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Research Article

Strategies for Improving Waterlogged Soils by Farmers for Increased Crop Production in Enugu State

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Abstract

The main purpose of the study was to determine the strategies for improving waterlogged soils by farmers for increased crop production in Enugu State. The study was guided by two research questions and two null hypotheses. A survey research design was adopted for the study. The population used for the study was 115 male and female farmers randomly selected from the various agricultural zones of Enugu State. The instrument used for data collection was structured questionnaire used to deduce respondents' perception about agricultural practices and techniques used to improve waterlogged soils for increased crop production in Enugu State. The Instrument was validated by three experts, two from Department of Technology and Vocational Education who majored in Agricultural Education and one from Measurement and Evaluation from Department of Mathematics and Computer Science Education, all from Faculty of Education Enugu State University Science and Technology, Enugu. The internal consistency of the questionnaire was determined by the use of Cronbach Alpha reliability test which yielded a value of 0.76. Data generated were analyzed using mean to answer research questions and t-test to test the null hypotheses at probability level of 0.05. Based on the data analysed, the study identified use of drainage system such as tiles, pipes, application of compost-manure, use of mulch or cover crop, and subsoiling techniques. Common strategies that could be used by both male and female farmers to improve waterlogged soils for improved crop production in Enugu State. Based on the findings of the study, the researcher recommend that extension workers should regularly organize farmers education programmes to retrain farmers on the innovative techniques and practices that can be deployed to manage waterlogged farm lands.

Keywords	*Waterlogged Soil; Soil Productivity; Crop Production; Farmers; Enugu State*
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Introduction

Soil is a vital component of agriculture as it serves as the medium for plant growth and sustenance. However, some soils are waterlogged which farmers faces the challenge that result from it. Waterlogged soil is a condition where excessive water saturates the soil, filling all available pore spaces and creating an anaerobic environment (Paola 2021). This lack of oxygen severely hampers root respiration and plant growth, resulting to various agricultural and environmental challenges.

Waterlogged soils are a common agricultural challenge that can have detrimental effects on crop growth and productivity. Waterlogging can result from several factors, including heavy rainfall, poor drainage, over irrigations a high-water table, and certain land topographies such as low-lying areas or depressions (Atiyong and Michael, 2022). One of the primary issues with waterlogged soil is the creation of anaerobic conditions (Gurpreet, et al., 2019). Plants need oxygen for root respiration, and with waterlogged soils, the oxygen supply is cut off, leading to root rot and reduced plant vitality (Michelle, Mauricio, & Gabriel, 2015). Furthermore, the excess water can cause essential nutrients like nitrogen to leach away from the root zone, making them unavailable to plants. This nutrient deficiency further exacerbates, the stress on plants already struggling with poor oxygen levels.

Waterlogging also negatively impacts soil stricture According to Akash, et al. (2023), prolonged saturation can breakdown the soils' natural structure, leading to compaction and reduced porosity. This compaction makes it even harder for water to infiltrate and for roots to grow, creating a vicious cycle of pour soul health. Additionally, waterlogged condition favour the growth of certain soil-borne pathogens and pests that can attack plants, further reducing crop yields and quality.

However, waterlogging is a significant issue in Enugu State, practically in areas with poor drainage. Enugu State is located in Southeastern Nigeria. The state's hilly terrain, with its many valleys and slopes, contributes to water runoff and erosion, rather than infiltration and recharge of ground water. This results in water logging, especially during heavy rainfall events. Also, the soil in Enugu State is primarily composed of sandy loam, clay loam, and sandy clay loam. This soil type is prone to waterlogging (Okeke & Nwajide, 2013). Waterlogging in Enugu State's soil has detrimental effects on agriculture, molding as it can lead to reduced crop yields, lower quality harvests, and also increased risk of waterborne diseases among others.

To mitigate these identified problems, several strategies can be employed to improve the negative effects of waterlogging on soils. These include improving drainage systems. These include improving drainage systems. This is crucial strategy for managing waterlogged soils. This involves installing drainage tiles or ditches to remove excess water from the soil and prevent waterlogging.

According to a Li (2012), effective drainage system can help improve soil aeration, reduce waterlogging and enhance crop productivity. Also installing French drains (perforated pipes buried in trenches filled with gravel) could help redirect excess water away from waterlogged areas (Vincenzo, et al., 2021). Using soil amendments such as addition of organic matter, lime and gypsum can help improve the physical and chemical properties of waterlogged soils. Organic matter can improve soil structure and nutrients availability, while lime and gypsum can help in reducing soil acidity and improving drainage. Studies by Sarkar et al (2019) have shown that amendments can alleviate the negative effects of waterlogging on soils and promote better crop growth. Also, the organic matter such as compost and well-rotted manures (Himanshu, Vivek, & Ramesh, 2023). These materials improve soil structure, increase aeration and enhance microbial activity which helps break up the already compacted soil and create channels for water and air flow.

Furthermore, constructing raised beds is also beneficial, as it elevates plant roots above the waterlogged soil level, ensuring better drainage and aeration. Soil aeration, achieved by using tools like garden forks or aerators to create holes in the soil, allows water to drain and air to penetrate further improving conditions for plant roots.

Amending soil texture by mixing coarse sand or gravel can improve drainage by increasing soil porosity. However, it is important to avoid the use of fine sand as it has the capacity to worsen compaction (Herzog, Stiker, Colmer, and Pederson, 2016). In some cases, grading the land to create a gentle slope can facilitate natural water runoff, reducing water accumulation in specific area substantial amount of benefits could be derived from improving waterlogged

soil. Improved drainage and aeration of waterlogged soil according to Nuruzzaman, et al. (2019) results to healthier plants and higher yield. This approach also allows for a wider variety of crops to be grown.

Statement of the Problem

Waterlogged soils present a significant challenge to farmers such as impeding crop growth and reducing agricultural productivity. These soils characterized by excessive moisture and poor drainage, can lead to root oxygen deficiency, nutrient imbalance, and increased susceptibility to plant diseases. It has been observed by the researcher that the soils in Enugu State are prone to waterlogging especially during heavy rainfalls as they are primarily composed of sandy loam, clay loam and sandy clay loam. Finally, the state's hilly terrain contributes to water runoff and erosion causing the water to accumulate the hilly areas. This water accumulation which causes the soil to be waterlogged seem to have effects on agriculture such as reduced crop yields, lowering quality harvests and increased water borne-diseases. This waterlogging according to Nwakauchi and Anikwe (2012) can lead to a 30% reduction in crop yields which causes significant economic losses to farmers.

Despite the fact that most of the topography of the land in Enugu State is sloppy, yet majority of the soils are waterlogged. As a result, it is believed that the extension workers need to create awareness and organize seminars and workshops to retrain farmers on the various strategies to improve waterlogged soils for increased crop production in Enugu state. It is also necessary that farmers should use sandy loam soils in agricultural production especially in growing crops to help excess water to drain off without accumulation since the nature (texture) of the soil plays a vital role in determining how water accumulates and drain off the soil. It is against this background that there is need to determine the strategies for improving waterlogged soils by farmers for increased crop production in Enugu State.

Purpose of the Study

The main purpose of this study was to determine the strategies for improving waterlogged soils by farmers for increased crop production in Enugu State. Specifically, the study sought to determine the:

1. Innovative agricultural related strategies for improving waterlogged soils by farmers for increased crop production in Enugu State.
2. Practical guidelines related strategies for improving waterlogged soils by farmers for increased crop production in Enugu State.

Research Questions

The following research questions guided the study:

1. What are the innovative agricultural related strategies for improving waterlogged soils by farmers for increased crop production in Enugu State?
2. What are the practical guidelines related strategies for improving waterlogged soils by farmers for increased crop production in Enugu State?

Hypotheses

The following null hypotheses tested at 0.05 level of significance guided the study:

H_{O1}: There is no significant difference in the mean responses of male and female farmers on the innovative agricultural strategies for improving waterlogged soils for increased crop production in Enugu State.

H_{O2}: There is no significant difference in the mean responses of male and female farmers on the practical guidelines adopted by farmers for improving waterlogged soil for increase crop production in Enugu State.

Method

The study adopted a descriptive survey research design. According to Nworgu (2015) and Alio (2018) descriptive survey research design is one in which a group of people are studied by collecting and analyzing data from only a few people or items considered to be representative of the entire group or the entire population if it is manageable. The design was considered necessary because of the wide distribution of the respondents and the polychotomusly structured instrument used for data collection from the entire people deemed to be the represents of the population. The area of the study was Enugu State of Nigeria. Enugu State is one of the five states in southeast geographical zones of Nigeria. The population for the study was 115 male and female practicing farmers randomly selected from the various agricultural zones of Enugu State. That is to say that this design was considered as it identified current conditions and provides information in which to base good decision.

The number was manageable hence there was no sampling. A structured questionnaire containing a total of 21 items was the instrument for data collection. The questionnaire was grouped into two parts. Part A contained the personal data of the respondents and Part B contained 21 items grouped into two sections according to the research questions that guided the study. The items in the instrument were structured in four points rating scale of Very Highly Required (VHR), Highly Required (HR), Moderately Required (MR) and Not Required (NR), with numerical values of 4, 3, 2 and 1 respectively.

The instrument was validated by three experts, two from Agricultural Education from Department of Technology and Vocational Education and one from Measurement and Evaluation Department of Computer Science and Mathematics Education all from Faculty of Education, Enugu State University of Science and Technology, Enugu. The reliability of the instrument was determined by administering 20 copies of the questionnaire to 20 male and female farmers in Ebonyi State. The data collected was analyzed using Cronbach Alpha and the reliability coefficient yielded 76. This is in line with Uzoagulu (2011) who noted that reliability coefficient above 0.6 indicated that the instrument is reliable. Out of 115 copies of questionnaire distributed 110 were properly filled and retrieved which indicated 95. 65% return rate. Data collected were analyzed using mean and standard deviation to answer the research questions while t-test was used to test the null hypotheses at .05 level of significance using SPSS. Decisions were made using the real limits of number on four-point rating scale as follows:

Very Highly Required (VHR)	3.50 – 4.00
Highly Required (HR)	2.50 – 3.49
Moderately Required (MR)	1.50 – 2.49
Not Required (NR)	1.00 – 1.49

The standard deviation was used to determine the homogeneity or otherwise of the opinions of the respondents. For the t-test statistics the t-test result was compared with the significant value (using SPSS) at .05 level of significance and at appropriate degree of freedom. The null hypothesis was significant where the probability value was less than the .05 significant level of appropriate degree of freedom, otherwise the null hypotheses was not significant.

Result of the Study

The results of the study are presented according to the research questions and hypothesis that guided the study.

Research Question 1
What are the innovative agricultural related strategies for improving waterlogged soils by farmers for increased crop productions in Enugu State?

Table 1: Mean responses and standard deviation of farmers on the innovative agricultural related strategies for improving waterlogged soils for increased crop production in Enugu State

S/N	*ITEMS*	*MEAN*	*SD*	*DECISION*
	Innovative agricultural related strategies for improving waterlogged soils include:			
1	Use of French drains.	3.18	0.66	HR
2	Use of subsoiling techniques	3.97	0.72	VHR
3	Use of farmland sloping techniques	3.16	1.02	HR
4	Use of soil aeration technique	3.97	0.80	VHR
5	Use of sand and gravel technique	3.56	0.77	VHR
6	Planting of cover crop	3.20	0.93	HR
7	Addition of organic manure	3.35	0.59	HR
8	Use of raised beds technique	3.09	0.91	HR
	Grand Cluster	**3.43**	**0.8**	HR

N= Number of respondents, SD=Standard Deviation

The result of data analysis on **Table 1** shows that the farmers mean responses on innovative agricultural related strategies for improving waterlogged soils for increased crop production in Enugu State, ranged from 3.09 to 3.35 for items 8, 3, 1, 6, and 7 showing that these items are highly required as the innovative agricultural related strategies for improving waterlogged soils for increased crop production. Farmers agreed that items 5, 2 and 4 are very highly required as innovative agricultural related strategies for improving waterlogged soils for increased crop production. These items had means of 3.56 to 3.97 respectively.

Hypothesis 1: There is no significant difference in the mean responses of male and female farmers on the innovative agricultural strategies for improving waterlogged soils for increased crop production in Enugu State.

Table 2: Summary of t-test on the mean responses of male and female farmers on the innovative agricultural related strategies for improving waterlogged by farmers for increased crop production in Enugu State

Farmers	*N*	*Mean*	*Std deviation*	*t-test*	*df*	*Sig*	*Decision*	*Reject*
Female	95	3.68	0.291	5.501	113	0.021		Ho_2
Males	20	3.74	0.198					

The t-value for the difference in mean scores of male and female famers on the Innovative agricultural related strategies for improving waterlogged soil by farmers for increased cop production in Enugu State was 5.501 significant at 0.021 level of significance. The value is lower than 0.05 level of significance set for the study. The null hypothesis is therefore not accepted. This implies that farmers in different local governments in Enugu State shave different views on the choice of agricultural related stations deployed to enhance waterlogged farmlands for increased crop productions.

Research Question 2

What are the identified practical guidelines developed by farmers to implement the innovative agricultural strategies for improving waterlogged soils?

Table 3: **Mean responses and standard deviation of male and female farmers on practical guideline related strategies for improving waterlogged soils for increased crop production in Enugu State**

S/N	*ITEMS*	*MEAN*	*SD*	*DECISION*
9	Adoption of surface drainage technique	3.40	0.55	HR
10	Introduction of farmer education programs	3.83	0.91	VHR
11	Addition of organic matter to waterlogged farm land	3.21	0.76	HR
12	Introduction of rain water harvesting	2.90	1.00	HR
13	Planting of cover crops	2.91	1.00	HR
14	Introduction of crop rotation techniques	2.91	1.00	HR
15	Invocation of deep tillage practices	3.50	1.13	VHR
16	Planting of flood tolerant crops	3.21	0.76	HR
17	Adoption of soil moisture sensor	2.91	1.00	HR
18	Introduction of controlled irrigation techniques	2.90	1.02	HR
19	Adoption of raised beds practices	2.90	1.01	HR
20	Introduction of regular soil test	3.50	0.56	VHR
	Cluster mean/standard deviation	3.17	0.8	HR

Note mean, SD=Standard Deviation

The result of date analysis on **Table 3** shows that male and female farmers on practical guideline related strategies for improving waterlogged soils for increased crop production in Enugu State, for items 9, 11, 12, 13, 14, 16, 17, 18, & 19 ranged from 2.90 to 3.40 showing that these items are highly required as practical guideline related strategies for improving waterlogged soils for increased crop production in Enugu State, for items 10, 15 and 20 are very Highly required as practical guideline strategies for improving waterlogged soils for increased crop production. These items have means of 3.50 to 3.83 respectively.

Hypothesis 2

There is no significant difference in the mean responses of male and female farmers on the practical guidelines adopted by the farmers for improving waterlogged soil for increased crop production in Enugu State.

Table 4: **Summary of t-test on the mean responses of male and female farmers on increasing the practical guidelines for implementing agricultural practical guideline for improving waterlogged soils for increased crop production in Enugu State**

Farmers	*N*	*Mean*	*Std deviation*	*t-test*	*df*	*Sig*	*Decision*	*Reject*
Female	95	3.49	0.57	2.92	113	0.09	Do not	Ho_1
Males	20	3.23	0.44					

The result of the data analyzed on **Table 4** showed that the t value for the difference in mean responses of male and female farmers on the practical guidelines to be followed to implement agricultural practices for improving waterlogged soil for increased crop production in Enugu State was 2.92 significant at 0.09 level of probability. This value is higher than the set level of significance of 0.05 for the study. The null hypotheses were therefore not rejected. This implies that farmers practicing in different local governments in Enugu State hold same opinion on the practical guidelines set out for implementing agricultural practices used to improve waterlogged soil for increased crop production in Enugu State.

Discussion of Findings

The result of findings according to research question one indicated the innovative agricultural related strategies for improving waterlogged soils by farmers for increased crop production in Enugu State. The identified strategies include use of French drainage application of sand and grit technique, application of raised beds among others. There is no significant difference in the mean responses of farmers on the innovative agricultural strategies for improving waterlogged soils for increased crop production in Enugu State. The findings agree with Gurprect et al (2019) who reported that increase in crop production/yield depends on the level of soil health and its nutrient content. The implication of the findings was that the identified highly required innovative strategies should be used by the farmers consistently in other to control waterlogged soil.

Also, the findings of the study revealed that mastery of appropriate waterlogging improving practices by farmers such as deep tillage practices, use of soil moisture sensors, and planting of flood tolerant plants among others improves a farmer's visibility and therefore, enables them to stay competitive in the food production industry. The study is congruent with the study carried out by Udeala, Ezeama & Kalu (2023) on the significance of competency-based training of building technologist. The researchers reported that competencies and skills required to maintain sustainable self-employment and become competitive are usually acquired through experience training. Further there is no significant difference in the mean responses of farmers on the practical guidelines adopted by the farmers for improving waterlogged soil for increased crop production in Enugu State.

The findings also revealed that waterlogged soil is a condition where excessive water saturates the soil, filling all available pore spaces and creating an anaerobic environment (Paola 2021). This lack of oxygen severely hampers root respiration and plant growth, resulting to various agricultural and environmental challenges. Plants need oxygen for root respiration, and with waterlogged soils, the oxygen supply is cut off, leading to root rot and reduced plant vitality (Michelle, Mauricio, & Gabriel, 2015).

Conclusion

The study determined the strategies for improving waterlogged soils for increased crop production in Enugu State. The findings revealed that application of organic matter, introduction of subsoiling technique application of French drains, techniques such as pipes, planting cover crops and regular soil tests are the common needed waterlogged improvement strategies to be adopted by practicing farmers in ensuring sustainable crop production. The study highlighted relevant waterlogging practical guidelines useful for implementing the identified soil enhancement practices and techniques by farmers to stay competitive in food production. It is therefore, the believe of the researchers that if farmers can explore these innovative techniques and practices as discussed in the study, crop production in particular, and food security in general will dominate the spheres of Enugu State.

Recommendations

The following recommendations were made based on the findings of the study:

1. Farmers should be encouraged to master the technique of organic matter application such as compost or green manures in a waterlogged farmland. This is because, soil health is improved by the presence of these economic organic elements. This practice not only will it help to control waterlogging, but will also boost soil fertility, leading to higher crop productivity.
2. Extension workers should be encouraged to regularly organize farmer's education programmes to retrain farmers on the innovative techniques and practices deployed to manage waterlogged farmlands. This approach would help to minimize wastages of arable farmlands occupied by flood.

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