control and the first consortium-treated variants ($p>0.05$), while the amount of pigments in the *Trichoderma*- and the second consortium-treated variants was higher compared to the control (1.9- and 1,7 times respectively) ($p<0.05$). Moreover, carotenoid synthesis was more active (by 10%) in *Trichoderma*-treated variant compared to the second consortium-treated one ($p<0.05$) (Fig. 3).

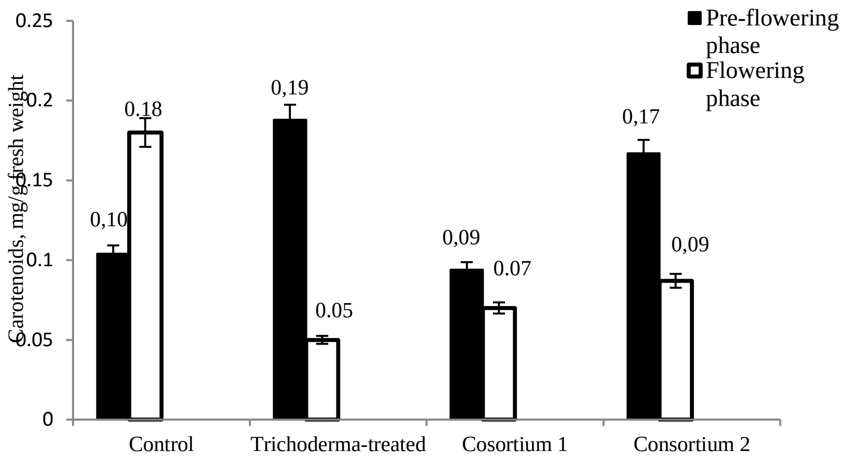

FIGURE 3: Content of carotenoids in pepper leaves

In flowering phase, the content of carotenoids in control and experimental variants was statistically different ($p>0.05$); moreover their content in control variant was significantly higher (1.8 times), compared to pre-flowering phase, and decreased in experimental variants: in the first consortium-treated variant - 1.3 times, in the second consortium-treated - 1.9 times; The content of carotenoids especially reduced in the *Trichoderma*-treated variant - 3.8 times (Fig. 3).

According to experimental results, it maybe assumed that inoculation with fungi increased the resistance of pigment system of experimental plants against drought stress. In particular, the first two "attacks" of water deficiency were not yet alarming for the plant, so the level of chlorophylls in the pre-flowering phase was the same in all tested variants. Along with the aggravation of the stress, probably the activity of endophytes also appeared. During the flowering phase, which is generally the most sensitive to stress, the chlorophyll content in the control variant decreased as a kind of adaptation to water deficit, while in the experimental variants its content remained almost at the level of the previous phase; that is, endophytes "relieved" the negative effect of water deficit on the pigment system so much that it did not change. Intensification of the stress pressure in the flowering phase caused a regular increase of carotenoids in the control variant; while the reduction of these pigments was noted in the inoculated variants. This can be considered as an indication that the pigment system of inoculated leaf was not particularly stressed.

What was the amount of one of the key compounds of the antioxidant system - ascorbic acid in leaves at that time? Its content in pre-flowering phase, under the influence of stress, was found to be lower in control plants compared to inoculated variants (Fig. 4). It should be assumed that the increase in ascorbate content is the “merit” of endophytes. Exacerbation of stress caused an increase of ascorbate in control variant (4-fold), which may be regarded as an adaptive response to stress. In treated variants, its content has changed little. In particular, in *Trichoderma*-treated variant ascorbate remained at the level of the pre-flowering phase (i.e. it did not change), while in consortia-treated variants it increased less compared to the pre-flowering phase (1.7-1.9 times); which may also be considered as an indication that the inoculated plants were not so acutely affected by stress as the control ones (Fig. 4).

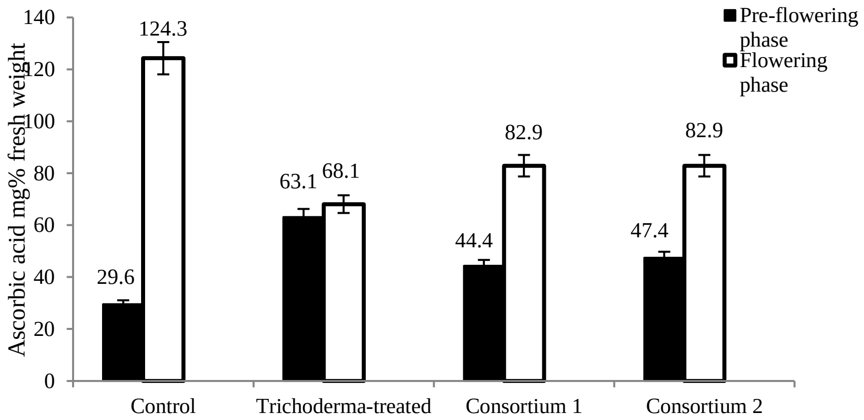

FIGURE 4: Content of ascorbic acid in pepper leaves

3.5 Sprouts development

The observation of pepper growth and development was begun after the spraying with biopreparations. Height of experimental plants was measured 4-times before flowering. The first measurement was carried out on the first day of spraying, when the effect of inoculation was not yet pronounced. These data were a kind of starting point for observing the changes in growth and development of experimental plants. Further measurements were taken at intervals of one week or more. In addition, the first two data were taken before exposure to artificial drought stress, the third - after the first stress, and the fourth - after three exposures to artificial drought.

According to the first measurement there were no statistical differences between the heights of different experimental variants ($p>0.05$); that is, sprouts growing under the same conditions developed equally. The second measurement revealed that the first consortium-treated plants were taller than all other options ($p<0.05$), and there was no statistical difference between them ($p>0.05$) (Fig. 5). The third measurement showed that the heights of the first and second consortium-treated plants were statistically close to each other ($p=0.3$) and prevailed over the control and *Trichoderma*-treated variants ($p<0.05$). By the fourth measurement, the first consortium-sprayed variant was still the leader in height ($p<0.05$) (Fig. 5).

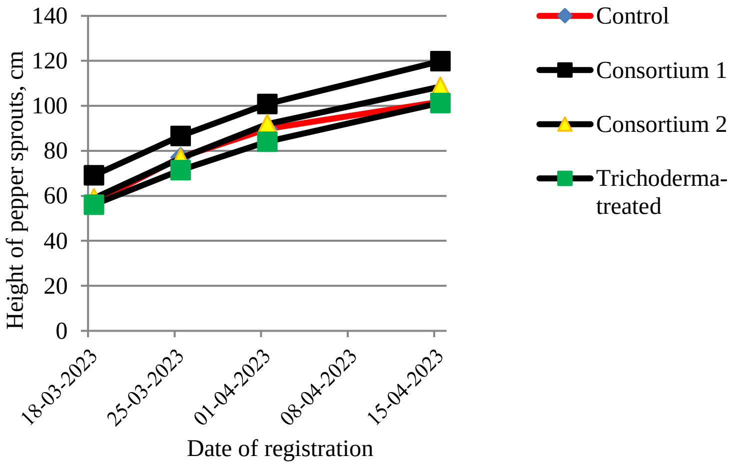

FIGURE 5: Dynamic of growth of pepper sprouts in pre-flowering phase

Based on the obtained results, it may be concluded that spraying with the first consortium had a stimulating effect on the growth and development of tested plants. The effect of the second consortium was relatively less pronounced.

Along with the growth stimulation, exposure to the first and second consortium also accelerated the transition of plants to flowering phase.

IV. CONCLUSIONS

1. Spraying pepper sprouts with biopreparations made from strains of microscopic fungi isolated from drought-resistant plants enhanced the drought stress resistance of experimental plants' photosynthetic apparatus.
2. Biopreparations stimulated the growth and development of test-plants and accelerated the onset of flowering.

REFERENCES

[1] Alam, B, Lı, J, Ge, Q, Khan, MA, Gong, J, Mehmood, S, Yuán, Y and Gong, W. (2021) Endophytic Fungi: From Symbiosis to Secondary Metabolite Communications or ViceVersa? Front. Plant Sci. 12:791033. doi: 10.3389/fpls.2021.791033

[2] Arnold, AE, Mejía, LC, Kyllo, D, Rojas, EI, Maynard, Z, Robbins, N, Herre, EA. (2003) Fungal endophytes limit pathogen damage in a tropical tree. Proceedings of the National Academy of Sciences, USA 100:15649–15654.

[3] Bilaiy, VI, Koval, EZ. (1988) Aspergills. Kiev, Naukova dumka 204p. (Russian). https://www.studmed.ru/bilay-v-i-koval-e-z-aspergilly-opredelitel_38402998290.html

[4] Carroll, G. (1988) Fungal endophytes in stems and leaves: from latent pathogen to mutualistic symbiont. Ecology, 69, 2–9.

[5] DeMers M. (2022) *Alternaria alternata* as endophyte and pathogen. Microbiology, 168(3):1-15. https://doi.org/10.1099/mic.0.001153

[6] Ermakov, AI, Arasimovich, VV, Yarosh, NP, Peruanskyi, JV. (1987) Methods of biochemical analysis of plants. Agropromizdat, Leningrad. 429p. (Russian)

[7] Gavrilenko, VF, Ladigina, ME, Khandobina, LM. (1975) Big practical handbook in plant physiology. Moscow, Visshaia shkola. 127-134 (Russian).

[8] Grabka, R, d'Entremont, TW, Adams, SJ, Walker, AK, Tanney, JB, Abbasi, PA, Ali, S. (2022) Fungal Endophytes and Their Role in Agricultural Plant Protection against Pests and Pathogens. Plants (Basel), 11(384):1-29. doi: 10.3390/plants11030384.

[9] Herbinger, K, Tausz, M, Wonisch, A, Soja, G, Sorger, A, Grill, D. (2002) Complex interactive effects of drought and ozone stress on the antioxidant defence systems of two wheat cultivars. Plant Physiol. Biochem., 40: 691–696.

[10] http://www.indexfungorum.org/

[11] http://www.speciesfungorum.org/

[12] https://www.mycobank.org/

[13] Hyde, KD and Soytong, K. (2008). The fungal endophyte dilemma. Fungal Diversity 33*:* 163-173.

[14] Kim, YC, Glick, BR, Bashan, Y, Ryu, C.-Min. (2012) Enhancement of Plant Drought Tolerance by Microbes. In: Plant Responses to Drought Stress Aroca (ed.). Springer-Verlag Berlin Heidelberg, pp.383-413.

[15] Kour, D, Yadav, N, Yadav, AN. (2023) Endophytic Fungi as Emerging Bioresources for Bioactive Compounds for Sustainable Development. J Appl Biol Biotech., 11(1):1-3.

[16] Lichtenthaller, HK, Buschmann, C. (2001) Chlorophylls and Carotenoides: Measurement and Characterization by UV-VIS Spectroscopy. Current protocols in food analytical Chemistry, F4.3.1-F4.3.8.

[17] Ma, Y, Dias, MC and Freitas, H. (2020) Drought and Salinity Stress Responses and Microbe-Induced Tolerance in Plants.Front. Plant Sci., 11:591911.doi: 10.3389/fpls.2020.591911

[18] Mafakheri, A, Siosemardeh, A, Bahramnejad, B, Struik, PC, Sohrabi, Y. (2010) Effect of drought stress on yield, proline and chlorophyll contents in three chickpea cultivars. AJCS, 4(8):580-585.

[19] Malloch, D. (1981) Moulds, Their Isolation, Cultivation and Identification. University of Toronto Press. Toronto Buffalo London. 97p.

[20] Maoka, T. (2020) Carotenoids as natural functional pigments. J Nat Med., 74(1):1-16. doi: 10.1007/s11418-019-01364-x. Epub 2019 Oct 1

[21] Mona, SA, Hashem, A, Abd_Allah, EF, Alqarawi, AA, Soliman, DWK, Wirth, S and Egamberdieva, D. (2017) Increased Resistance Of Drought By Trichoderma Harzianumfungal Treatment Correlates With Increased Secondary Metabolites And Proline Content. Journal of Integrative Agriculture, 16(8): 1751-1757.

[22] Rashmi, M, Kushveer, JS and Sarma, VV. (2019) A worldwide list of endophytic fungi with notes on ecology and diversity. Mycosphere, 10(1): 798–1079.

[23] Rezaei, EE, Webber, H, Asseng, S *et al.* (2023) Climate change impacts on crop yields. Nat Rev Earth Environ. https://doi.org/10.1038/s43017-023-00491-0

[24] Schulz, B and Boyle, C. (2005) The endophytic continuum. Mycol. Res., 109 (6): 661–686.

[25] Strzalka, K, Kostecka-Gugala, A, and Latowski, D. (2003) Carotenoids and Environmental Stress in Plants: Significance of Carotenoid-Mediated Modulation of Membrane Physical Properties. Russian Journal of Plant Physiology, 50(2):168–172.

[26] Venkatesh, J and Park SW. (2014) Role of L-ascorbate in alleviating abiotic stresses in crop plants. Botanical Studies, 55:38.

[27] Vujanovic, V, St-Arnaud, M, Barabé, D, and Thibeault, J. (2000) Viability testing of orchid seed and the promotion of colouration and germination. Ann. Bot., 86:79–86. doi:10.1006/anbo.2000.1162

[28] Waksman, SA. (1916) Soil fungi and their activities. Soil Sci., 2(1):103-105.

[29] Yang, Y, Han, C, Liu, Q, Lin, B, Wang, J. (2008) Effect of drought and low light on growth and enzymatic antioxidant system of *Picea asperata* seedlings. Acta Physiol Plant., 30: 433–440.

[30] Yasha, NB, Qindeel, F, Sitara, N, Jannat, I and Sadia, A. (2017) Drought Tolerance In Plants: A Review. International Journal of Ecology and Environmental Sciences, 5(4):20-28.

Challenges of Transportation System on Upland Rice Production: A Case Study of Ojjor Rice Producing Community in Uzo Uwani Local Government Area of Enugu State Nigeria

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Abstract— *Transportation challenges facing upland rice production in Ojjor community in Uzo Uwani Local Government Area of Enugu State of Nigeria is studied. Rice is the most populous cereal and a major staple food in Nigeria whose demand is constantly on the increase owing to the growing demand by the increasing population. Upland rice refers to rice grown under dry condition which depends on rainfall for growth. Agricultural products are biological materials which often are vulnerable to external influences such as environment and handling techniques. It depends heavily on elaborate bulk handling system for bringing inputs to farm, evacuation of farm produce from the farm storage centers or to market, delivering the products to processors and finally to ultimate consumers. Survey trips were made to the study area during which primary data was collected from 100 respondents who were randomly chosen. These respondents were administered with structured questionnaires designed to assist in obtaining information that were analyzed to reach to the results, conclusion and recommendations made in the study. Result show that about 77% of the respondents are engaged in agricultural production, 12% are in petty trading, while the rest (1%) is engaged in one form of business or another. The prevailing mode of transportation in the study area is head portage (71%), other modes of transportation are: wheel barrow (13%), bicycle and motorcycle (11%) and public transport using motor vehicle (5%). The predominant types of access roads in the area are bush paths (79%), followed by earthen roads (13%). The study revealed that the inadequate transportation system in the area is adversely affecting upland rice cultivation in the study area.*

Keywords— Upland Rice Production, Transportation Mode, Agricultural Development, Rural Area.

I. INTRODUCTION

Rice has become one of the most important crops in the world, and now being consumed by more than 50% of the world's population (World Bank, 1996). In Nigeria, rice is the most populous cereal and a major staple food whose demand is constantly on the increase owing to the growing demand by the increasing population. Nigeria is the largest producer of rice in West Africa and second largest producer in Africa after Egypt (Imolehin and Wada, 2008). However, local demand for the product has far outstripped production which has made the Federal Government of Nigeria to commence importation of rice into the country to avert hunger (Muochebe, 2021). For instance, the Federal Ministry of Agriculture and Water Resources in July 2008 reported that the actual production of rice in Nigeria dropped from 3.18 million metric tons (mmt) in 1999 to 2.76mmt in 2006. Oladeebo (2006) reported that Nigeria produces only 525,000 metric tons of rice per annum, from about 1.4 million hectares of land while it consumes about 2.5 mmt per annum. Central Bank of Nigeria (2007) reported that import bill on rice were $259 million, $655million, and $578 million in 2000, 2001, and 2002 respectively while $750 million was spent on importation of 2.2mmt of rice in 2007 alone.

IFPRI, (2013) attributed food crises in Nigeria to low investment in agricultural sector of economy and recommended to the Federal Government of Nigeria to formulate programmes aimed at improving food security in the country, adding that the food crisis could be resolved if Nigeria government could pay more to agriculture. The Presidential Initiative on Rice Production and Export which was launched in 2003 aimed at raising Nigeria's rice production capacity from 2.3 mmt to 5 mmt in 2006 and to 6.0 mmt in 2007 could not achieve much as desired. Umeghalu (2013) noted that some of the reasons responsible for failures of government policies and programmes aimed at fighting food crisis in Nigeria are inconsistency of government policies, lack of funding, poor infrastructure in rural areas, lack of commitment, bureaucracy and entrenched corruption in government businesses.

1.1 Upland Rice Production in Nigeria:

Upland rice refers to rice grown on dry soil rather than on flooded rice paddies which depends on rainfall for moisture (Ukoha *et al*. 2010; Umeghalu *et al*, 2013). It can be grown under a wide range of rainfall regime from as low as 400mm to 4,000mm per annum. Rice can be cultivated in a broad variety of climate and soil circumstances and is produced in more than 100 nations except in Antarctica (Nguu and Aldo, 2006; Shaobing *et al*. 2009). Approximately more than 50% of the world's rice is cultivated in emerging nations such as Asia (Paul *et al.* 2009). However, *O. Glaberrima* rice variety is cultivated on a tiny scale in Western Africa, particularly in the inland of the Niger Delta; the Sokoto-Rima Valley and other floodplains in the extreme northern part of Nigeria. As seen in Table 1, Nigeria has the most arable land for rice cultivation in West Africa (Somado *et al*., 2008).

TABLE 1
TOTAL AREA OF LAND UNDER RICE CULTIVATION IN VARIOUS ECOLOGIES ACROSS COUNTRIES IN WEST AFRICA

Country	Total area (ha)	Mangrove Swamp	Deep Water	Irrigated lowland	Rainfed lowland	Rainfed Upland
Mauritania	23,000	0	0	23,000	0	0
Senegal	75,000	6,000	0	33,750	35,250	0
Mali	252,000	0	161,280	52,920	30,240	7,560
Burkina Faso	25,000	0	0	6,750	16,250	2,000
Niger	28,000	0	14,000	14,000	0	0
Chad	31,000	0	28,520	620	1,860	0
Cameroon	15,000	0	0	14,700	300	0
Gambia	19,000	2,660	0	1,330	12,160	3,040
Guinea-Bissau	65,000	31,850	0	0	14,300	18,850
Guinea	650,000	84,500	65,000	32,500	162,500	305,500
Sierra Leone	356,000	10,680	0	0	103,240	245,640
Liberia	135,500	0	0	0	8,100	126,900
Côte d'Ivoire	575,000	0	17,250	34,500	69,000	454,250
Ghana	81,000	0	0	12,150	12,150	56,700
Togo	30,000	0	0	600	5,400	8,190
Benin	9,000	0	0	360	360	8,190
Nigeria	1,642,000	16,420	82,100	262,720	788,160	492,600
Total	4,011,000	160,440	360,990	481,320	1,243,410	1,764,840

Source: (Somado, Guei and Keya, 2008).

In Nigeria, upland rice is mostly grown by small subsistence farmers. The grain yields are generally low between 0.5 to 1.5 metric tons per hectare (mt/ha) in Africa and 1 – 4mt/ha in Latin America. A broad variety of indigenous and enhanced rice varieties can be found in Nigeria, in particular, *NERICA*, which has been launched in the last two decades (Somado et al., 2008). According to Muochebe (2021), new rice varieties known as *Africa Rice* have now been developed and circulated by research agencies such as the National Cereal Research Institute (NCRI) and the West African Rice Development Association (WARDA).

One reason for the failure of most agricultural ventures in Nigeria is insufficient study of geographical conditions. Inadequate knowledge of climatic, soil, and vegetation data, and hydrographical conditions are some of the vital factors which make any large-scale agricultural development scheme a risk (Onwualu *et al*. 2006). The use of primitive implement for production such as hoes and cutlasses also contribute to low agricultural productivity. These implements are labour intensive and discourages the younger people who are energetic for agricultural production to leave the rural areas where agricultural production are practiced for urban areas searching for white collar jobs that are not there (Nwuba........). The result is that the aged and aging persons left behind to undertake agricultural productions are now too weak to farm and whose numbers are critically decreasing by the day (Onwualu *et al.*, 2006). This has significantly been contributing to low agricultural production in the country.

1.2 Factors affecting upland rice production in Nigeria.

The high cost of modern implements like tractors, harvesters, and threshers which can aid and increase agricultural productivity prevent small farm holders to expand their farm holdings. In addition, the conservative attitudes of farmers to their primitive ways of agricultural production due to illiteracy contribute to the backwardness of mechanizing agricultural practices in the country. Most farmers find it very difficult to accept modern methods of agricultural production for fear of unknown. Many of the researches carried out by agricultural officers are not adopted by the farmers; as they believe that it is risky using the new methods which they are not sure of its success (Odigbo, 2008). Even agricultural inputs such as fertilizers, herbicides, insecticides which will enhance the growth of their crops and better crop yields are difficult to be accepted by the farmers.

Lack of marketing facilities is another reason for poor agricultural production. A farmer is discouraged to expand his production when what he has previously produced is not sold because of poor marketing facilities. He may decide to crop less hectares to avoid the loss he suffered during the previous season (Oni *et al*., 2009). Farmers who may wish to increase their production or improve their methods of cultivation find it difficult to obtain loans; while those who were able to obtain loans do not make proper use of them or obtain enough harvest to enhance their breaking even. However, when obtaining a loan from the banks is possible, poverty prevents farmers to provide the required security required by banks for obtaining loans. Lack of processing and storage facilities make it very difficult for farmers to process and store their products after harvest especially during rainy season production. These forces farmers to sell off their products immediately after harvesting but often, prices offered for these products at this time are generally low leaving farmers with little or no profit margin which would encourage or enable them to increase their production.

Infrastructures such as roads, electricity, and good contribute to low agricultural productivity. Farming in Nigeria is mainly carried out in rural areas where good roads are absent. This prevents the use of farm machineries when available as there is no road to take them to the farms. Electricity which is necessary for storage of most of farm products is absent in most rural areas.

1.3 Transportation

Economic and agricultural activities are primarily concerned with the production, distribution and consumption of goods and services which are of value to humans. People must use the natural resources of the earth to satisfy the necessity of life, to provide food, clothing and shelter to the teeming population of the country. Not only for these basic necessities but also to use the resources to make life more pleasant, comfortable and rewarding. However, these resources are not usually found all in one place and no location is endowed with all the resources. There is therefore need to transport some of these natural resources from places where they abundantly available to areas where they are needed but not available. Transportation has made it possible for consumption of goods or food items produced in distant places because the transportation cost is low. Foods that are produced in only certain climates and soil condition are now available almost everywhere. According to Tunde and Adeniyi (2012), transportation is a means of breaking down the spatial barrier between the production and consumption.

Transportation is a vital aspect of the production process starting from gathering of raw materials, factors of production, mobility and distribution of the final product to consumers (Ijeoma and Alphonsus, 2014). Following Dorosh *et al.* (2009) in the study of the assessment of the implications of location and transport investments for crop production and productivity in Sub-Saharan Africa (SSA), by adopting his conceptual framework in which transport investments affect both the supply and demand for crop production; on the supply side, the production of crop *j* under production system *l* in a location *i* depends on the agronomic potential *pj*, under the production system *l* in location *i*, and un-observed location-specific variables (*Ωi*) such as output and factor prices, and available technology. Demand for a crop produced in location *i* depends on the size of the local market surrounding location *i*, which is in turn determined by the population, distribution of per capita incomes, and trade regime.

The effects of better transportation are assumed to take place through a reduction in the transport costs of goods and services, which raises the producer prices of crops. Reduced transport costs also lower the costs and profitability of supplying modern inputs such as fertilizers, seeds, extension services, and other technologies (Ahmed and Hossain, 1990). As lower transport costs result in a greater percentage reduction in the price of perishable and bulky items such as vegetables, the profitability of these items increases relative to nonperishable crops, (Minten and Kyle, 1999). They also discovered that the more perishable and the higher value the agricultural products, the less distance they are transported. Again, it is generally recognized that transport operating costs, are higher on rough roads than on good quality bitumen roads and generally this will be reflected in passenger fares and freight tariffs.

Transport charges and costs by conventional vehicles are not uniform. Not only are there large differences in costs between different countries for the same type of transport (particularly between Africa and Asia), there are large differences between rural short haul transport (usually carried out by pickups or small rigid trucks) and long distance interurban transport that is more often carried out by heavy tractor and semi-trailer, (Yunusa *et al*. 2002; Oni *et al*. 2009; Ijeoma and Alphonsus, 2014). The proportion of transport charges to final market price will vary with a range of factors such as commodity type, the efficiency of the transport and marketing sectors and travel distance. The impact of total transport costs on agriculture will be higher than these figures indicated because the critical factor is the relationship between transport costs and what the farmer receives for his produce at the farm gate, (Oni and Okanlawon, 2006; Ogunsanya, 1993). Both marketing margins and transport costs (including the high cost of head loading produce to the village or roadside) need to be subtracted from the final market price. The results will, of course, vary from country to country, season to season and year to year. For instance, A wide range of transport costs have also been found in different countries for similar types of transport operation on similar roads. This indicates that there is substantial scope for improving efficiency of transport operations in the rural areas of many countries. A comparative study of rural transport carried out in Ghana, Zimbabwe, Thailand, Pakistan and Sri Lanka in 1994-5 (Ellis and Hine, 1998) has shown that Ghana and Zimbabwe have transport charges that are two to two and half times more expensive than for Asian countries for comparable journeys of up to 30km. In this case data was collected from a variety of different types of vehicles including tractors, power tillers pickups and trucks.

Road investment has an important part to play in reducing transport costs; however improving short lengths of feeder roads may have little impact if no change in transport mode occurs. It has been calculated that upgrading 5km of feeder road from earth to gravel standard might only increase farm gate prices by about one tenth of one per cent (Queiroz *et al*. 1992). The above analysis has largely assumed that changes in transport costs will be passed to farmers and not go to transporters, food wholesalers and retailers or the final urban consumers. Competitive transport and food marketing is required to ensure that the benefits from reductions in transport costs are passed on to farmers and to final consumers. Therefore, transportation cost is also connected with road roughness and seasonality (Oni and Okanlawon, 2006).

The price of transport is not the only disincentive to increased agricultural production. There is evidence from all over Sub-Saharan Africa that sometimes, crops remain un-harvested, or are spoiled once they have been harvested, because of inadequate supply of vehicles to transport them from the farm to the market or to the place where they would be processed.. For example, Gaviria (1991) presented evidence from Tanzania that in some regions after the 1987/88 harvest that up to 89% of harvest remained stranded with typical figures in the region of 10-40%. Additionally, an improved transport reduces operating costs to vehicle users and provides more direct and cost effective access to public utilities (World Bank, 1989).

Notwithstanding that agriculture that formed the backbone of Nigerian economy until oil was discovered in the country in the 1960’s has been neglected, agriculture still plays major role in the socio-economic and political life of the country in the areas of food security, provision of raw materials for the industries, employment, and foreign exchange earnings for the country.

However, regardless agricultural impact on the country's economy, its production is predominantly practiced in rural areas by the rural dwellers. Most of these rural dwellers are traditional peasant farmers who employ outmoded methods in agricultural practices (Umeghalu, 2013). Though their individual contribution is insignificant, but collectively they form an important bed-rock for economic life of the country which represents about 90% of food and fiber produced in Nigeria (Ajiboye and Afolayan, 2009).

1.4 Effect of Rural Transportation System on Agricultural Productivity in Nigeria.

Rural transportation can be defined as a derived demand which serves to bridge the distance between origin and destination (Tunde and Adeniyi, 2012; Ajiboye, 1995). According to Adesanya et al. 2011), transportation serves as a connector while distance is a major determinant of the intensity of relationship between various sets of phenomenon distributed in space of other sectors of the economy with agriculture inclusive in space.

The dominant mode of transport in Nigeria rural space is head portage (Adedeji *et al.*, 2014). This form of transport persists principally because of road inadequacy and the state of disrepair of the entire rural road network especially during the rainy season. All these have serious implications on the cost and volume of products being moved on the road network (Sieber, 1999; Aloba, 1986). Agricultural buoyancy, productivity and development are anchored by road network infrastructure, because poorly maintained road militates against evacuation of farm products to the market, or processing centers. Also so many economic benefits will accrue to areas that are linked with good network of roads.

1.5 Prevalent routes in Rural Areas in Nigeria.

There are three types of routes prevalent in rural areas of Nigeria which are bush paths, un-surfaced rural roads, and surfaced rural roads. However, bush paths are very rampant and the least developed compared with other types of routes. These bush paths link the villages with farmsteads and they are usually narrowed, winding and sometimes overgrown by weeds especially during the rainy season (Oni et al., 2009). Where in the rural areas motorable roads exist, they are mostly of unpaved surface, narrow in width, circuitous alignment and with low quality bridges. In most cases, they are clad with potholes or characterized by depressions and aging (Filani, 1993). Most of the rural areas in Nigeria still have no access roads while about 90% of the rural roads which were estimated at between 130,000km and 160,000km nationwide were in poor condition (FERMA, 2003). Most rural roads deteriorate and become impassable during the rainy season, and this poses a threat to sustainability of rural socio-economic development. Tunde and Adeniyi (2012) noted that the condition of most rural roads is very poor compared with inter-urban and intra-urban roads in the country.

It could be right to say that in Nigeria, the more remote a rural area is, the lower its degree of transport infrastructural development. Availability of transport facilities is a critical investment factor that stimulates economic growth through increased accessibility, its efficiency and effectiveness (Ajiboye, 1995; Oyatoye, 1994). When these are lacking in our society, then transportation system will not be effectively utilized. These facilities include: good tarred inter-village, inter-community and inter-state roads to enhance easy conveying of agricultural products.

II. MATERIALS AND METHODS

2.1 Study Area:

Fig. 1 below shows the map of Enugu State of Nigeria. The State is within the South East Geopolitical Zone of Nigeria. She is bordered to the North by Kogi and Benue States, Ebonyi State to the East and Abia State to the South, while to the West is Anambra State. Enugu State is located within 6° 30'N and 7° 30'E of Greenwich Meridian. The State is located within the Tropical Rain Forest Zone of Nigeria, however, man's activities has turned most of the state's vegetation into Derived Savanna. Enugu State has an area of about 7,534 km^2 with a population of 4.4 million people (NPC, 2016).

The Mean Annual rainfall in the state hovers around 1,738.4 mm (NMA, 2009) which favours crop production in the state such as rice, yam, maize, cassava, palm products, vegetables etc. Coal is mined in commercial quantity in Enugu State.

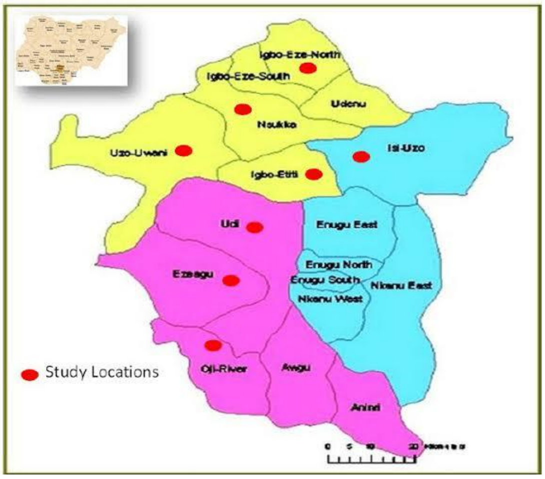

FIGURE 1: Map showing Enugu State with its local government areas.

Ojjor community, the study area is in Uzo Uwani Local Government Area of Enugu State. Uzo Uwani Local Government Area of Enugu State with their neighbor Anambra West Local Government Area in Anambra State are blessed with natural resources including crude oil and natural gas which is rated as having the highest crude oil reserve in Nigeria with large amount of untapped natural oil and gas. The local government area council is bordered to the north by Kogi State and Nsukka Local Government Area of Enugu State, to the East by Udi Local Government Area, to the South by Ezeagu Local Government Area and to the West by Anambra State.

Uzo Uwani Local Government Area lies within 6° 30' 22'' N and 7° 06' 01" E and covers approximately an area of 855km^2 and has the population of about 182,500 persons (NPC, 2016).

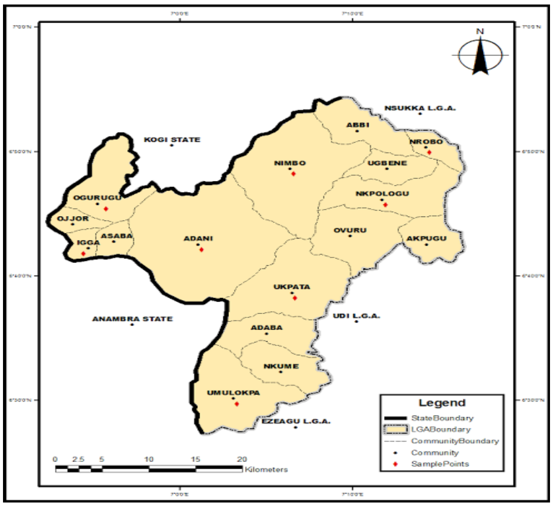

FIGURE 2: Map showing Uzo Uwani Local Government Area of Enugu State and the study area.

2.2 Data Collection and Analysis.

Primary data for the study was collected from respondents during the survey trips made to the study area with the aid of structured questionnaires designed to assist in obtaining information such as the age of respondents, level of education, size of house hold, nature of roads, occupation, size of farm holding, mode of transportation, accessibility to farms and markets etc. The questionnaires were administered to 100 respondents selected randomly from the community. In addition to the structured questionnaires, other instruments such as Focus Group Discussion (FGD) and interviews were conducted with other stakeholders such as transporters and traders in the study area. The interview was relevant for profiling the transportation mode in the study area and factors that facilitate or mare upland rice cultivation and agricultural development in general in the area. Secondary data was obtained from news paper publications. The data collected were statistically analyzed which assisted in arriving at the conclusions and recommendations given at the end of the study.

III. RESULTS AND DISCUSSION

3.1 Socio- Economic Characteristics of Farmers

TABLE 1
SOCIO- ECONOMIC CHARACTERISTICS OF FARMERS

S/N	Frequency	Percentage (%)
Male	73	73
Female	27	27
Total	**100**	**100**
Age bracket		
18-30	18	18
31-50	46	46
above 50	36	36
Total	**100**	**100**
Marital Status	**Frequency**	**Percentage %**
Married	34	34
Single	66	66
Total Education	**100**	**100**
None	0	0
Primary	30	30
Secondary	50	50
Tertiary	20	20
Total	**100**	**100**
Record Keeping		
Yes	62	62
No	38	38
Total	**100**	**100**
Group Farming/ Cooperative		
Yes	46	46
No	54	54
Total	**100**	**100**
Land Acquisition		
By inheritance	62	62
By Leasing	8	8
By Purchasing	30	30
Total	**100**	**100**
Farming Experience		
Below 5 years	8	8
6-10 years	54	54
11-20 years	24	24
above 20years	14	14
Total	**100**	**100**
Farming Practices		
Mono-cropping	44	44
Mixed Cropping	56	56
Total	**100**	**100**

The socio- economic characteristics of the sampled farmers are shown in Table 1 which reveals that the larger percentage (73%) of the farmers in the study area are male while (27%) are female. This implies that there are more male farmers in the study area than female. Farmers of ages between 18 – 30 years constitute (18%), those of age between 31 -50 years and about 46% while farmers of age above 50 years are about 36%. About 34% of the farmers are married while 66 % are unmarried. About 30% of the farmers have primary school education, 50% acquired secondary education while about 20% of the farmers had tertiary education. This implies that the farmers are educated and can easily adopt new farming technics that can improve their agricultural productivity. It is also seen that about 38% of the farmers do not keep record of their yearly farming activities while about 62% of the farmers keep. The majority of the farmers do not participate in a Farmers' Association or in any Agricultural Cooperative Societies probably due to lack of incentives from such associations, levies and laws guiding the association, so most farmers decide to be on their own. Most food farmers who acquired their land by inheritance are about 62%, followed by about 30% who acquired their land through purchase and those who acquired through lease are about 8%.

Furthermore, the study reveals that about 8% of the sampled farmers have less than 5 years farming experience, 54% of the farmers have at about 6-10 years farming experience, and 24% of the farmers have between 11 and 20 years' experience while about 14% have more than 20 years' experience in farming. . This indicates that most of the farmers sampled have enough farming experience. However, majority of the farmers (56%) practice mixed cropping while others 44% practice mono-cropping mainly upland rice farming.

3.2 Types of Crop Grown:

Respondents were asked about the major crops grown in the study area. Their responses revealed that they grow crops like rice, cassava, cocoyam, yam, potato, maize, melon as well as vegetable plants. They indicated that 56% grow grains such as rice, maize etc as shown in Fig. 3. About 32% of the farmers produce root/tubers which include yam, potato, etc. it was further revealed that 12% of the farmers grow other crops other than grain and root crops, which includes vegetable, leguminous crops, etc.

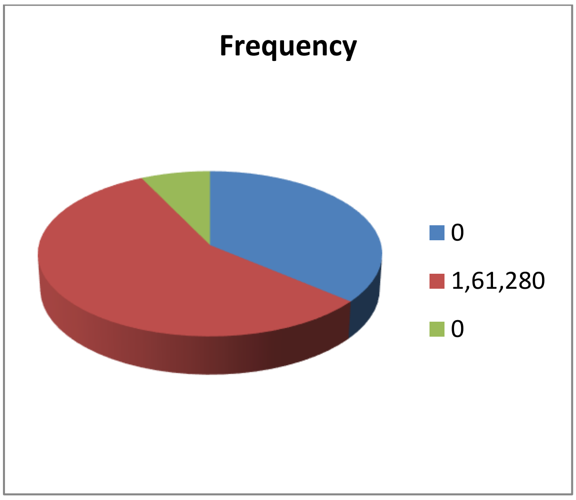

FIGURE 3: Pie chart representing various crops grown in the study area

3.3 Modes of Transportation

Road is an important transport component that encourages the use of intermediate modes of transportation (IMT). The study reveals that mainly non-motorable paths lead to the farmers' farm scattered at various distances from their homes. This is the resultant of the nature of the land tenure system which is characterized by land fragmentation, however, farmers' attitude to farm fertile lands for good harvest also lend credence to this. Respondents were however asked about the different modes of transportation of produce to their houses as well as the market. The study reveals identified the mode of transportation in the study area to include head porterage, motorcycle, wheelbarrow, public transport such as pick-up vans. Figure 4, shows that about 71% of the farmers use head porterage which is readily available, 5% of the respondents use public transport, 13% use wheel barrow while the remaining 11% use motorcycle.

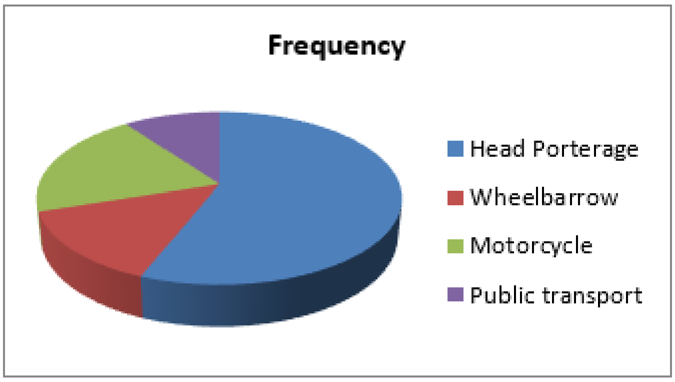

FIGURE 4: Pie chart representing various mode of transportation in the study area.

3.4 Transportation Costs of Agricultural Produce

Cost of transportation of agricultural produce from the farm sites to the market has a great impact on production and income of farmers. This is because transport charges on agricultural produce vary with type of crops, the efficiency of the transport and distance travelled. Fig. 5 reveals that 53% of farmers spend at above N1600 to transport their produce from the farm to the market. 35% spend between N600-N1500, while 12% spend below N500.

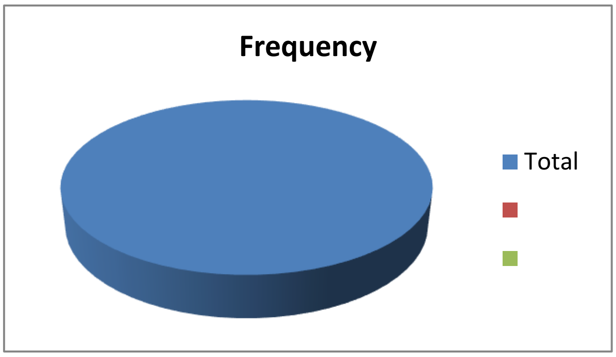

FIGURE 5: Pie chart representing cost of transportation from farm to the market.

3.5 Costs of transportation from the farm to farmers homes or to storage centers.

On the other hand, Fig. 6 shows that about 58% of farmers spend at above N1600 to transport their farm produce from their farm to their homes either for long term or temporary storage before taking the products to the market. About 29% of respondents spend between N600-N1500, while 13% spend below N500. This means that a significant proportion of the farmers' income is spent on transportation as a result of inadequate road infrastructure in the study area. The high cost of transportation would definitely translate to high selling price and however, if the price is too high when compared with farmers' products from other areas, customers will not buy and this may result to their selling at a loss. High transportation cost on the other hand will also limit their production capacities; hence they may likely decide to reduce their production.

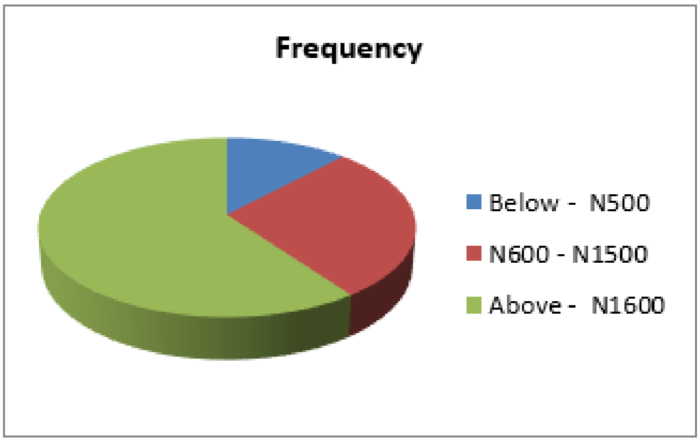

FIGURE 6: Pie chart representing cost of transportation from the farm to their homes or storage centers.

3.6 Farmer's Agricultural Productivity Level in Relation to Transportation of their Produce

Some factors are found to influence the quantity of crops produced by farmers in the study area and these vary from farm to farm and settlement to settlement. Such factors include availability of transport facilities, distance to markets, farm size and costs of farm input. Transportation problems contributed significantly to reduction in farmer's production capacity. This is because after a bumper harvest, most of the farm produce deteriorates if not transported to the market for sale within a limited period of time.

3.7 Distances between farmers farm and the nearest motorable roads.

Fig. 7 below reveals that about 45% of the farmers travel a distance of about 3-5km from their farms to the nearest motorable road before harvested can be transported to the market or industry. About 37% of the respondents travel less than 2km while 18% travels above 5km respectively before having access from their farms to motorable roads.

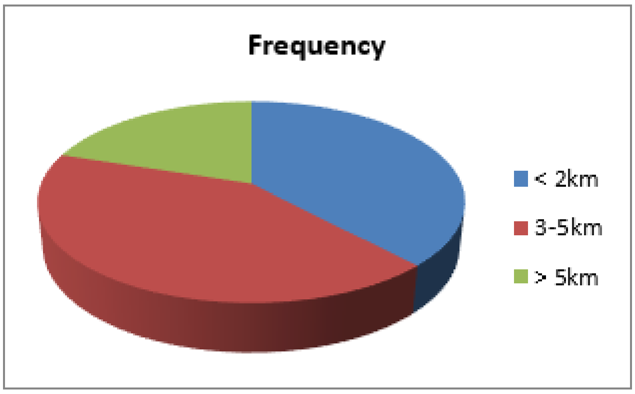

FIGURE 7: Pie chart representing of distance to nearest motorable road.

The respondents also expressed belief that transportation influences their level of agricultural production level although this varies from settlement to settlement. In absence of adequate transport facilities, farmers would likely not be motivated to produce more since they would not be sure of the means to evacuate their products from their farms. Thus, the prices of the little available crops in the markets would be very high that many people may not be able to afford it. Similarly, it would negatively affect the health of the citizenry, the production level of the agro-based industries and the general economy.

Some of the respondents believed that an improvement on road condition among other factors can motivate them to grow more crops and this in essence will mean more improvement in transport services will attract more buyers to the area leading to farmers increasing their holdings for possible higher profit margins for the products. It was further gathered that road transport does not only have impact on the development of the agricultural production but also on the socio-economic development of the rural people as a whole.

Transporters also pointed out that they prefer to be plying settlements that are well connected with good roads than those that are not. They noted that bad road conditions cause serious damages to their cars forcing them to spend much on maintenance of their vehicles. Furthermore, they indicated that their patronage of the study area is act of patriotism for being indigenes the community.

Field observation also show that the roads are characterized with unpaved surfaces, narrow width, circuitous alignment, bushy and filled with potholes, water logged and are generally in deplorable state. Moreover, most of the roads are seasonal in nature and are used mainly during the dry seasons as they remain flooded and impassable almost all part of rainy seasons. This seasonal nature of the roads was also observed to be a by- product of poor drainage, flooding and inadequate maintenance of roads. The poor quality of the roads in the study area affects the quality/ freshness of farm products which makes them attract low price and indirectly affect also the quality of life and well-being of the farmers. This is because farmers' spend their little income on buying drugs and treating themselves for sprains, pains, headaches and overall body ache due to long distances and hours of trekking with loads on their head because of absence of adequate transport facilities.

IV. CONCLUSION

Transport plays significant role in determining the level of agricultural production and marketing. The lower transport cost is for transportation of agricultural produce to the market or to other places they are needed, the more difference in the level of rural incomes. Agricultural products are biological products and are vulnerable to deterioration as soon as they are harvested, therefore, adequate transportation facilities are necessary to enhance their quick evacuation to the places they are required to avoid spoilage.

It is pertinent to avoid losses experienced by farmers especially during flooding when they are forced to harvest their crops prematurely. Absence of transportation facilities which would have enhanced quick evacuation of the crops lead to many farmers losing various percentage of their crops.

However, this study reveals that transportation of agricultural productivity in study area is not easily available when required and also very costly due to poor transport infrastructure. These leave farmers with heavy losses and little or no profit which discourages them from increasing their productivity. Where seasonal flooding is experienced like in the study area, farmers are forced to harvest their crops prematurely this also leads losses due to absence of drying and preservation facilities thus, this also reduce farmers productivity.

The study further reveals that adequate and efficient transportation system forms the corner stone which will encourage farmers in the rural areas to increase their farm produce and make more income and profit that will raise their standard of living create more employment and reduce poverty level in the rural areas.

V. RECOMMENDATIONS

Based on the identified problems and findings in this study, some useful recommendations are made which are all geared towards ensuring greater income and improved standard of living of rural farmers as well as inhabitants in the study area.

1. All roads in the rural areas should be converted to all weather roads connecting farmers to their farms to enhance easy evacuation of farm produce, improve rural spatial integration and accessibility to goods, services and opportunities.
2. Government should build collection centers equipped with processing facilities such as dryers and storage facilities in the study area to assist farmers minimize losses of their agricultural produce especially during rainy season. Paddy rice harvested during the rainy period is prone to deterioration if they are not dried immediately to reduce their moisture content.
3. Standard drainage systems, bridges and channels should be constructed for easy flow of flood water. This will minimize flooding.

REFERENCES

[1] Adedeji, O., Olafiaji, E.M., Omole, F.K., Olanibi, J.A., and Yusuff.L, (2014). An Assessment of the Impact of Road Transport on Rural Development: A Case Study of Obokun Local Government Area of Osun State, Nigeria. Department of Urban and Regional Planning, School of Environmental Technology, Federal University of Technology Akure, Ondo State, Nigeria.British Journal of Environmental Sciences Vol.2, No.1, pp.34-48.

[2] Adesanya, A., Philips, A.O, and Titilayo, S.T. (2011). Transportation Development in Nigeria in 2010 Ibadan: Nigerian Institute of Social and Economic Research (NISER).

[3] Ahmed, R. and Hussain, M. (1990). Development Impact of Rural Infrastructure in Bangladesh.Research Report, No. 83. International Food Policy Research Institute. Washington, DC.

[4] Ajiboye A.O. (1994). 'Rural Accessibility and Transportation Problems.A case study of Ijebu North Local Government Area, Ogun State'.Unpublished PGD in Transport Thesis, Department of Geography and Regional Planning, OgunState University Ago-Iwoye.

[5] Ajiboye A.O. (1995). 'Transportation and Distribution of Agricultural Products. A case study of Kola nut Production in Remoland Ogun State'.Unpublished M.Sc Transport Studies Thesis Ogun State University, Ago-Iwoye.

[6] Ajiboye, A.O and Afolayan, O. (2009). The Impact of transportation on agricultural production in a developing country: a case of kola nut production in Nigeria. International Journal of Agricultural Economics &Rural Development 2(2): 49-57.

[7] Aloba, O. (1986). Rural Transportation In: Falola, SA Olarewaju (Eds.): Transport Systems in Nigeria. Syracuse University, Maxwell School of Citizenship and Public Affairs. Series XLII: 125-138.

[8] Dorosh, P., W. Hyoung-Gun, Y. Liang, and E. Schmidt. (2009). Crop production and road connectivity in Sub-Saharan Africa: A spatial analysis. World Bank, Washington, D.C. Unpublished manuscript.

[9] Ellis, S, and Hine, J. (1998).The provision of rural transport services sub- Saharan African transport policy program. No 37 World Bank Washington DC Working paper.

[10] Filani, M.O. (1993). Transport and Rural Development in Nigeria. Journal of Transport Geography, 1: 248-254.

[11] FederalRoad Maintenance Agency FERMA. (2003)..Operation 500 roadshttp://www.ferma.gov.ng.

[12] Gavaria, J. (1991). Rural Transport and Agricultural Performance in SSA: 6 Country Case Studies. Sub-Saharan African Transport Program. Washington D.C: World Bank

[13] International Food Policy Research Institute (IFPRI), (2013). Policy options for accelerated growth and competitiveness of the domestic rice economy in Nigeria. Series number: 35 http://www.ifpri.org/publication/policy-options-accelerated-growth-and-competitiveness-domestic-rice-economy - Nigeria.

[14] Ijeoma, G. I. and Alphonsus, A. (2014). The Effects of Road Transport characteristics on the marketing of Agricultural Produce in Nsukka LGA, Enugu State, Southeastern Nigeria. Department of Geography, University of Nigeria, Nsukka, Enugu, Nigeria.Vol 2, Issue 1.

[15] Imolehin, E. D., and Wada, A. C. (2000).Meeting the production and consumption demands of Nigeria with improved technologies. *International Rice Commission Newsletter, 49, FAO, Rome*, 23-41.

[16] Kassali R., Ayawelu, A. B., and Idowu E. O. (2012). Effect of Rural Transportation System on Agricultural Productivity in Oyo State, Nigeria.Journals of Agriculture and Rural Development in the Tropics and Subtropics.Vol. 113 No. 1.Pg 13-19.

[17] Minten, B., and Kyle, S. (1999). The effect of distance and road quality on food collection, and marketing margins, and traders' wages: Evidence from the former Zaire. Journal of Development Economics 60: 467–495.

[18] Muochebe, B.A. (2021). Determination of the Optimal Parboiling Condition of Fara-44 Rice Variety for enhanced Quality of Milled Rice. A Thesis Submitted to the Department of Agricultural and Bioresources Engineering, Faculty of Engineering, Nnamdi Azikiwe University. Awka in partial fulfillment of the requirement for the award of Masters Degree (M. Eng.) in Agricultural and Bioresources Engineering.

[19] Nguu, V.N. and Aldo, F. (2006). Meeting the Challenges of Global Rice Production. Published Online @ Springer Verlag 2005/Paddy West Environ, 4: 1-9; Dol. 10.1007/s 10333 – 005 – 0031 – 5.

[20] Nigerian Population Commission (NPC), (2016). Nigerian National Census.

[21] Odigboh, E.U. (2008). Global Food Crisis: Intensified Agricultural Mechanization Imperative For Nigeria. Lead Paper Presented at The First South-East Regional Conferences of The NIAE held Ay Nnamdi Azikiwe University Awka, August 2008. Pg 12-19.

[22] Ogunsanya, A. A. (1993). Directions in Urban Transport Studies in Nigeria. In Ikya, S.G. (ed.). Urban Passenger Transportation in Nigeria, Heinemann Educational Books (Nig.) Plc.

[23] Oladeebo, J. O. (2006). "Economic Efficiency of Rain-Fed Upland Rice Production in Osun and Oyo States Of Nigeria." Phd Thesis Department of Agricultural Economics and Extension, FUTA, Akure.

[24] Oni, O., J. Pender, D. Phillips, and E. Kato. (2009). Trends and Drivers of Agricultural Productivity in Nigeria. Nigeria Strategy Support Program (NSSP) Report 001: IFPRI.

[25] Oni, S., and Okanlawon, K. (2006). "Nigeria's transport infrastructural development: an integral part of the national economic empowerment and development strategy (NEEDS)", Journal of Social and Policy Issues, 3(2), pp. 7-13.

[26] Onwualu, A. P., Akubuo, C.O. and Ahaneku, I.E. (2006). Fundamentals of Engineering for Agriculture. Immaculate Publications Limited, 2 Aku Street, Ogui New Layout, Enugu, Nigeria.

[27] Owen, W. (1968). Distance and development. The Brooking Institution, Washington D.C.

[28] Oyatoye, E. T. O. (1994). The impact of Rural Roads on Agricultural Development in Nigeria: A case study of Kwara State. Ife Journal of Agriculture, 16, 114–122.

[29] Paul. D, Hyoung-Gun. W., Liang. Y, and Emily. S. (2009). Crop Production and Road Connectivity in Sub-Saharan Africa: A Spatial Analysis. Africa Infrastructure Country Diagnostic Working Paper 19. A publication of the World Bank.

[30] Shaobing, P.Q .T. and Yingbin, Z. (2009). Current Status and Challenges of Rice Production in China. Plant Production Science, 12: 1, 2-8: Dol; 10.1626: pps. 12.3

[31] Sieber, N. (1999). Transporting the yield. Appropriate transport for agricultural production and marketing in Sub-Saharan Africa.Transport Reviews, 19 (3), 205–220.

[32] Somado, E. A., Guei, R. G., and Keya, S. O. (2008). NERICA: The new rice for Africa: A compendium. Africa Rice Center (WADA).

[33] Tunde, A.M., and Adeniyi, E.E. (2012). Impact of road transport on Agricultural Development: A Nigerian

[34] Example. Ethiopian Journal of Environmental Steadies and management EJESM; Vol.5 No.3: pp 232-38.

[35] Ukoha, O. O., B. C. Okoye, and J. Emetu. (2010). Analysis of the Determinants of Total Factor Productivity among Small-Holder Cassava Farmers in Ohaa L.G.A of Abia State.United Nations Development Program. (2009). Human Development Report, 2009. New York: United Nations Development Programme.

[36] Umeghalu, I.C.E.,Ngini, J.O., and Chukwuma, E.C. (2013). Challenges and Prospects of Lower Anambra River Irrigation Project, Omor, Anambra State, International Journal of Agriculture and Bioresources. 2 (4); pp 141-143.www.ijagbio.com

[37] Queiroz, C.A.V. and Gautam, S.P. (1992). Road infrastructure and economic development: some diagnostic indicators, Infrastructure Operations Division, Western Africa Department and Transport Division, Infrastructure and Urban Development Department, World Bank, Washington, DC.

[38] World Bank (1989). The Rural Road Question and Nigeria's Agricultural Development. Managing Agricultural Development in Africa (MADIA), Discussion Paper No. 10. World Bank. Washington, DC.

[39] Yunusa, M., Shaibu, I. Ambi, Y. A., Yusuf, A. and Abdulkarim, B. (2002). "Road Rehabilitation: The Impact on Transport and Accessibility." In Fernando, P. and Porter, G. (eds.) Balancing the Load: Gender, Women and transport. Zed Books. London.

Varieties and Soil Amendments (Poultry Manure) effect on growth and yield of Bambara Groundnut in Owerri, Southeastern Nigeria

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Abstract— *Bambara groundnut is an underutilize legume with poor yield because of inadequate knowledge about high yielding varieties and soil amendment rates. This experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri, to determine the growth and yield potentials of five varieties and different poultry manure rates of Bambara groundnut. The five varieties used were TVSU 1482, TVSU 688, TVSU 921, Black local and White local, while the soil amendment rates were 0kg/ha, 4000kg/ha, 6000kg/ha, and 8000kg/ha of poultry manure. The experiment was set up in a split block using a randomized complete block design (RCBD). Data collected include plant height, 50% flowering, days to 50 % maturity, pod per ha and Seed yield per hectare. The data collected were analyzed using the GLM SAS software while the means were separated using the Duncan's multiple range test as described. Result showed that variety TVSU 688 had higher performance than other varieties but not significantly better (P<0.05). The manure rates were also significantly better than control (0kg/ha) in growth and yield parameters. The experiment revealed that TVSU 688 has the highest growth and yield traits in Owerri, while poultry manure applied at 4000 kg/ha is also the most effective poultry manure rate to be considered in Bambara groundnut cultivation*.

Keywords— Bambara Groundnut, Manure, Poultry, Variety.

I. INTRODUCTION

The Bambara groundnut (*Vigna subtarranea (*L) Verdc) belongs to the family *Fabaceae*, subfamily *Papilionoidea*. It is an indigenous African legume (10) which originated in the Sahel region of present day West Africa. Its name originated from the Bambara tribe who now live mainly in Mali (6). Bambara groundnut is the third most important grain legume after groundnut. Although considerably less popular throughout the world, cultivation of Bambara groundnut has remained common in all of West Africa. It is has also been established that the crop is one of the most underutilized in the developing world (6). The micronutrients and amino acids in Bambara groundnut is comparable to that of soybean. Seeds and nuts can be eaten raw or cooked while the protein extracts can be used in making cosmetic formulations. Bambara groundnut is a good source of human protein. It also contain high amount of phosphorus and potassium. It helps in bone development and proper functioning of kidney (4, 11). They also play a role in nutrition of many people in Africa where they can be processed into flour, *akara, okpa, moin-moin,* milk, *tubani,* and *dawadawa,* which provide nutrients to fight malnutrition across the continent (12).

As having access to proper balanced diet continues to be a challenge across Africa continent as a result of the rapid growth in population, migration crisis, depletion of soil nutrients and effects of climate change (13). There is a need for diversification of diet and Agricultural production system in other to fully maximize crop output. This also underscores the importance of using different approach in improving the growth and yield of underutilized crops like Bambara groundnut. Therefore, the aim of this experiment was to determine the effect of poultry manure rates as soil amendment on selected growth and yield parameters of Bambara groundnut varieties.

II. MATERIALS AND METHOD

2.1 Study and planting area

The experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri. A land area of 27.5m x 13m was cleared and prepared for the experiment. The field was marked out into five main plots and each plot further divided into 4 sub plots. The sub plots were well prepared seed beds of dimension 3m x 0.8m (0.00034ha).

2.2 Treatments and Experimental Design

2.2.1 Collection and sowing of seeds:

A total of five varieties were used for this experiment. Three of them TVSU 1482, TVSU 688 and TVSU 921 were sourced from IITA, Ibadan, the other two, Black and White were collected from local farmers in Mubi Adamawa State. Three seeds were sowed directly on the field which was latter tinned down to one per stand. The sowing was done at a spacing of 60cm x 30 cm and 2-3cm depth. It was sown at the rate of 1 seed per hole. This gave a planting density of 55,555 plants/ha

2.2.2 Treatment application and experimental design:

The soil ammendment used was a Poultry manure (broiler droppings) collected from Ubochi Farm in Aboh-Mbaise Imo State. The poultry manure (PM) was cured for four weeks while application was carried out four days before sowing at the rates of 0kg/ha, 4000kg/ha, 6000kg/ha, and 8000kg/ha. A Split Plot in Randomized Complete Block Design (RCBD) with three replications was used and planting was done twice. The first planting was September while the second was late October. The Five varieties of Bambara groundnut were allocated to the main-plot while the four levels of Poultry manure were applied to the sub-plots: forming a 5 x 4 x 3 split plot in RCBD.

To supplement water during the dry spell, surface irrigation was applied to the October planting at the rate of 0.5 litres per plant every 48 hours. This water was sourced from the IMSU farm borehole. Manure weeding was done throughout the period of the experiment to reduce the competition with weeds for nutrients, water and sunlight.

2.3 Data Collection and Analysis

Data were collected include days to plant height, 50% flowering, days to 50 % maturity, and Seed yield per hectare. The data collected were analyzed using the GLM SAS software. The means were separated using the Duncan's multiple range test as described by Onuh and Igwemma (2007).

III. RESULTS

Table 1 shows the effect of five varieties and different rates of poultry manure on the plant height of Bambara groundnut in September and October. Result showed that the varieties were not significantly different from each other in September and October. However, the plant height of TVSU 688 was higher than other varieties in both months (22.9 and 21.2 for September and October respectively). Result also indicated that all varieties performed than local varieties in September, however, the local varieties performed than improved varieties in October (although not significant) except TUSV 688.

For the manure rates, result showed that height of plants treated with poultry manure were significantly higher than control. Among the manure treatments, 6,000 (kg/ha) had the highest plant height for September (25.7) and October (23.8), although the differences were not significant.

TABLE 1
EFFECT OF VARIETIES AND MANURE RATES ON PLANT HEIGHT

	August				October			
Treatment	**3WAP**	**5WAP**	**7WAP**	**9WAP**	**3WAP**	**5WAP**	**7WAP**	**9WAP**
TVSU 1482	13.3	15.4	17.36	20.1	10.5	12.8	15.2	16.5^{ab}
Black local	10.6	13.2	14.2	17.9	11.2	13.8	16.4	17.7^{ab}
TVSU 921	12.1	16.4	18.6	19.3	11.8	12.4	14.6	15.0^{ab}
White local	12.8	14.9	16.4	17.5	10.1	14.6	17.9	18.4^{ab}
TVSU 688	14.8	18.9	20.4	22.9	12.8	14.6	18.9	21.2^{a}
Manure rates (kg/ha)								
0	10.1	12.6	13.9	15.5^{b}	10.6	11.4^{b}	13.9^{b}	14.6^{b}
4000	14.1	15.8	18.3	24.8^{a}	12.2	17.5^{ab}	19.6^{ab}	22.9^{a}
6000	13.9	16.2	20.7	25.7^{a}	12.4	18.3^{ab}	19.5^{ab}	23.8^{a}
8000	13.2	15.5	19.8	24.4^{a}	11.8	19.5^{a}	21.4^{a}	22.1^{a}

Table 2 shows the effect of varieties and poultry manure rates on emergence, days to 50% flowering and days to 50% maturity of Bambara groundnut. The result of August planting shows that TVSU 688 recorded the highest mean number of days (10 days) to 50% emergence. This was not significantly different (P<0.05) from the other varieties. The black local variety which had the shortest mean number of days (9 days) to emergence was also not significantly (P<0.05) different from the other varieties (10 days). manure rate of 8000kg gave the highest mean number of days to emergence (9.9) which was not significantly different (P<0.05) from the other treatments. Meanwhile, 4000kg/ha of poultry manure which had the lowest mean number of days (9.6 days) to 50% emergence was statistically similar to 0kg/ha and 6000kg/ha with 9.7 days respectively.

In October planting, TVSU 1482 recorded the highest mean number of days to emergence (7.5days) which was not significantly different (P<0.05) from other varieties. Apart from the black local variety which took 7.1 mean numbers of days, TVSU 921, TVSU 688 and white local varieties took 7.0 days to attain 50% emergence. There was a more uniform germination in October planting than in August planting. Though 4000kg/ha poultry manure recorded the highest mean number of days to emergence (7.2days), there was no significant difference (P<0.05) between the poultry manure means in October planting.

TVSU 921 recorded the highest number of days to flowering at both planting dates with 41.9days and 39.5days respectively and these were not significantly different from the black local variety which recorded the lowest mean number of days to flowering at both planting dates with 38.0days and 36.3days respectively. The highest means were not significantly different (P<0.05) from the lowest at both planting dates. There was more uniformity in days to flowering in October than in August planting where there was more significantly different (P<0.05) means.

Poultry manure effects were not significantly different (P<0.05) at both planting dates. In August planting, 8000kg/ha rates of poultry manure recorded the highest (40.3days) while 0kg/ha rates of poultry manure recorded the lowest mean of 38.8 days. In October, 0kg/ha rates gave the highest mean (37.4days) while 4000kgHa- recorded the lowest mean of 37.1. Apart from the control, poultry manure effect followed the same pattern (4000kg/ha<6000kg/ha<8000kg/ha) in both seasons. This indicates delay in flowering with increase in poultry manure rate.

TVSU 1482 and TVSU 921 were observed to be late maturing varieties. Their mean number of days to maturity was very high. TVSU 1482 had the highest number of days to 50% maturity in both planting dates with 126.3 days and 126.2 days. The lowest was TVSU 688 in August (88.1), while the white local variety had the lowest days to maturity in October (88.2).

In August planting, there was a significant difference (P<0.05) between the highest mean 102.1days (8000kg/ha PM) and the lowest mean 97.7 days (4000kg/ha PM) poultry manure mean. 8000kg/ha of poultry manure had the highest mean of 102.1 days which was not significantly different (P<0.05) from those of 0kg/ha and 6000kg/ha rates. The lowest mean was 38.800

recorded by 4000kg/ha rates. In October planting, poultry manure effect was not significant. 8000kg/ha and 4000kg/ha also maintained the highest and lowest means (as in August planting) of 101.6 and 100.5 days.

TABLE 2
EFFECT OF VARIETIES AND POULTRY MANURE RATES ON DAYS TO EMERGENCE, 50% FLOWERING AND 50% TO MATURITY OF BAMBARA GROUNDNUT

	August				October		
Treatment	**Days to emergence**	**Days to flowering**	**Days to maturity**		**Days to emergence**	**Days to flowering**	**Days to maturity**
TVSU 1482	9.8	39.5	126.2[a]		7.5	37.4	126.6[c]
Black local	9.2	38	89.1[c]		7	36.3	92.7[a]
TVSU 921	9.5	41.9	108.5[b]		7.1	39.5	110.2[b]
White local	10	40.5	88.3[c]		7	36.5	88.2[a]
TVSU 688	10.2	39.5	88.4[c]		7	36.8	88.7[a]
Manure rates (kg/ha)							
0kg/ha	9.7[b]	38.8	101.7		7.1[a]	37.4	101
4000kg/ha	9.6[b]	40.8	97.4		7.2[a]	37	100.4
6000kg/ha	9.7[b]	40.2	101.4		7.1[a]	37.2	101.2
8000kg/ha	9.9[a]	40.3	102.1		7.1[a]	37.4	101.6

Means in the column of same letters are not significantly different at P<0.05 according to Duncan's multiple range tests

3.1 Seed yield

Table 3 shows the response of Bambara groundnut to different varieties and poultry manure at different planting seasons on number of pods and the seed yield. In August planting, there were variations in the seed yield of the 5 different varieties. TVSU 688 had the highest seed yield of 620kg/ha which was significantly different ($P<0.05$) than TVSU 1482, black local, and white local varieties. Similarly in October, TVSU 688 (468.8kg) also had the highest seed yield which was significantly different ($p<0.05$) to TVSU 1482 (125.3kg) with the lowest seed yield, but statistically not different from other varieties.

In both months, 4000kg poultry manure had the highest mean seed yield of 427kg/ha and 403.24kg/ha respectively. In August the highest mean of 427kg/ha recorded in plants treated with 4000 kg/ha had no significant difference ($P<0.05$) from other manure rates but significantly higher from the control (202.0 yield/ha). Similarly in October planting, there was no significant difference ($P<0.05$) between the poultry manure means but the manures were significantly higher than the 0 kg/ha (control) which had the lowest seed yield of 223.1.

The effect of varieties and poultry manure rates on Bambara groundnut is shown in table 3. Result revealed that in August, variety TVSU 688 had the highest pod/ha which was significantly different from other varieties (2,530,067). This was followed by Black local which was also significantly higher than TVSU 1482, TVSU 921 and the White local varieties. TVSU 688 also had the highest pods in October (895,824) which was significantly higher than other varieties except TVSU 921 (472,218).

Result also showed variations in the poultry manure rates and the control. In both August and October, there were no significant differences among the manure rates but performed significantly better than the o kg/ha (control). In August, manure rate of 8000 kg/ha had the highest pod (1,196,284) while 4000 kg/ha had the highest pod/ha (464,810) in October. Notwithstanding, they were not significantly different from the other manure rates in both monts.

IV. DISCUSSION

The annual production of Bambara groundnut is estimated to be 0.3 million metric tons, with majority of them (0.2 million metric tons) produced in Africa (Esan). This is a very low output compared to similar legumes like soybean with annual production of more than 200 million metric tons. It is also noteworthy that Bambara groundnut is drought-tolerant and thrives well in poor soil conditions. Yet, the outputs remain low. To maximize growth and yield of Bambara groundnuts, many studies have indicated the need to determine the Agronomic performance of different varieties under different environments with a view to identifying the variety with best vegetative and yield traits under specific environment. This was demonstrated in this experiment as the agronomic performance of five varieties of Bambara groundnuts in the Southeast Nigeria was revealed.

Generally, variety TVSU 688 had better performance than other varieties in respect to both vegetative and yield traits. The performance of the variety could be attributed to its ability to adapt well to the agro-climate of the area. Previous study by (2), noted that varieties of Bambara groundnuts that produce high yield do so when all growth and yield factors correlate with environmental factors. This is also similar to the observation of (7), that temperature, rainfall and other biotic factors in a particular environment cause differences in agronomic performance and yield outputs of Bambara groundnut. Another study by (1), showed that environment is the most important source of variation in crops which plant breeders should pay attention to when considering varieties with high growth and yield potentials. The performance of TVSU in this particular experiment showed it was able to utilize the biotic and abiotic factors in the environment relatively better than other varieties. Among the local varieties, Black local seems promising signs in terms of early emergence and days to maturity. In respect to August and October planting dates, previous study by (9), observed that Bambara groundnut planted during the season of extended exposure to photoperiods favour vegetative growth while those with less exposure favours pod and seed growth. This was not particularly the case in this experiment as there was no obvious difference during the August and October planting. It should be noted that those planted in August have less exposure to photoperiod because of rainfall.

The growth and yield parameters of Bambara groundnut showed that application of poultry manure at different rates lead to increase in growth and yield of the plant. All the manure rates applied in this experiment have higher performance than the control. This is could be as attributed to the presence of nutrients present in the manure that supplements the soil nutrients, thereby increasing the growth and yield of the plant. Another author (3), observed that poultry manure contain the highest nitrogen, phosphate and potassium of all animal manure. Interestingly, this elements are also easily accessible by the plant which make them to be useful almost immediately after application. Similarly, poultry manure also helps in improving soil structure which could help in boosting water penetration, especially during dry spells. This is also similar to early study by (8) that reported the increase in growth and yield of Bamabara groundnut by the application of poultry manure. It is also in agreement with (5), which observed increase in nutrient, water intake and growth of plants as a result of poultry manure.

V. CONCLUSION AND RECOMMENDATION

This experiment showed that variety TVSU 688 is the most superior Bambara variety for maximum growth and yield in Imo State Southeastern Nigeria. Result also showed the application of poultry manure increase growth and yield of Bambara groundnut.

We therefore recommend the cultivation of TVSU 688 in the state. However, in places where the variety is not available, local Black variety should be cultivated. We also recommend the application of poultry manure at the rate of 4000 kg/ha to maximize yield.

REFERENCES

[1] Aremu, C. O. *et al.* (2019). Morphometric analysis and characterization of the nutritional quality in African yam bean accessions. *Plant Physiol. Rep.* 24, 446–459. https://doi.org/10.1007/s40502-019-00472-w

[2] Azam-Ali, S. N. *et al.* Assessing the potential of an underutilized crop–A case study using bambara groundnut. *Exp. Agric.* **37**, 433–472 (2001)

[3] Babu, A., Singh, U. M., Ramawatar, D., Basant, J., and Raj, M. (2021). The Use of Poultry Manure as Organic Fertilizer in Different Crops. 1. 14-15.

[4] Belewu, M. A., Fagbemi, T., Dosumu, O. O. & Adeniyi, M. O. (2008). Physico-chemicaland anti-nutritional properties of some lesser known tree and leguminous seeds. Int. J.Agric. Res., 3 (3), 237-242 *(10) (PDF) Nutritional Evaluation of Bambara Groundnut (Vigna subterranea (L.) Verdc) From Lapai*. Available from:

https://www.researchgate.net/publication/356788477_Nutritional_Evaluation_of_Bambara_Groundnut_Vigna_subterranea_L_Verdc_From_Lapai [accessed Oct 14 2023].

[5] Boateng, S. A., Zickermann, J. and Kornahrens, M. (2006). Poultry Manure Effect on Growth and Yield of Maize. West Africa Journal of Applied Ecology, 9, 1-11 –ISSN: 0855-4307

[6] FAO, (2017) Regional Overview of Food Security and Nutrition in Africa 2016. The Challenges of Building Resilience to Shocks and Stresses.

[7] Esan, V. I., Oke, G. O., & Ogunbode, T. O. (2023). Genetic variation and characterization of Bambara groundnut [Vigna subterranea (L.) verdc.] accessions under multi-environments considering yield and yield components performance. *Scientific Reports*, *13*(1), 1-19. https://doi.org/10.1038/s41598-023-28794-8

[8] Jaja, E. T., and Ikechukwu, A. (2018) Productivity of Maize/ Bambara Groundnut Intercrop with Poultry Manure Rates. Journal of Biology, 8(4) 60-73, Agriculture and Healthcare www.iiste.org ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)

[9] Linnemann, A.R. 1994. Photothermal regulation of phenological development and growth in bambara groundnut [Vigna subterranea (L.) Verdc.]. PhD Thesis, Wageningen Agricultural University, The Netherlands.

[10] Massawe, F.J. (2005). "Breeding in Bambara groundnut (Vignasubterranea (L.)Verdc.): strategic considerations". *African Journal of Biotechnology* **4** (6): 463–471.

[11] Musah M., Azeh Y., MathewJ.T., Nwakife C.N.,Mohammed A.I., Saidu F.(2021), Nutritional Evaluation of Bambara Groundnut (Vignasubterranea (L.) Verdc) FromLapai, Nigeria. AfricanJournal of Agriculture andFood Science 4(4), 32-39.DOI:10.52589/AJAFS_SQI5U7CN *(10) (PDF) Nutritional Evaluation of Bambara Groundnut (Vigna subterranea (L.) Verdc) From Lapai*. Available from:

https://www.researchgate.net/publication/356788477_Nutritional_Evaluation_of_Bambara_Groundnut_Vigna_subterranea_L_Verdc_From_Lapai [accessed Oct 14 2023].

[12] Olatunde, Sogo & Ogundele, Opeolu & Oyedokun, James & Chinma, Chiemela & Shittu, Taofik & Onoja, Victor. (2021). Traditional Food Uses of Bambara Groundnut. 10.1007/978-3-030-73920-1_9.

[13] Tan, X. L., Goh, E. V., Mustafa, M., Chai, H. H., Ho, W. K., Mayes, S., Mabhaudhi, T., & Massawe, F. (2020). Bambara Groundnut: An Underutilized Leguminous Crop for Global Food Security and Nutrition. *Frontiers in Nutrition*, *7*, 601496. https://doi.org/10.3389/fnut.2020.601496.

The Impact of Climate Change on Human Population and Environmental Health in Sub-Saharan Africa

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Abstract— *This paper focused on the impact of climate change on human population and environmental health in Sub-Saharan Africa. Africa is among the most vulnerable continents to climate change has a result of human's explorative activities. Throughout this region there are spatial and temporal discrepancies in temperature and precipitation trends; with dread impacts on human population, its sustainability and environmental health. The effects of climate change are warming temperatures, fluctuations in precipitation, harsh weather events, rising sea levels, population migration and displacement of coastal communities. These impacts threaten human population, population distribution and settlement, health, water quality and supply, agriculture and our ecosystems. Climate change impacts our health in a number of ways by: reducing the availability of safe food and drinking water; damaging roads and bridges, disrupting access to communication, utility, and health care services; increasing emission of greenhouse gases from human activities, such as the burning of fossil fuels (coal, natural gas, and oil) for energy and transportation; risk of respiratory, cardiovascular and vector borne disease; and increasing mental health problems like as depression and post-traumatic stress disorder (PTSD). For effective management of this risk, it requires the integration of mitigation and adaptation strategies in the management of ecosystem, agriculture and human health population in Africa.*

Keywords— Climate Change, Human Population and Environmental Health.

I. INTRODUCTION

Climate change is already a reality in Africa, this relates to aspects of climatic changes within the continent. Intergovernmental Panel on Climate Change reports that surface temperatures have increased over Africa since the late 19th century to the early 21st century by about 0.5 °C while observed precipitation trends indicate spatial and temporal discrepancies in variability among regions (1). Africa is among the most vulnerable continents to climate change, due to a range of factors that includes weak adaptive capacity, high dependence on ecosystem for livelihoods and crude agricultural production system (4). This climate change poses a great risk to the sustainability of various sectors which include: human population, population distribution and settlement, health, water quality and supply, agriculture and our ecosystems biodiversity with severe consequence on lives and sustainable development prospects in Africa. In order to contain this risk very well, it requires the combination of mitigation and adaptation strategies in the handling of ecosystem goods and services, and the agriculture production systems in Africa (19).

Climate change refers to any significant deviation from the measures of climate lasting for a long period of time. Climate change therefore includes prominent changes in temperature, precipitation, or wind patterns, etc, that occur over a very long period. While global warming an offshoot of climate change refers to the recent and ongoing rise in global average temperature near earth's surface. It is as a result of increasing concentrations of greenhouse gases (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Ozone (O_3), and Chlorofluorocarbons (CFCs)) in the atmosphere. Global warming is causing climate patterns to change. Human beings are largely responsible for recent climate change. Over the years, large amounts of carbon dioxide and other greenhouse gases have been released into the atmosphere through burning of fossil fuels to produce energy, deforestation and industrial processes. Consequently, the buildup of greenhouse gases has triggered a change in earth's climate resulting in dangerous effects to human health, water supplies, agriculture, power and transportation systems and ecosystems.

TABLE 1
PROJECTED CLIMATE CHANGES IN AFRICA

Change	Region
Average conditions	
Temperature increase	Entire continent (median projected increase in annual average temperature: 3 to 4 °C (end of century to present)
Decrease in rainfall	West coast of Africa as far south as 15° N Southern Africa
Increase in rainfall	Northern parts of East Africa
Uncertain projections for rainfall	Sahel (already high variability) Guinean coast Southern Sahara
Sea level rise	Low lying islands and coastal zones Delta regions
Extremes	
Increase in intense	Entire continent (this applies also in regions of mean
precipitation events	drying because there is a proportionally larger decrease in the number of rain days)
Cyclones	Uncertain — changes in magnitude and frequency, and shifts in cyclone tracks possible

Source [12]

The earth is warming. According to Global Change Programme (14), there has been an increase by 1.5^0F in earth's average temperature over the past century, and will likely by another 0.5 to 8.6°F in hundred years to come. These minute changes in the average temperature of the planet can translate to mighty and potentially dangerous shifts in climate and weather. Increasing global temperatures have caused lots of changes in weather and climate. There have been changes in rainfall pattern in many parts of the world, resulting in increased frequency and intensity of floods and droughts, as well as more frequent and severe heat waves. Also, oceans and glaciers are warming and becoming more acidic, ice caps are melting, and sea levels are rising. These and other changes present challenges to our society and our environment.

II. GREENHOUSE GAS EFFECT

Greenhouse gases are those gases that trap heat in the atmosphere and they include carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), Ozone (O3), and Chlorofluorocarbons (CFCs) in the atmosphere. The recent climate change has been attributed to CO_2. CO2 is absorbed and emitted naturally as part of the carbon cycle, through plant and animal respiration, volcanic eruptions, and ocean-atmosphere exchange. Burning of fossil fuels (coal, natural gas, and oil) for energy and transportation, some industrial processes and changes in land use, release large amounts of CO2, causing increase in its atmospheric concentrations. Human activities have been estimated to release over 30 billion tons of CO2 into the atmosphere per annum. The devastating effect of increased greenhouse gas concentrations in the atmosphere include:

- Increase earth's average temperature
- Influence the patterns and amounts of precipitation
- Reduce ice and snow cover, as well as permafrost
- Raise sea level
- Increase the acidity of the oceans
- Increase the frequency, intensity, and/or duration of extreme events
- Shift ecosystem characteristics
- Increase threats to human health including
- Negative impact on our food supply, water resources, infrastructure and ecosystems.

TABLE 2
MAIN SOURCES OF GREENHOUSE GASES, CURRENT LEVEL, GLOBAL WARMING POTENTIAL AND THEIR LIFETIME IN THE ATMOSPHERE

Green House Gases	Atmospheric Life time	Recent Level	Global Warming Potential (in 100 yrs) time zone	Main Source
C02	1 OOyrs	389 ppm	1	Anthropogenic activities, fossil fuel etc.
CH4	12yrs	1748- 18709 PPb	25	Land wastes, livestock etc.
N20	114yrs	323ppb	298	Agriculture, industry and combustion etc
CFCs	12 - 1 OOyrs	75 - 534ppt	5000- 10900	Industries, old air conditioners and refrigerators etc.
3	Hours to days	34ppb	n.a	Fuel combustion, organic compound evaporation etc.

Source [12]

III. IMPACTS OF CLIMATE CHANGE IN SUB-SAHARAN AFRICA

The world average temperature is rising due to the greenhouse effect caused by increasing levels of greenhouse gases, especially carbon dioxide. As the global temperature changes, so also changes in climate are expected across the earth. Regional effects of global warming vary in nature, some are the result of a generalized global change or change in specific ocean current or weather system; resulting in local effects, such as melting or forming ice, changes in the hydrological cycle (evaporation and precipitation), changes of currents in the oceans and air flows in the atmosphere and rise of sea levels.

3.1 Human Population

Africa is considered vulnerable to climate variability and change due to some predisposing factors such as poverty, political conflicts, and ecosystem degradation and low adaptive capacity. Climate change is projected to cause decrease in the availability of freshwater. With population growth and increasing demand from higher standards of living, this decrease would have negative effect on overwhelming percentage of world population in the future. Islands, located in the tropics or higher latitudes, are already exposed to extreme weather events and changes in sea level. Regional temperature increases have affected most oceans resulting in changes in regional rainfall patterns, earlier leafing of trees and plants over many regions; movements of species to higher latitudes and altitudes in the Northern Hemisphere and shifting of the oceans' plankton and fish from cold- to warm-adapted communities (24).

According to the Report of Intergovernmental Panel on Climate Change (11), by 2050, between 350 million and 601 million people in Africa are projected to experience increased water stress due to climate change and displacement of large populations of low-lying coastal areas due to projected sea level rise. Rising sea levels and extreme events threaten indigenous groups that inhabit low-lying island nations. The results from various assessments of impacts of climate change on human population show that sea-level rise could increase flooding, particularly on the coasts of Eastern Africa (18). Also, higher temperatures and reduced snow, ice, etc, threaten the wellbeing of inhabitants of mountainous and polar areas. Climate effects in these areas affects businesses such as hunting, fishing, transport, and other activities (1).

It was projected by (4) that in many African countries and regions, agricultural production and food security would probably be severely compromised by climate change and climate variability this means there will be high food insecurity, in the face of the ever-increasing population. Furthermore, climate variability and change can negatively affect human health and population. In many African countries, the prevalent health threats such as malnutrition, malaria and other diseases can be exacerbated by climate change, leading to tolling death- rate and decrease in population.

3.2 Population Distribution and Settlement

Climate change plays critical role in the migration of people within and between countries around the world. Harsh environmental factors such as resource scarcity, degraded ecosystem services, lack of viable agricultural land or fresh water, flooding, drought, and hurricanes force many people to migrate into other areas. Droughts have long contributed to human migration, cultural separation, population dislocation and the collapse of prehistoric and early historic societies (21). One-third of the people in Africa resides in drought-prone areas and is vulnerable to the impacts of droughts (25). In Africa, for example, several million people regularly suffer impacts from droughts and floods. These impacts are often further exacerbated by health problems, particularly diarrhea , cholera and malaria (7).

Many types of extreme events- hurricane, flooding, are becoming more frequent and severe because of climate change, which increases the rate of human migration and relocation of great mass of population to seek shelter in other places; indigenous people groups in the coastal region are greatly endangered by this threat. This will likely increase the numbers of people migrating during and after these types of events (1).

Deterioration in coastal conditions, such as beach erosion and coral bleaching, will likely affect local resources such as fisheries, as well as the value of tourism destinations. Coastal settlements and low-lying areas are particularly vulnerable to climate change impacts, such as sea level rise, erosion, and extreme storms. Rising ocean temperatures and acidity threatens coastal ecosystems (24). As coastal habitats such as barrier islands, wetlands, deltas, and estuaries are destroyed, coastal settlements can become more vulnerable to flooding from storm surges and erosion. Climate change effects such as increases in coastal erosion, changes in the ranges of some fish, increased weather unpredictability are currently disrupting traditional hunting and subsistence practices of indigenous people communities in Africa, and may force relocation of many coastal villages.

3.3 Health

Climate variability and change may also interact with other existing stresses and vulnerabilities of Sub-Sahara Africa such as compromised populations (HIV/AIDS), conflict and war (9) in the future, resulting in increased susceptibility and risk of other infectious diseases (e.g., cholera, diarrhea), vector borne diseases (malaria) and malnutrition. Countries with low capacity to prevent and control sicknesses and epidemic are highly susceptible to climate-sensitive diseases with its attendant health impacts. Many health challenges are related to climate change, some of which include: frequent and severe heat stress linked to increases in temperatures; exacerbate respiratory and cardiovascular diseases due to worsened air quality that often accompanies heat waves or wildfires and increase of malnutrition and prevalence of food-borne illnesses (6, 22). Increases in the frequency or severity of some extreme weather events, such as extreme precipitation, flooding, droughts, and storms, threaten the health of people during and after the event. The people most at risk include young children, older adults, people with disabilities or medical conditions, and the poor.

Climate changes can influence the spread of infectious diseases. The spread of vector- borne diseases such as malaria, dengue, and West Nile virus may increase in areas projected to receive more rainfall and flooding. Mosquito pupation rates and larval-to-pupal development have been observed to be significantly faster in farmland habitats than in swamp and forest habitats (16). Floods can also trigger malaria epidemics in arid and semi-arid areas (23). Increases in rainfall and temperature can cause spreading of dengue fever. The spread of cholera and meningococcal (epidemic) meningitis is often linked to climate changes, especially as drought, very low humidity and a dusty condition predisposes population to its spread. Areas of Sub-Saharan Africa are sensitive to the spread of meningitis, and will be particularly at-risk if droughts become more frequent and severe (17).

The effects of global climate change on mental health and well-being are integral parts of the overall climate-related human health impacts. Mental health consequences of climate change range from minimal stress and distress symptoms to clinical disorders; such as anxiety, depression, post-traumatic stress, and suicidal thoughts (6). Exposure to extreme heat can lead to heat stroke and dehydration, as well as cardiovascular, respiratory, and cerebrovascular disease (14). Excessive heat is more likely to affect populations in northern latitudes with excessive temperatures, outdoor workers, student athletes and the homeless.

Climate change has increased the production of unhealthy levels of ground-level ozone, a harmful air pollutant, and a component in smog. It affects allergies and respiratory health. Ground-level ozone can damage lung tissue, reduce lung function, and inflame airways. This can aggravate asthma or other lung diseases. Children, older adults, outdoor workers, and those with asthma and other chronic lung diseases are particularly at risk of dying prematurely (6).

Changes in precipitation patterns and extreme weather events can lead to devastating health effects, particularly in low-income countries when power, water, or transportation systems are disrupted. Adverse health effects from climate change particularly diarrhoea diseases from contaminated water and food sources are a major concern to vulnerable populations especially children, older adults, urban people living in poverty, traditional societies, subsistence farmers, and coastal populations. Rural populations, older adults, outdoor workers, and those without access to air conditioning are often the most vulnerable to heat-related illness and death (22).

3.4 Water Quality and Availability

Climate change has the potential to impose additional pressures on water availability, accessibility and demand in Africa. Water quality is important for domestic purposes, agriculture, ecosystems, human health and sanitation. The water sector is strongly influenced by changes in climate. Increases in temperature, changes in precipitation, sea level rise, and extreme events can diminish water quality in many regions. Large rainstorms may introduce large amounts of pollutants into rivers and estuaries. Increased pollution as well as increasing water temperatures can cause algal blooms and potentially increase bacteria in water bodies (13). In coastal areas and small islands, saltwater from rising sea level and storm surges threatens water supplies. These impacts greatly affect the availability of safe water resources for human and animal uses.

Particularly, semi-arid and arid areas of Africa are vulnerable to the impacts of climate change on water supply, especially areas already water-stressed due to droughts, population pressures, and water resource extraction. The availability of water is strongly related to the amount and timing of runoff and precipitation. With a 2.7°F rise in global mean temperature, annual average stream flow is projected to increase by 10-50% at high latitudes and in some wet tropical areas, but decrease by 10-50% in some dry regions at mid-latitudes and in the subtropics (13). As temperatures increases, snowpack is reducing in many regions and glaciers are melting at unprecedented rates, making water less available in areas that depend on it from melting snow and glaciers during spring and summer; droughts and flooding are likely to become more widespread.

Agriculture

In many parts of Sub Sahara Africa, farmers and pastoralists are faced with the challenges of extreme natural-resource scarcity, poor soil fertility, pests, crop diseases, and a lack of access to inputs and improved seeds. These challenges are usually aggravated by periods of prolonged droughts and floods. Hence, the potential of climate change to affect global food security is important for food producers and consumers in Africa. Climate change is a detrimental factor that affects global, regional, and local food security by disrupting food availability, decreasing access to food, and making utilization more difficult. Climate risks to food security are greatest for poor populations and in tropical regions (11). Changes in climate could have significant impacts on food production around the world. Temperature rises can reduce the productivity of major crops and increase their water requirements, thereby directly decreasing crop water-use efficiency. Heat stress, droughts, and flooding events may lead to reductions in crop yields and livestock productivity. Areas that are already affected by drought in Sub-Sahara Africa, will likely experience reductions in water available for irrigation; invariably, increasing the demand for irrigation. Additional risks that could be exacerbated by climate change include greater erosion, reductions in crop growth period and deficiencies in yields from rain-fed agriculture of up to 50% during the 2000-2020 period have been projected (2).

Global fish production is affected by climate change. Apparently, increasing ocean temperatures have shifted some marine species to cooler waters outside of their normal range; as a result of the adverse effect of climate change. Fisheries as an important sector of many economies are affected by any reduction in water flows and increases in sea level. This is because water quality to a large extent depends on rate of flow of water.

IV. ECOSYSTEMS

Ecosystems are critical in Africa, contributing significantly to biodiversity and human well-being (3, 15). The rich biodiversity in this region is experiencing ecosystem change induced by complex land-use/climate interactions, such as the migration of species, invasive species and land-use change and the interaction with fire (10). Deforestation poses a great threat to Africa's forests due to over dependency on trees for fuel-wood and charcoal; a major source of energy in rural areas, and are estimated to contribute , about 80 to 90% of the residential energy needs of low-income households in the majority of

Sub-Saharan countries. Moreover, fire incidents represent a huge threat to tropical forests in Africa. Bush fires are a particular threat to woodlands, causing enormous destruction of both flora and fauna. The ecosystem of African continent suffers greatly from the impacts of desertification. At present, almost half (46%) of Africa's land area is vulnerable to desertification (8).

V. ADAPTATION MEASURES

There is a need to improve our understanding of the effect of complex socio-economic, socio-cultural and biophysical systems on environmental change and its links with climate change. In order to develop adaptation measures to combat climate change in Africa. The Intergovernmental Panel on Climate Change defines adaptation as the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate change and its effects. Adaptation is the adjustment in natural or human systems to a new or changing environment that takes advantage of beneficial opportunities or moderates negative effects. Some adaptation measures include:

- Educating people to help them avoid diseases that could become more prevalent as the climate changes such as malaria, cholera, diarrhoea, meningitis, heat stroke, dehydration respiratory and cardiovascular diseases due to worsened air quality that often accompanies heat waves or wildfires.
- Planting trees and expand green spaces in cities to reduce the "urban heat island" effect.
- Improve water use efficiency and build additional water storage capacity.
- Protect and restore stream and river banks to provide wildlife habitat and safeguard water resources.
- Protect and expand wildlife habitats to allow species to migrate as the climate changes.
- Reduce pollution, habitat loss, and other stressors that make ecosystems more vulnerable to climate change.
- Preserve wetlands and open spaces to protect coastal communities from flooding and erosion from storms and sea level rise.
- Develop crop varieties through plant breeding and biotechnology techniques that are more tolerant of heat, drought, or flooding from heavy rains.
- Provide more shade and air flow in barns to protect livestock from higher summer temperatures.

VI. CONCLUSION

The extent of climate change in the coming years depends largely on our efforts towards reduction greenhouse gas emissions today. The more we emit greenhouse gas through indiscriminate human activities such as burning of fossil fuels (coal, natural gas, and oil) for energy and transportation and hazardous industrial processes the larger the future climate changes will be. Continuous emissions of greenhouse gases will lead to further climate changes. The future expected changes include a warmer atmosphere, a warmer and more acidic ocean, higher sea levels, and larger changes in precipitation patterns. Climate change will likely increasingly stress coastal communities and habitats, leading to displacement of settlement, migration of population and scarcity of quality water. These impacts would threaten human population, environmental health, vital infrastructure, ecosystem, settlements, and facilities that support the livelihood of indigenous communities. Hence, the need to adopt adaptation measures to help combat the devastating effect of climate change ravaging the population of Sub-Sahara Africa.

REFERENCES

[1] Adger, W.N., J.M. Pulhin, J. Barnett, G.D. Dabelko, G.K. Hovelsrud, M. Levy, U. Oswald Spring, and C.H. Vogel (2014): Human security. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects, Chapter 12 (Human security). Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 755-791.

[2] Agoumi, A., (2003): Vulnerability of North African countries to climatic changes: adaptation and implementation strategies for climatic change. Developing Perspectives on Climate Change: Issues and Analysis from Developing Countries and Countries with Economies in Transition. IISD/Climate Change Knowledge Network, pp. 14 http://www.cckn.net//pdf/north africa.pdf.

[3] Biggs, R., E. Bohensky, P.V. Desanker, C. Fabricius, T. Lynam, A.A. Misselhorn, C. Musvoto, M. Mutale and Co-authors, (2004): Nature Supporting People: The Southern African Millennium Ecosystem Assessment Integrated Report. Millennium Ecosystem Assessment, Council for Scientific and Industrial Research, Pretoria, pp. 68.

[4] Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda, (2007): Africa. Climate Change (2007): Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK, 433-467.

[5] Collins, Jennifer M. (2011): "Temperature Variability over Africa". Journal of Climate. 24 (14): 3649-3666.

[6] Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds.(2016): The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program (USGCRP), Washington, DC, pp. 312.

[7] Few R., M. Ahem, F. Matthies and S. Kovats, (2004): Floods, health and climate change: a strategic review. Working Paper 63, Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, pp. 138.

[8] Granich, S., (2006): Deserts and Desertification. Tiempo, 59, 8-11.

[9] Harrus, S. and G. Baneth, (2005): Drivers for the emergence and re-emergence of vector-borne protozoal and bacterial diseases. Int. J. Parasitol., 35, 1309-1318.

[10] Hemp, A., (2005): Climate change-driven forest fires marginalize the impact of ice cap wasting on Kilimanjaro. Glob. Change Biol., 11, 1013-1023.

[11] Hijioka, Y., E. Lin, J.J. Pereira, R.T. Corlett, X. Cui, G.E. Insarov, R. D. Lasco, E. Lindgren, and A. Surjan (2014): In: Climate Change 2014: Impact, Adaptation and Vulnerability. Part B: Regional Aspects. Chapter 24. Contribution of Working Group II to the Fifth

Assessment Report of Intergovernment Panel on Climate Change (IPCC), pp. 1327-1370.

[12] IPCC (2007). Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B.Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[13] Jimenez Cisneros, B.E., T. Oki, N.W. Amell, G. Benito, J.G. Cogley, P. Doll, T. Jiang, and S.S. Mwakalila (2014): Freshwater Resources. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Chapter 3 (Freshwater Resources), pp. 229-269.

[14] Karl, T.R., J.M. Melillo, and T.C. Peterson (eds.) (2009):. Global Climate Change Impacts in the United States. United States Global Change Research Program (USGCRP). Cambridge University Press, New York, NY, USA, pp 1234-1436.

[15] Muriuki, G.W., T.J. Njoka, R.S. Reid and D.M. Nyariki, (2005): Tsetse control and land-use change in Lambwe valley, south-western Kenya. Agr. Ecosyst. Environ., 106, 99-107.

[16] Munga, S., N. Minakawa, G. Zhou, E. Mushinzimana, O.O.J. Barrack, A.K. Githeko and G. Yan, (2006): Association between land cover and habitat productivity of malaria vectors in western Kenyan highlands. Am. J. Trop. Med. Hyg., 74, 69-75.

[17] Niang, I., O.C. Ruppel, M.A. Abdrabo, A. Essel, C. Lennard, J. Padgham, and P. Urquhart, 2014: Africa. In: Climate Change (2014): Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265.

[18] Nichollas, R.J., (2004): Coastal flooding and wetland loss in the 21st century: changes under the, SRES climate and socio-economic scenarios. Global Environ. Chang.(14) 69-86.

[19] Ofoegbu, C., Chirwa, P. W. (2019): "Analysis of rural people's attitude towards the management of tribal forests in South Africa". Journal of Sustainable Forestry. 38 (4): 396-411.

[20] Ofoegbu, C., Chirwa, P. W.; Francis, J.; Babalola, F. D. (2019). "Assessing local-level forest use and management capacity as a climate-change adaptation strategy in Vhembe district of South Africa". Climate and Development. 11 (6): 501-512.

[21] Pandey, D.N., A.K. Gupta and D.M. Anderson, (2003): Rainwater harvesting as an adaptation to climate change. *Carr. Sci. India,* 85, 46-59.

[22] Smith, K.R., A. Woodward, D. Campbell-Lendrum, D.D. Chadee, Y. Honda, Q. Liu, J.M. Olwoch, B. Revich, and R. Sauerborn (2014): Human health: impacts, adaptation, and cobenefits. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects, Chapter 11 (Human Health). Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). pp. 709-754.

[23] Thomson, M.C., F.J. Doblas-Reyes, S.J. Mason, R. Hagedorn, S.J. Connor, T. Phindela, A.P. Morse and T.N. Plamer, (2006): Malaria early warnings based on seasonal climate i forecasts from multi-model ensembles. Nature, 439, 576-579.

[24] Wong, P.P., I.J. Losada, J.-P. Gattuso, J. Hinkel, A. Khattabi, K.L. Mclnnes, Y. Saito, and A. Sallenger (2014). Coastal Systems and Low-Lying Areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. EXIT Part A: Global and Sectoral Aspects, Chapter 5 (Coastal systems and low-lying areas). Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). pp. 361-409.

[25] World Water Forum, (2000): The Africa Water Vision for 2025: Equitable and Sustainable Use of Water for Socioeconomic Development. UN Water/Africa, 34 pp.

Effect of Vermicompost and Fertility Levels on Productivity and Quality of Barley (*Hordeum vulgare L.*)

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Abstract— *A field experiment entitled "Effect of Vermicompost and Fertility Levels on Productivity and Quality of Barley (Hordeum vulgare L.)" was conducted at Research Farm, Vivekananda Global University, Jaipur during Rabi season of 2021-22. The experiment was laid out in factorial randomized block design with three replications and consisting three vermicompost levels (control, vermicompost @ 2.5 t ha-1 and vermicompost @ 5.0 t ha-1) and three fertility levels (75% RDF, 100% RDF and 125% RDF). The barley var. RD - 2035 was used for experimentation. Results showed the interaction effect of vermicompost and fertility levels on yield and net returns of barley was found significant, therefore, application of vermicompost at 2.5t ha-1 with 125% RDF, closely followed by application of vermicompost at 5.0 t ha-1 with 100% RDF may be recommended for higher productivity and profitability of barley as it gave highest net returns of 66602 ha-1 with highest B: C ratio of 2.87.*

Keywords— Vermicompost, Fertility, Productivity, Quality, Economics.

I. INTRODUCTION

Barley (Hordeum vulgare L.) is a valuable crop because it is grown for several purposes such as food for human being and feed for cattle and poultry birds. It is one of the first domesticated cereals of world agriculture which is a member of grass family grown in temperate climates globally. Its grain is also valued for smothering and cooling effect on the body for easy digestion and as a source of vitamin B complex. Besides these conventional uses, it is an important industrial crop used as raw material for beer, whisky for brewing industries. Each 100 g of barley grains comprise 10.6 g protein, 2.1 g fat, 64.0 g carbohydrate, 50.0 mg calcium, 6.0 mg iron, 31.0 mg vitamin B1, 0.1 mg vitamin B2 and 50.0 μg folate (Vaughan et al., 2006). Its β– glucans located in the cell wall of endosperm is useful in reducing the risk of cardio- vascular diseases. Thus, this crop is frequently being described as the most cosmopolitan of the crops and also considered as poor man's crop because of the low input requirement and better adaptability to drought, salinity, alkalinity and marginal land (FAO, 2002). It is cultivated in almost all parts of the world. The major barley producing countries are China, Russia, Germany, USA, Canada, India, Turkey and Australia. In India, barley is mainly grown in Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, West Bengal and Bihar. In India, barley is grown over an area of 0.61 m ha with a production of 1.82 m t and yield of 2988 kg ha-1 (Anonymous, 2021). In Rajasthan, it is grown over an area of 0.26 m ha with a production of 0.96 m t and productivity of 3607 kg ha-1 (Anonymous, 2021). The average productivity of barley in the state is more than that of productivity in India but it is far behind in the attainable yield of 45-50 q ha-1 due to water and nutritional stresses. Its cultivation in India was suffered during green revolution period due to replacement of barley from marginal land and rainfed areas by more remunerative oilseed and pulses. The productivity of this crop could be increased by the use of different fertilizers but one of the major constraints in boosting up the barley production is the deteriorating effect on soil health due to the imbalanced and heavy use of chemical fertilizer. Soil health deterioration is the prime threat to Indian agriculture which is being aggravated with excessive use of fertilizers particularly in less responsive soils which have low organic matter content. The improper use of inorganic fertilizer has led to think about the use of FYM, vermicompost, poultry manure; bio-fertilizers etc. in growing areas for sustainable production system but organic manure alone cannot produce the sufficient food for present population and other uses. Under these circumstances, integrated use of organic manures with inorganic fertilizers shown promising results not only in sustaining the productivity but have also proved effective in maintaining soil health and enhanced nutrient use efficiency (Chesti et. al., 2013). Among 17 essential plant nutrients, N and P play the most important role in augmenting agriculture production which is required in the larger quantity of all the mineral nutrients absorbed by plant roots.

II. MATERIAL AND METHOD

A field experiment entitled "Effect of Vermicompost and Fertility Levels on Productivity and Quality of Barley (*Hordeum vulgare L.*)" was carried out during Rabi season of 2021-22 at Research Farm, Vivekananda Global University, Jaipur.

Geographically, the study area is located at 75o 88'99" E longitude and 26o 81'17" N latitude and this region falls under agro-climatic zone III A (Semi-arid Eastern Plain Zone) of Rajasthan. The details of procedure adopted for raising the crop and criteria adopted for evaluation of treatments during the course of present investigation are described in this chapter. The climate of this region is typically semi-arid, characterized by extremes of temperature during both summer and extremes of temperature during both summer and winters. During summers, the temperature may go as high as 48 °C, while in winters, it may fall as low as - 1.0°C. The maximum and minimum temperatures during the crop season ranged between 17.9 0C to 40.50C and 6.0 0C to 23.1 0C, respectively. A total of 43.4 mm rainfall was recorded during the cropping season. The relative humidity fluctuated between 18.5 to 85.0 per cent, while the average sunshine hours ranged between 2.0 to 10.4 hrs. / day. The soil of the experimental field was loamy sand, slightly alkaline, with low available nitrogen (132.73 kg/ha), high available phosphorus (19.92 kg/ha) and potassium (231.76 kg/ha), status. The experiment consisting three vermicompost levels (control, vermicompost @ 2.5 t ha-1 and vermicompost @ 5.0 t ha-1) with variety RD-2035, and 3 levels of fertilizer [75%, 100%, 125% recommended dose of fertilizer (RDF)] making 9 treatments combination. There were laid out in a factorial randomized block design with 3 replications. The fertilizer 60 kg N + 30 P2 O5 + 40K2O kg/ha was applied as per treatments. Half dose of nitrogen and full dose of phosphorus and potash was applied as basal at sowing through urea, DAP and MOP and remaining half dose of nitrogen was top dressed at first irrigation.

Seeds were treated with carboxin at 2 g kg-1 seed and fipronil 5 SC at 30g a.i. quintal-1 of seed as prophylactic measures against seed borne diseases and control of termite. The crop was sown by "kera" method in rows spaced at 20 cm apart on, using 100 kg seed/ha. In barley crop, four irrigations were applied as per the requirement of crop using sprinkler irrigation method. The barley crop was harvested separately from each net plot, tied in bundles and tagged. These bundles were left on the threshing floor for sun drying.

Threshing was done by beating with wooden sticks and winnowed traditionally. The cleaned produce thus obtained from each net plot was weighed on physical balance to record seed yield in kg plot-1. The straw yield was computed by deducting the weight of seed from total biological yield. The crude protein content in grain was calculated by multiplying the nitrogen per cent in grain with a factor 6.25 as suggested (AOAC, 1984). The grain yield was expressed in t/ha.

Straw yield was obtained by subtracting the grain yield from the weight of total biological yield for individual plots and was expressed in tones/ha. The net returns of each treatment were calculated by deducting the total cost of cultivation from gross returns of respective treatments and the benefit: cost ratio was calculated by dividing the net returns with total cost of cultivation. Experimental data recorded in various observations were statistically analyzed with the help of analysis of variance technique (Panse and Sukhatme, 1985). The critical difference (CD) for the treatment comparisons was worked out wherever the variance ratio (F test) was found significant at 5% level of significance.

III. RESULT AND DISCUSSION

3.1 Grain and Straw yield:

The significantly highest grain yield (4141 kg ha-1) of barley was recorded with application of vermicompost at 5 t ha-1 as compared to control (2962 kg ha-1) and vermicompost at 2.5 t ha-1 (3703 kg ha-1). The increase in grain yield due to application of vermicompost at 5 t ha-1 in terms of per cent was 39.79% and 11.83%, respectively over control and vermicompost at 2.5 t ha-1. The effect of fertility levels on Further reference of data given in (table 1) revealed that grain yield of barley was significantly increased due to the different fertility levels. The highest grain yield (4043 kg ha-1) of barley was recorded under the treatment of 125% RDF which was significantly higher by 39.05% over 75% RDF and remained statistically at par with 100% RDF which produced grain yield of 3855 kg ha-1.

Straw yield of barley was increased due to application of vermicompost over control. Application of vermicompost at 5 t ha-1 gave highest straw yield (6327 kg ha-1) of barley which was significantly higher when compared with control and vermicompost at 2.5 t ha-1. The corresponding increase in straw yield due to application of vermicompost at 5 t ha-1 in terms of per cent over control and vermicompost at 2.5 t ha-1 was 41.06% and 12.79%, respectively. The fertility levels of data presented in (table 1) revealed that straw yield of barley was increased significantly due to the different fertility levels. The application of 125% RDF recorded highest straw yield of 6148 kg ha-1 of barley which was significantly higher over application of 75% RDF and closely Biological yield of barley indicated presented in (table 1) clearly revealed that biological yield of barley was significantly increased due to application of vermicompost over control. The application of vermicompost at 5 t ha-1 produced maximum biological yield (10468 kg ha-1) of barley which was significantly higher than control and vermicompost at 2.5 t ha-1. The application of 45 vermicompost at 5.0 t ha-1 resulted 40.56% and 12.40% increase in biological yield of barley over control and vermicompost at 2.5 t ha-1, respectively. Among the different fertility levels, application of 125% RDF remained statistically at par with application of 100% RDF, produced highest biological yield (10191 kg ha-1) of barley which was significantly superior to application of 75% RDF. The increase in biological yield due to application of 125% RDF as compared to application of 75% RDF was 39.17%. Harvest index (table 1.) indicated that the application of vermicompost did not bring any significant effect on harvest index of barley and all the treatment remained statistically at par with each other and the effect of fertility levels on harvest index of barley was found non-significant and all the treatments recorded similar values of harvest index of barley.

TABLE 1
EFFECT OF VERMICOMPOST AND FERTILITY LEVELS ON YIELDS OF BARLEY

Treatments	Yield (kg ha-1)			Harvest index (%)
	Grain Yield	Straw Yield	Biological Yield	
Vermicompost (t ha-1)				
Control	2962	4485	7447	39.82
2.5	3703	5610	9313	39.76
5	4141	6327	10468	39.58
SEm ±	78	115	153	0.64
CD (P=0.05)	233	345	458	NS
Fertility Levels				
75%	2908	4415	7323	39.82
100%	3855	5859	9714	39.68
125%	4043	6148	10191	39.65
SEm ±	78	115	153	0.64
CD (P=0.05)	233	345	458	NS
VC x F	SIG	SIG	SIG	NS

NS=Non-significant

3.2 Crude protein content in grain (%) Effect of Vermicompost:

An examination of data on crude protein content in grain presented in (table 2) showed that the application of vermicompost at 5 t ha-1 recorded significantly maximum crude protein content in grain which was 28.61% and 7.54% higher over control and vermicompost at 2.5t ha-1, respectively.

3.3 Effect of fertility levels:

The findings presented in (table 2) revealed that application of fertility levels had significant influence on crude protein content in grain. Application of 125% RDF recorded highest crude protein content in grain of barley which was significantly superior by 30.33% and 6.62% over application of 75% RDF and 100% RDF, respectively.

TABLE 2
EFFECT OF VERMICOMPOST AND FERTILITY LEVELS ON CRUDE PROTEIN CONTENT IN GRAIN AND ECONOMICS OF BARLEY

Treatments	Crude Protein Content in grain (%)	Economics		
		Gross returns ₹(ha-1)	Net returns ₹(ha-1)	B:C ratio
Vermicompost (t ha-1)				
Control	7.76	69652	39931	2.33
2.5	9.28	87074	52354	2.5
5	9.98	97425	57704	2.45
SEm ±	0.15	1737	1737	0.05
CD (P=0.05)	0.44	5208	5208	0.15
Fertility Levels				
75% RDF	7.65	68385	34594	2
100% RDF	9.37	90668	55947	2.62
125% RDF	9.99	95099	59448	2.67
SEm ±	0.15	1737	1737	0.05
CD (P=0.05)	0.44	5208	5208	0.15
VC x F	NS	--	SIG	SIG

NS = Non-significant, RDF = Recommended dose of fertilizer

3.4 Net returns and benefit: cost ratio:

The application of vermicompost at 5 t ha-1 recorded significantly highest net returns (57704 ha-1) of barley over control and vermicompost at 2.5 t ha-1. The fertility levels are significantly increased the highest net returns of barley (59448 ha-1) were recorded under the treatment of 125% RDF which was significantly higher when compared with application of 75% RDF (34594 ha-1) and benefit cost ratio of vermicompost at 2.5 t ha-1 gave maximum B: C ratio (2.50) and the different fertility levels are highest B: C ratio of barley (2.67) were recorded with the application of 125% RDF which was significantly higher when compared with application of 75% RDF (2.00).

REFERENCES

[1] Akhtar, N., Ramani, V. B., Yunus, M., & Femi, (2018). Effect of different nutrient management treatments on growth, yield attributes, yield and quality of wheat (Triticum aestivum L.). International Journal of Current Microbiology and Applied Sciences, 7, 3473-3479.

[2] Singh, S., Kumar, A., Ramadas, S., Khippal, A., Kumar, R., & Singh, G. (2022). All India Coordinated Research Project (AICRP) on Wheat and Barley Progress Report 2021-22: Social Sciences.

[3] Behera, U.K., Pradhan, S., & Sharma, A.R. (2007). Effect of integrated nutrient management practices on productivity of durum wheat in the Vertisols of central India. Journal of Agricultural Sciences, 77(10), 635-638.

[4] Bouyoucos, G.J. (1962). A hydrometer method improved for making particle and size analysis of soil. Agronomy Journal, 54, 464-466.

[5] Brady, N. C., Weil, R. R., & Weil, R. R. (2008). The nature and properties of soils (Vol. 13, pp. 662-710). Upper Saddle River, NJ: Prentice Hall.

[6] Chesti, M.H., Kohli, A., & Sharma, A.K. (2013). Effect of integrated nutrient management on yield and nutrient uptake by wheat (Triticum aestivum) and soil properties under intermediate zone of Jammu and Kashmir. Journal of the Indian Society of Soil Science, 6(1), 1-6.

[7] Chopra, R., Sharma, M., Sharma, S.K., Nepalia, V., Jain, H.K., & Singh, A. (2016). Effect of integrated nutrient management on growth and yield of wheat (Triticum aestivum L) in Haplustepts. International Journal of Science and Nature, 7(3), 622-628.

[8] Choudhary, S., Yadav, L.R., Yadav, S.S., Sharma, S.S., & Keshwa, G.L. (2013). Integrated use of fertilizers and manures with foliar application of iron in Barley (Hordeum vulgare L.). Indian Journal of Agronomy, 58(3), 363-367.

[9] Dar, S.B., & Hari, Ram. (2017). Productivity of wheat (Triticum aestivum L) in relation to hydrogel as influenced by different irrigation regimes and nutrient levels. International Journal of Chemical Studies, 5(5), 609-613.

[10] Dhaliwal, J.K., Saroa, G.S., & Dhaliwal, S.S. (2015). Effect of nutrient management practices on wheat grain quality under basmati rice-wheat system. Agricultural Research Journal, 52, 43-47.

[11] Dinesh, S.K., Vivek, Kumar, A., Dev, I., Kumar, S.V., Singh, V., & Dwivedi, A. (2016). Effect of nutrient management options on performance and nutrient use efficiency of wheat (Triticum aestivum L.) in light texture soil. International Journal of Agriculture Sciences, 8(55), 2969-2973.

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