World Rural Observations

Websites:
http://www.sciencepub.net
http://www.sciencepub.net/rural

Emails:
editor@sciencepub.net
sciencepub@gmail.com

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

MULTIVARIATE ANALYSIS ON THE RESPONSE OF CROP TO FERTILIZER AND SOIL TYPE USING SPLIT PLOT DESIGN

Lasisi T. A.(1), Oladimeji O. A.(2)*, Longe I. O. (2), Oyeniyi R. O.(3), and Ogunbanwo T. A. (4)

[1]Department of Statistics, Ladoke Akintola University of Technology, Ogbomosho Oyo State, Nigeria
[2]Department of Statistics, Federal Polytechnic, Ile-Oluji, Ondo State, Nigeria
[4]Department of Mechanical Engineering, Osun State College of Technology, Esa-Oke, Osun State, Nigeria
[3]Department of Mathematics and Statistics, Osun State College of Technology, Esa-Oke, Osun State, Nigeria
*Corresponding Author: adedipupo.oladimeji@gmail.com

ABSTRACT: This research work is primarily aimed at determining the significance effect of factors and other consideration on yield of plant. The method of data collection is transcription from record from the department of Agricultural Technology of the Federal Polytechnic Ado-Ekiti. Analysis of variance using split plot design to eliminate the effect of those factors accordingly after the data analysis are concluded from the analysis of variance on yiled that replicates (soil types) and fertilizer effect are individually (main effect) statistically not significance at 5% significance level since P-value > 0.05. Also, interaction effect of fertilizer and replicates is statistically not significance since P-value > 0.05 accordingly.

[Lasisi T. A., Oladimeji O. A., Longe I. O., Oyeniyi R. O., and Ogunbanwo T. A. **MULTIVARIATE ANALYSIS ON THE RESPONSE OF CROP TO FERTILIZER AND SOIL TYPE USING SPLIT PLOT DESIGN.** World Rural Observ 2022;14(2):23-33]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 5. doi:10.7537/marswro140221.05.

Keywords: Factorial Treatment, Experimental Units, Fertilizer, Crops Yield, Synthetic, Split-Plot Design, Blocking, Experimental Error, Dependant Variable

INTRODUCTION

Crop production is an integral part of agriculture, the other part is animal production or husbandry. Crop production can either be on a subsistence or commercial level. It is subsistence when the farmer produces for himself and family with a little for sale but it can be commercial when the farmer produces in a large scale for market consumption. Whichever type of production; a farmer wants to embark upon, the knowledge of fertilizer and the nature of the soil is of utmost importance as this would go a long way in determining the farmers output. Since 90's agriculture in Nigeria that use to be at the front burner as the nation's chief income earner as suddenly taken a back stage as a result of over dependency on crude. Agriotypes overtime as been a major sustainer of Nigeria's economy before the discovery of crude oil otherwise known as black gold Okoro (2005).

Since its relegation to the background in Nigeria, it has been practiced at an alarming peasant level with most of the active stakeholder been largely subsistence agriculturists. Soil and fertilizer type are very significant factors in crop production. It is highly heterogeneous and this is the cause of differential rates of growth and yield on a parcel of land planted to the same crop at the same time and with the same management package Olalokun, (1998). This is a source of frustration to crop farming as farmers cannot think of a particular management package suitable for their farmlands. Intensive cultivation and fertilizer application have become the cardinal aspect of soil management especially in the West African sub region. The Response to fertilizer application in some cases is nothing to write home about; hence many farmers have been forced to abandon their farmlands.

Nitrogen phosphorous potassium (NPK) fertilizer

The agriculture industry relies heavily on the use of NPK fertilizer. There are various nutrients that plants need for healthy and effective growth. Soils often lack these elements, either naturally, or as a result of over cultivation or depletion, and needs to have these nutrients into it.

NPK fertilizer is primarily composed of three main elements: Nitrogen (N), Phosphorus (P), and Potassium (K), each of these being essential in plant nutrition and growth. Among other benefits, Nitrogen helps plants grow quickly, also it increases the production of seed, fruit, and bettering the quality of crops. Nitrogen is also a component of chlorophyll, the substance that gives plants their green color, and also aids in photosynthesis which is the most important process in every crop development as a lot depends on how well a plant photosynthesizes.

Healthy soil is the foundation of the food system namely: It produces healthy crops that in turn nourish people. Maintaining a healthy soil demands care and effort from farmers because farming is not benign. By definition, farming disturbs the natural soil processes including that of nutrient cycling - the release and uptake of nutrients.

Plants obtain nutrients from two natural sources: organic matter and minerals. Organic matter includes any plant or animal material that returns to the soil and goes through the decomposition process. In addition to providing nutrients and habitat to organisms living in the soil, organic matter also binds soil particles into aggregates and improves the water holding capacity of soil. Most soils contain 2 to 10 percent organic matter. However, even in small amounts, organic matter is very important.

Soil is a living, dynamic ecosystem. Healthy soil is teeming with microscopic and larger organisms that perform many vital functions including converting dead and decaying matter as well as minerals to plant nutrients. Different soil organisms feed on different organic substrates. Their biological activity depends on the organic matter supply.

Nutrient exchanges between organic matter, water and soil are essential to soil fertility and need to be maintained for sustainable production purposes. Where the soil is exploited for crop production without restoring the organic matter and nutrient contents and maintaining a good structure, the nutrient cycles are broken, soil fertility declines and the balance in the agro-ecosystem is destroyed.

Soil organic matter - the product of on-site biological decomposition - affects the chemical and physical properties of the soil and its overall health. Its composition and breakdown rate affect: the soil structure and porosity; the water infiltration rate and moisture holding capacity of soils; the diversity and biological activity of soil organisms; and plant nutrient availability. Many common agricultural practices, especially ploughing, disc-tillage and vegetation burning, accelerate the decomposition of soil organic matter and leave the soil susceptible to wind and water erosion. However, there are alternative management practices that enhance soil health and allow sustained agricultural productivity. Conservation agriculture encompasses a range of such good practices through combining no tillage or minimum tillage with a protective crop cover and crop rotations. It maintains surface residues, roots and soil organic matter, helps control weeds, and enhances soil aggregation and intact large pores, in turn allowing water infiltration and reducing runoff and erosion. In addition to making plant nutrients available, the diverse soil organisms that thrive in such conditions contribute to pest control and other vital ecological processes. Through combining pasture and fodder species and manuring with food and fibre crop production, mixed crop-livestock systems also enhance soil organic matter and soil health. This document recognizes the central role of organic matter in improving soil productivity and outlines promising technologies for improved organic matter management for productive and sustainable crop production in the tropics.

Soil organic matter content is a function of organic matter inputs (residues and roots) and litter decomposition. It is related to moisture, temperature and aeration, physical and chemical properties of the soils as well as bioturbation (mixing by soil macrofauna), leaching by water and humus stabilization (organ mineral complexes and aggregates). Land use and management practices also affect soil organic matter.

Farming systems have tended to mine the soil for nutrients and to reduce soil organic matter levels through repetitive harvesting of crops and inadequate efforts to replenish nutrients and restore soil quality. This decline continues until management practices are improved or until a fallow period allows a gradual recovery through natural ecological processes. Only carefully selected diversified cropping systems or well-managed mixed crop-livestock systems are able to maintain a balance in nutrient and organic matter supply and removal.

Farmers can take many actions to maintain, improve and rebuild their soils, especially soils that have been under cultivation for a long time. A key to soil restoration is to maximize the retention and recycling of organic matter and plant nutrients, and to minimize the losses of these soil components caused by leaching, runoff and erosion. However, rebuilding soil quality and health through appropriate farming practices may take several years, especially in dryland areas where limited moisture reduces biomass production and soil biological activity. Thus, the challenge is to identify soil management practices that promote soil organic matter formation and moisture retention and ensure productivity and profitability for farmers in the short term.

FAO recognizes that conservation agriculture can make an important contribution to the agriculture sector through its multiple environmental and economic benefits. Conservation agriculture uses holistic production management systems that promote and enhance agro-ecosystem health, including aboveground and belowground biodiversity, biological cycles, and biological activity. These systems apply specific and precise standards of production based on no- or minimum-tillage techniques and selected cover crops and crop rotations. Their aim is to achieve optimal agro-ecosystems that are socially, ecologically and economically sustainable. Through effective harnessing of agro-ecological processes, conservation agriculture provides an opportunity for reducing external input requirements and for converting low-input agricultural systems into more productive ones. A better understanding of the linkages between soil life and ecosystem function and the impact of human interventions will enable the reduction of negative impacts and the more effective capture of the benefits of soil biological activity for sustainable and productive agriculture.

Throughout human history, our relationship with the soil has affected our ability to cultivate crops and influenced the success of civilizations. This relationship between humans, the earth, and food sources affirms soil as the foundation of agriculture.

Human society has developed through utilization of our planet's resources in amazingly unique, creative, and productive ways that have furthered human evolution and sustained global societies. Of these resources, soil and water have provided humans with the ability to produce food, through agriculture, for our sustenance.

OBJECTIVES OF THE STUDY

This study is aimed at the following objectives:

i. to determine if there is a relationship and the nature of this relationship (if any) between soil type, fertilizer type and crop yield.
ii. to determine if there is a relationship between soil type and crop yield.
iii. to determine if there is a relationship between fertilizer type and crop yield.
iv. to determine the best combination of fertilizer and soil type that yields more crops.
v.

SIGNIFICANCE OF THE STUDY

The significance or importance of this study is mainly to determine if there is any relationship between fertilizer type, nature of soil and crop yield. Another importance of this survey is to determine the soil type that encourages more crop yield. A major significance of this study is to determine if there is a relationship between the following:

LITERATURE REVIEW

Growth, yield and quality of a plant species differ with soil types, soil nutrient status, and fertilizer management; and a plant species requires suitable soil for higher yield and better quality Akamine et al., (2007); Chowdhury et al., (2008); Hossain & Ishimine, (2005); Hossain et al., (2011); Islam et al., 2011; Oya, (1972); Oya et al., (1977). Soil fertility and crop productivity differ significantly with the amount and combination of Na, K, Ca, Mg, S. P, Fe, Al, pH, and N in soil Broadley et al., (2012a, 2012b); Hawkesford et al., 2012; Oya, (1972). Study on growth characteristics of a plant species in local soils is important to develop management practices for higher yield with good quality Hossain &Ishimine, (2005). Different plant species respond differently to fertilizer rates and combination and a plant species requires balanced fertilizers to maximize growth, yield, and quality Akamine et al., (2007); Chowdhury et al., (2008); Hafsi et al., (2011); Hossain et al., (2004). The major nutrients (N, P, K) individually or in combination maintain growth, yield, and quality of plants Hafsi et al., (2011); Ivonyi et al., (1997); Mazid, (1993); Nakano & Morita, (2009). Nitrogen influences chlorophyll formation, stomatal conductance, and photosynthetic efficiency, which is responsible for 26–41% of crop yield Ivonyi et al., (1997); Maier et al., (1994). Potassium plays catalytic roles and regulates functions of various minerals in plants, and promotes N uptake efficiency of plants. Insufficient K causes shoot yellowing, poor growth, and low resistance to cold and drought of plant Oya, (1972). Phosphorus promotes absorption of other nutrients and plant growth Akamine et al., (2007). Amaranthus, a genus consisting of more than 50 species, is an important promising food crop for its resistance to heat, drought, diseases and pest, and high nutritional value Rastogi & Shukla, (2013); Sreelathakumary& Peter, (1993); Svirskis, (2003). Amaranthus species are severe weeds in crop fields, which significantly reduce yield and quality Guo& Al-Khatib, (2003; Holm et al., 1977). Many Amaranthus species have been cultivated as vegetable and grain in many countries and are popularly consumed as vegetable in Africa, Bangladesh, Caribbean, China, Greece, India, Nepal, and South Pacific Islands Begum, (2000); Prakash & Pal, (1991); Stalknecht & Schulz-Schaeffer, amaranth lines for developing management practices in Okinawa.

Materials and methods Soil collection Dark red soil (Shimajirimahji) and gray soil (Jaagaru) were collected from the top 50-cm layer of fields at the Subtropical Field Science Center, University of the Ryukyus, and red soil (Kunigamimahji) from the same layer of a field in northern part of Okinawa, Japan. Chemical properties of the soils are presented in the Table 1. According to Hossain and Ishimine (2005), coarse sand, fine sand, silt, clay, and apparent density are 3.61%, 30.94%, 24.32%, 32.84%, and 0.90 g cm−3, respectively, for the gray soil; 2.93%, 7.33%, 23.94%, 57.24%, and 0.87 g cm−3, respectively, for the dark red soil; and 16.92%, 20.44%, 26.62%, 30.92%, and 0.92 g cm−3, respectively, for the red soil.

Amaranth lines The Amaranthus tricolor lines IB (India Bengal line, red leaf amaranth), TW (Taiwan line, green leaf amaranth), BB (Bangladesh B line, red stem amaranth), and BC (Bangladesh C line, red leaf amaranth) provided higher yield in our previous study (Ohshiro et al., in press) were evaluated in this study.

Glasshouse experiment: effects of soil types on amaranth 4 lines A glasshouse experiment was conducted using gray soil, dark red soil, and red soil at the Subtropical Field Science Center of the University of the Ryukyus, from 10 July to 30 August 2011. each planter (planter-65e type, IRIS Ohyama, Japan) was filled with 13 kg of air-dried soil; and seeds of the amaranth 4 lines were placed on soil surface and covered with a thin layer (<0.5 mm) of soil. The plants were thinned to eight healthiest stands per planter at 2- to 3-leaf stage. each soil treatment consisted of three planters (replications). The planters were arranged randomly in the house. Water was applied as required every day. Fertilizer was not applied during the course of the experiment in order to determine the actual effect of three Okinawan soils on the amaranth lines.(1993); Svirskis, (2003). Vegetable amaranth is equal or superior in taste to spinach (Spinaciaoleracea), which has higher carotenoids (90–200 mg kg−1), protein (14–30%), and ascorbic acid (28 mg 100 g−1) Abbott & Campbell, (1982); Prakash & Pal, (1991). Some amaranth species contains 11.94 mg β-carotene, 43 mg vitamin C, 374 mg Ca, 5.0 g carbohydrate, 5.3 g protein, 0.1 g fat, and 43 kcal per 100 g of dry edible portion Begum, (2000); Makus, (1984); Shittu et al., (2006); Shukla et al., (2005). Amaranthus species also contains various volatiles and polyphenols, and has antioxidant, antimalarial, and antiviral properties, which prevent cancer, cardiovascular diseases, diabetes, etc. Dasgupta& De, (2007); Jiang et al., (2011); Khandaker et al., (2008); Scalbert et al., (2005); Shukla et al., (2010). It was reported that amaranth contains protein, ascorbic acid, and mineral nutrients of Ca, Fe, Mg, P, K, and Na, which are considered as the nutritional value in vegetables (USDA, 1984).

Amaranthus grows very fast in tropical and subtropical areas, and is cultivated in many countries under a variety of soils and agro-climatic conditions during summer when vegetables are not available Begum, (2000); Makus, (1984); Singh & Whitehead, (1996). In Okinawa, some Amaranthus species are found as weed in various crops and vegetables (personal survey) in the major soil types, dark red soil, red soil, and gray soil, and summer vegetables are very limited in supply during this period Hossain & Ishimine, (2005; Okinawa Prefecture Agriculture, Forestry and Fisheries, (2008). We evaluated growth speed, yield per plant, total nutrient (minerals) per plant, and total l-ascorbic acid per plant of 12 amaranth lines cultivated under a management condition, and selected some high-yielding amaranth lines with high quality as summer vegetables in Okinawa Ohshiro et al., in press). Shittu et al. (2006) reported that balanced fertilizers in a specific soil provide higher yield and nutrient compositions of amaranth in Nigeria, but no study has yet been conducted on the selected amaranth lines regarding these factors in Okinawa. It is thought that growth, yield, and quality of amaranth plants differ with chemical fertilizers and soil types possessing different levels of minerals, pH, and N. Therefore, the objectives of these studies were to (i) identify the best soil type, and (ii) evaluate rates of fertilizer combinations on growth, yield, and quality of four selected.

Food and nutritional requirements for the increasing human population in SSA call for sustainable intensification in the current agricultural land. Research has identified intensification options in agricultural production including integrated options such as combined use of organic and inorganic inputs, micro dosing of fertilizers, legume-cereal integration through rotations and intercropping, conservation agriculture and agro forestry options, among others Vanlauwe et al., (2015). The use of external inputs is a nutrient management option that has attracted the most studies in SSA. Several decades of research show that deficiencies of macronutrients such as N, P, and K are major limitations to crop production Ayalew, (2011); Aleminew and Legas, (2015); Argaw and Tsigie, (2015), and recently the limitations of secondary nutrients and micronutrient deficiencies are gaining traction Habtegebrial and Singh, (2009); Habtegebrial, (2013). Variable responses to fertilizer application are reported across most geographies and countries in SSA. Based on a large and consistent crop response to fertilizer data covering five countries in SSA, four categories of response have been identified, ranging from low response to any nutrient combination to high response to N Kihara et al., (2016). While some of the responses can be explained by management factors (e.g. timeliness of farm operations or type of fertilizer), others are due to biophysical attributes (e.g. variability in soils and climate).

The resulting utilization efficiencies and profitability/ benefits of fertilizer use is variable. The increasing benefits of fertilizer application requires the development of plausible fertilizer recommendation domains targeted at specific systems, landscapes and farm typologies, and management practices Bronson et al., (2003); Zingore et al., (2007); Chikowo et al., (2014). In the complex landscapes of Ethiopia, the position of fields within soil catena will probably influence the observed responses to fertilizer application as observed in other places Terra et al., (2006); The lemann et al., (2010). Further, the type of cropping system influences the soil nutrient status; the availability of nutrients to succeeding crops require context-specific targeting of fertilizer application using conditions and systems that optimize fertilizer use efficiency Kihara and Njoroge, (2013).The realization of site-specific management recommendations is elusive in Ethiopia as it is in other parts of SSA Haileslassie et al., (2007). In Ethiopia, agriculture is still characterized by low productivity, a high level of nutrient mining, low use of external inputs, traditional farm management practices and limited capacity to respond to environmental shocks Assefa et al., (2013); Amante et al., (2014); Agegnehu et al., (2016). As a first step, context-specific decision guidelines can be derived from examining meta analysis of existing crop responses to fertilizer research data (through peer-reviewed publications and gray literature in universities and research institutes). With such guidelines, it is possible to target fertilizer applications to specific agro ecologies and soil fertility problems and to increase economic returns for fertilizer investments. We hypothesize that the crop response to fertilizer is influenced by landscape positions and cropping systems (e.g. the previous crop). The objective of this study is to assemble a comprehensive database and generate a country-level distributions of crop response to fertilizers and generate guidelines for fertilizer management that result in increased nutrient use efficiency based on meta-analysis of research data. This meta-analysis of existing information over the last three decades on crop response to both application and management of fertilizers and soil protection and rehabilitation approaches across soil types, agro ecologies and cropping systems will provide a baseline for development of site-specific fertilizer recommendations. In addition, it will assess the economic and yield benefits of fertilizer use on farmer fields and identify the factors that contribute to successes and failures and corresponding challenges and opportunities for fertilizer use and soil conservation. The analysis will also provide information that will help to identify entry points for best-bet fertilizer types and combinations.

METHODOLOGY

The split-plot design is an experimental design that is used when a factorial treatment structure has two levels of experimental units. In the case of the split-plot design, two levels of randomization are applied to assign experimental units to treatments 1. The first level of randomization is applied to the whole plot and is used to assign experimental units to levels of treatment factor A. The whole plot is split into subplots, and the second level of randomization is used to assign the subplot experimental units to levels of treatment factor B. 1, 2 since the split-plot design has two levels of experimental units, the whole plot and subplot portions have separate experimental errors 2.

Usually the split-plot design is an analysis of variance technique where the levels of one factor are assigned at random to large experimental units within blocks of such units. The large units are then divided into smaller units, and the levels of the second factor are assigned at random to the small units within the larger units. In the terminology of agricultural research, where these designs were developed, the large units are called whole plots or main plots, while the small units are called split-plots or subplots.

In the split-plot design the whole-plot factor effects are estimated from the large units, while the subplot effects and the interaction of the whole-plot and subplot factors are estimated from the small units. In view of the fact that there are two sizes of unit, there are two experimental errors, one for each type of unit. Generally, the error associated with the subplots is smaller than that for the whole plots.

STATISTICAL ANALYSIS OF THE FIXED EFFECTS MODEL

Mathematical Model - Split Block

$Y_{ijk} = \mu\ldots + M_i + B_j + d_{ij} + S_k + (MS)_{ik} + e_{ijk}$

Where Y_{ijk} = an observation

μ = the experiment mean

M_i = the main plot treatment effect

B_j = the block effect

d_{ij} = the main plot error (error a)

S_k = the subplot treatment effect

$(MS)_{ik}$ = the main plot and subplot treatment interaction effect

e_{ijk} = the subplot error (error)

i = a particular row treatment

j = a particular block

k = a particular column treatment

$\mu = \bar{y}_{\ldots}$

$R_i = \bar{y}_{i..} - \bar{y}_{\ldots}$

$B_j = \bar{y}_{.j.} - \bar{y}_{...}$

$C_k = \bar{y}_{..k} - \bar{y}_{...}$

$(ab)_{jk} = \bar{y}_{.jk} - \bar{y}_{i..} - \bar{y}_{.j.} + \bar{y}_{...}$

$SS_{rep} = \frac{1}{ab}\sum_{i=1}^{a} y^2{}_{i..} - \frac{y^2{}_{...}}{abr}$

$SS_A = \frac{1}{br}\sum_{j=1}^{b} y^2{}_{.j.} - \frac{y^2{}_{...}}{abr}$

$SS_{M.P} = \frac{1}{b}\sum_{ij=1}^{b} y^2{}_{ij.} - \frac{y^2{}_{...}}{abr}$

$SS_{Error(A)} = SS_{m.p} - SS_A - SS_{rep}$

$SS_B = \frac{1}{ar}\sum_{j=1}^{b} y^2{}_{..k} - \frac{y^2{}_{...}}{abr}$

$SS_{AB} = \frac{1}{r}\sum_{j=1}^{b} y^2{}_{.jk} - \frac{1}{br}\sum_{j=1}^{b} y^2{}_{.j.} + \frac{1}{ar}\sum_{j=1}^{b} y^2{}_{..k} + \frac{y^2{}_{...}}{abr}$

$SS_T = \sum_{j=1}^{b} y^2{}_{ijk} - \frac{y^2{}_{...}}{abr}$

$SS_{e(ab)} = SS_T - SS_{rep} - SS_a - SS_{error(A)} - SS_b - SS_{ab}$

DATA AND ANALYSIS

DATA

P_1 = Maize, P_2 = Watermelon, P_3 = Tomatoes

Table 1: shows the data on

	CLAY SOIL				LOAMY SOIL		
WEEKS	FERTILIZER	P_1	P_2	P_3	P_1	P_2	P_3
2	NPK 15:15:15	11.4	10.2	11.6	10.1	10.8	9.7
	POULTRY MANURE	10.2	9.8	8.7	8.6	8.8	8.9
	CATTLE DUNG	9.8	8.6	8.2	8.1	8.7	10.1
4	NPK 15:15:15	18.7	18.8	19.8	18.7	18.5	19.2
	POULTRY MANURE	18.0	18.3	19.7	18.9	18.3	18.9
	CATTLE DUNG	18.1	18.7	19.1	18.6	18.7	18.20
6	NPK 15:15:15	25.2	23.7	21.5	24.2	24.7	26.2
	POULTRY MANURE	22.4	20.4	25.4	23.7	26.2	25.2
	CATTLE DUNG	22.4	23.3	26.2	25.4	22.2	26.2
8	NPK 15:15:15	41.2	45.1	32.3	34.6	33.1	41.2
	POULTRY MANURE	51.3	48.1	49.2	50.1	54.3	53.2
	CATTLE DUNG	54.3	54.4	31.5	51.2	45.1	49.2
10	NPK 15:15:15	65.7	56.2	66.1	58.9	68.7	69.0
	POULTRY MANURE	51.2	48.6	58.0	48.2	42.3	48.9
	CATTLE DUNG	58.2	65.0	61.3	58.0	49.0	56.3

CALCULATING THE MEAN OF FERTILIZER FOR THE 10WEEKS IN EACH PLANT FOR EACH SOIL.

Mean of fertilizer for clay soil.

NPK for P_1 = 11.4 + 18.7 + 25.2 + 41.2 + 65.7 = 162.2

$\overline{p_1}$ = 162.2 ÷ 5 = 32.44

NPK for P_2 = 10.2 + 18.8 + 23.7 + 45.1 + 56.2 = 154.0

$\overline{p_2}$ = 154.0 ÷ 5 = 30.80

NPK for P_3 = 11.6 + 19.8 + 21.5 + 32.3 + 66.1 = 151.3

$\overline{p_3}$ = 151 ÷ 5 = 30.26

Poultry manure for P_1 = 10.2 + 18.0 + 22.4 + 51.3 + 51.2 = 153.1

$\overline{p_1}$ = 153.1 ÷ 5 = 30.62

Poultry manure for P_2 = 9.8 + 18.3 + 20.4 + 48.1 + 48.6 = 145.2

$\overline{p_2}$ = 145.2 ÷5 = 29.04

Poultry manure for P_3 = 8.7 + 19.7 + 25.4 + 49.2 + 58.0 = 161.0

$\overline{p_3}$ = 161.0 ÷ 5 = 32.20

Cattle dung for P_1 = 9.8 + 18.1 + 22.4 + 54.3 + 58.2 = 162.8

$\overline{p_1}$ = 162.8 ÷ 5 = 32.56

Cattle dung for P_2 = 8.6 + 18.7 + 23.3 + 54.4 + 65.0 = 170.0

$\overline{p_2}$ = 170.0 ÷ 5 = 34.00

Cattle dung for P_3 = 8.2 + 19.1 + 26.2 + 31.5+ 61.3 = 146.3

$\overline{p_3}$ = 146.3 ÷ 5 = 29.26

Mean of fertilizer for loamy soil.

NPK for P_1 = 10.1 + 18.7 + 24.2 + 34.6 + 58.9 = 146.5

$\overline{p_1}$ = 146.5 ÷ 5 = 29.30

NPK for P_2 = 10.8 + 18.5 + 24.7 + 33.1 + 68.7 = 155.8

$\overline{p_2}$ = 155.8 ÷ 5 = 31.16

NPK for P_3 = 9.7 + 19.2 + 26.2 + 41.2 + 69.0 = 165.3

$\overline{p_3}$ = 165.3 ÷ 5 = 33.06

Poultry manure for P_1 = 8.6 + 18.9 + 23.7 + 50.1 + 48.2 = 149.5

$\overline{p_1}$ = 149.5 ÷ 5 = 29.90

Poultry manure for P_2 = 8.8 + 18.3 + 26.2 + 54.3 + 42.3 = 149.9

$\overline{p_2}$ = 149.9 ÷ 5 = 29.98

Poultry manure for P_3 = 8.9 + 18.9 + 25.2 + 53.2 + 48.9 = 155.1

$\overline{p_3}$ = 155.1 ÷ 5 = 31.02

Cattle dung for P_1 = 8.1 + 18.6 + 25.4 + 51.2 + 58.0 = 161.5

$\overline{p_1}$ = 161.5 ÷ 5 = 32.30

Cattle dung for P_2 = 8.7 + 18.7 + 22.2 + 45.1 + 49.0 = 143.7

$\overline{p_2}$ = 143.7 ÷ 5 = 28.74

Cattle dung for P_3 = 10.1 + 18.2 + 26.2 + 49.2 + 56.3 = 160.0

$\overline{p_3}$ = 160.0 ÷ 5 = 32.00

Table2: shows the means of fertilizer for clay soil

Fertilizer	P_1	P_2	P_3
NPK 15:15:15	32.44	30.80	30.62
Poultry manure	30.62	29.04	32.20
Cattle dung	32.56	34.00	29.26

Table3: shows the means of fertilizer for loamy soil

Fertilizer	P_1	P_2	P_3
NPK 15:15:15	29.30	31.16	33.06
Poultry manure	29.90	29.98	31.02
Cattle dung	32.30	28.74	32.00

Arranging the data for each soil in Split-Plot design

Where: NPK = N, Poultry manure = M, Cattle dung = C
P_1 = Maize, P_2 = Watermelon, P_3 = Tomatoes

Table 4: shows the arrangement of fertilizers on soil type

Clay soil			
P_1	32.44N	30.62M	32.56C
P_2	34.00C	30.80N	29.04M
P_3	32.2M	29.26C	30.62N

Loamy soil			
P_1	32.30C	29.30N	29.90M
P_2	29.98M	28.74C	31.16N
P_3	33.06N	31.02M	32.00C

Computation of data

Table 5 shows the computation arrangement of fertilizers on soil type

Clay soil				Total
P_1	32.44N	30.62M	32.56C	95.62
P_2	34.00C	30.80N	29.04M	93.84
P_3	32.2M	29.26C	30.62N	92.08
Total	98.64	90.68	92.22	281.54

Loamy soil				Total
P_1	32.30C	29.30N	29.90M	91.5
P_2	29.98M	28.74C	31.16N	89.88
P_3	33.06N	31.02M	32.00C	96.08
Total	95.34	89.06	93.06	277.46

Grand total = 281.54 + 277.46 = 559

$$SS_{rep} = \frac{repI^2 + erepII^2}{9} - CF$$

$$SS_{rep} = \frac{281^2 + 277.46^2}{9} - \frac{559^2}{9}$$

$$SS_{rep} = 17360.98036 - 17360.05556$$

$$SS_{rep} = 0.9248$$

$$SS_{plant} = \frac{{P_1}^2 + {P_2}^2 + {P_3}^2}{6} - CF$$

$$SS_{plant} = \frac{187.12^2 + 183.72^2 + 188.16^2}{6} - \frac{559^2}{9}$$

$$SS_{plant} = 17361.85307 - 17360.05556$$

$$SS_{plant} = 1.79751$$

$$SS_{error(A)} = \frac{(R_1P_1)^2 + (R_1P_2)^2 + (R_1P_3)^2 + (R_2P_1)^2 + (R_2P_2)^2 + (R_2P_3)^2}{3} - CF - SS_{rep} - SS_p$$

$$SS_{error\ (A)} = \frac{95.62^2 + 93.84^2 + 92.08^2 + 91.50^2 + 89.88^2 96.08^2}{6} - \frac{559^2}{9} - 0.9248 - 1.79751$$

$$SS_{error\ (A)}) = 17368.6876 - 17360.05556 - 0.9248 - 1.79751$$

$$SS_{error\ (A)}) = 5.90973$$

$$SS_{fertility} = \frac{{F_1}^2 + {F_2}^2 + {F_3}^2}{6} - CF$$

F_1 = NPK = 32.44 + 30.80 + 30.62 + 29.30 + 31.16 + 33.06 = 187.38

F_2 = Poultry manure = 30.62 + 29.04 + 32.2 + 29.90 + 29.98 + 31.02 = 182.76

F_3 = Cattle dung = 32.56 + 34.00 + 29.26 + 32.30 + 28.74 + 32.00 = 188.86

$$SS_{fertilizer} = \frac{187.38^2 + 182.76^2 + 188.86^2}{6} - \frac{559^2}{9}$$

$SS_{fertilizer} = 17363.43027 - 17360.05556$
$SS_{fertilizer} = 3.37471$

$$SS_{replicate\ x\ fertility} = \frac{(F_1R_1)^2 + (F_1R_2)^2 + (F_2R_1)^2 + (F_2R_2)^2 + (F_3R_1)^2 + (F_3R_2)^2 +}{3} - CF$$

$F_1R_1 = 32.44 + 30.80 + 30.62 = 93.86$
$F_1R_2 = 29.30 + 31.16 + 33.06 = 93.52$
$F_2R_1 = 30.62 + 29.04 + 32.2 = 91.86$
$F_2R_2 = 29.90 + 29.98 + 31.02 = 90.90$
$F_3R_1 = 32.56 + 34.00 + 29.26 = 95.82$
$F_3R_2 = 32.30 + 28.74 + 32.00 = 93.04$

$$SS_{replicate\ x\ fertility} = \frac{93.86^2 + 93.52^2 + 91.86^2 + 90.90^2 + 95.82^2 + 93.04^2}{3} - \frac{559^2}{9}$$

$SS_{replicate\ x\ fertility} = 17364.8912 - 17360.05556 = 4.83564$
$SS_{replicate\ x\ fertility} = 4.83564$
$SS_{error} = SS_T - SS_{rep} - SS_p - SS_f - SS_{error(A)} - SS_{replicate\ x\ fertility}$
$SS_{error} = 39.29724 - 0.9248 - 1.79751 - 3.37471 - 5.90973 - 4.83564 = 22.45485$
$SS_{error} = 22.45485$

Analysis of Variance (ANOVA TABLE) and interpretation

Table 6. shows the Analysis of Variance on the response of crop on fertilizers and soil type

SV	Degree of Freedom	Sum of Square	Mean Square	F_{ratio}
REP	1	0.9248	0.9248	0.3130
PLANT	2	1.79751	0.8988	0.3042
ERROR (PLANT)	2	5.90973	2.9549	
FERTILIZER	2	3.37471	1.6874	0.6012
FERTILITY × REPLICATE	2	4.83564	2.4178	0.8614
ERROR	8	22.45485	2.8069	
TOTAL	17	39.29724		

F_{tab} for the first statement
$F_{2,\ 1,\ 0.95} = 18.5$
F_{tab} for the second statement
$F_{2,\ 2,\ 0.95} = 19.0$
$F_{8,2,\ 0.95} = 4.46$
Since $F_{cal} = (0.3130, 0.3042) > F_{crit} = (18.5, 19.0)$, we reject the null hypothesis and hereby conclude that there is no significance difference in the replicates and the plants. Also in the interaction, there is no significance difference between the interaction (soil types and fertilizer types) i.e$F_{cal} < F_{tab}$(0.8614 < 4.46) and there is no significant difference in the fertilizer i.e$F_{cal} < F_{tab}$(0.6012 < 4.46).

Tests of Between-Subjects Effects

Table 4.7. shows the statistical package using spss on response of plants to fertilizer and soil type

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	17366.267	1	17366.267	10664.911	.000
	Error	3.257	2	1.628[a]		
REPLICATE	Hypothesis	.971	1	.971	3.706	.194
	Error	.524	2	.262[b]		
PLANT	Hypothesis	1.860	2	.930	.509	.635
	Error	7.306	4	1.827[c]		
FERTILIZERS	Hypothesis	3.257	2	.	.	.
	Error	.	.[d]	.		
REPLICATE * PLANT	Hypothesis	7.007	2	3.503	.753	.528
	Error	18.611	4	4.653[e]		
zREPLICATE * FERTILIZERS	Hypothesis	.524	2	.262	.056	.946
	Error	18.611	4	4.653[e]		
PLANT * FERTILIZERS	Hypothesis	7.306	4	1.827	.393	.806
	Error	18.611	4	4.653[e]		
REPLICATE * PLANT * FERTILIZERS	Hypothesis	18.611	4	4.653	.	.
	Error	.000	0	.[f]		

a. MS(FERTILIZERS)
b. MS(REPLICATE * FERTILIZERS)
c. MS(PLANT * FERTILIZERS)

e. MS(REPLICATE * PLANT * FERTILIZERS)
f. MS(Error)

Since all P-value of our source of variation greater than 0.05 we do not reject the null hypothesis on the effect of the factors on yield of plants under consideration and we therefore conclude that there is no significant effect of the factors (main and interaction) on yield of the plant at 0.05 significant.

SUMMARY

This research is interested in determining the significance effect on yield of the factors under consideration. The method of data collection is transcription from record from the Department of Agricultural Technology, Federal Polytechnic Ado-Ekiti. Factors considered are soil type, plants used and fertilizers applied, all of which effect on yield would be determine accordingly. Analysis of variance using split-plot design is done in previous chapter to estimate the effect of those factors under consideration. The soil type is of two levels namely loamy soil and clay soil. The fertilizers are NPK 15:15:15, poultry manure and cattle dung, that is, three levels. The plants considered are maize, watermelon and tomato, which their yield were measured and recorded for analysis.

CONCLUSION

After the analysis, we conclude that main effect of replicates (that is soil types), and fertilizer effect on yield of plants under consideration are both statistically not significant at 5% level of significance, since their individual F-calculated is less than F-tabulated and based on the decision rule of hypothesis testing procedures we always reject the null hypothesis when F-tabulated is greater than F-calculated at a given level of significance or when P-value is less than or equal to the level of significance. Also the interaction effect of fertilizer and replicate is statistically not significance since its F-tabulated (4.46) > F-calculated

(0.8614) at 5% level of significance all based on the research (data collected) and scope of the study.

Also, using statistical package to analyze the data, it shows that there is no significant effect of the factors (main and interaction) on yield of the plant at 0.05 significant.

REFERENCES

[1]. **Alexandratos, N. (1999),** World food and agriculture: Outlook for the medium and longer term. *Proceedings of the National Academy of Sciences of the United States of America 96, 5908-5914.*

[2]. **Bernhard, A. (2010).** *The Nitrogen Cycle: Processes, Players, and Human Impact. Nature Education Knowledge 2.*

[3]. **Bongaarts, J. (2009).** Human population growth and the demographic transition. *Philosophical Transactions of the Royal Society B-Biological Sciences 364, 2985-2990, (2009). doi:10.1098/rstb.2009.0137.*

[4]. **Brady, N. C. and Weil, R. R. (2002).** *The Nature and Properties of Soil, 13th ed. Prentice Hall.*

[5]. **Brady, N. C. and Weil, R. R. (2008).***The Nature and Properties of Soil, 14th ed. Prentice Hall.*

[6]. **Brodt, S., *et al.* (2011).** *Sustainable Agriculture. Nature Education Knowledge 3.*

[7]. **Chambers. E. Manhattan, K. S, (2011)** *Course notes in Descriptive Sensory Analysis, Kansas State University.*

[8]. **Harlan, J. R. (1992).***Crops and Man. Am. Soc. Agron. and Soil Sci. Soc. Am.*

[9]. **Havlin, J. L. *et al.* (2005).** *Soil Fertility and Fertilizers . 7th ed,.*

[10]. **Hillel, D. (1992)** Out of the Earth: *Civilization and the Life of the Soil. University of California Press.*

[11]. **Jenny. H. (1941**). *Factors of Soil Formation . McGraw-Hill, 1941.*

[12]. **Kuehl, R.O. (2000**). *Design of Experiments:* Statistical Principles of Research Design and Analysis, 2nd Ed., pp. 469-472, Brooks/Cole, Pacific Grove, California.

[13]. **Lawless, H. T. and Heymann, H. (1998).** *Sensory Evaluation of Food:* Principles and Practices, pp. 714-715, Aspen Publishers, Inc., Gaithersburg, Maryland.

[14]. **Meilgaard, M. C, Civille, G. V. and Carr, B. T. (1991).** *Sensory Evaluation Techniques, 2nd edition*, pp. 266-267, CRC Press, Boca Raton, Florida.

[15]. **Ott, R. L. and Longnecker, M. (2010).** *An introduction to Statistical Methods and Data Analysis*, 6th Ed., pp. 1095-1101, Brooks/Cole, Pacific Grove, California.

[16]. **Stone, H. and Sidel, J. L, (2004).** *Sensory Evaluation Practices, 3rd edition*, pp. 128-133, Elsevier Academic Press, London.

4/25/2022