Mathematics and Computer Science
2016; 1(4): 108-112
http://www.sciencepublishinggroup.com/j/mcs
doi: 10.11648/j.mcs.20160104.16

Analysis of Factors Influencing the Yield of *Manihot esculenta* in Umudike, Abia State, Nigeria

Victoria Matthew Akpan

Department of Statistics Akwa Ibom State Polytechnic, Ikot Osurua, Ikot Ekpene, Nigeria

Email address:
vickmakpan@gmail.com

To cite this article:
Victoria Matthew Akpan. Analysis of Factors Influencing the Yield of *Manihot esculenta* in Umudike, Abia State, Nigeria. *Mathematics and Computer Science.* Vol. 1, No. 4, 2016, pp. 108-112. doi: 10.11648/j.mcs.20160104.16

Received: September 6, 2016; **Accepted**: November 8, 2016; **Published**: December 21, 2016

Abstract: Manihot esculenta popularly called Cassava is a root tuber that is highly consumed. It is one of the staple foods commonly grown in the tropical region found to be readily available and constitutes economical raw material that can sustain many industries. Many factors affect its yield, three of these factors: cassava type, planting season, soil composition on cassava yield were examined. Data used were obtained from Federal University of Agriculture, Umudike. 2^3 factorial design was employed where the factors are regarded as main effects and their interactions where each of the factors was examined at two levels conventionally regarded as low and high levels. The result of the analysis showed that the 3 main factors have significant effects on the yield of cassava at α=1% and 5% levels of significance. Thus farmers are called upon to arise and grow good species of cassava while giving consideration to the planting season and the type of soil for bumper harvest that will boost job creation and wealth creation for our people and then sustain industrialization.

Keywords: Cassava Yield, Factorial Design, Analysis of Variance, Effects, Interaction

1. Introduction

Cassava is a root crop with tuberous yield. It was introduced into Africa by the Portuguese in the 16^{th} century [10].

It is a staple food source in Nigeria and other tropical countries. It can be taken raw, boiled or when processed into garri, foofoo, starch, flour and is effectively able to combat hunger. [2] offered that there are several different species of cassava but mainly differentiated as bitter and sweet types. It has a growing cycle of 9 to 24 months depending on the type and the environmental condition. Currently, there are improved varieties that mature in 6months. It is capable of growing well between 30^0 North and 30^0 South in areas where annual rainfall is more than 750mm a year. It is sensitive to frost (but tolerant of long dry periods), soils with low ph, high aluminium and low fertility. It thrives well in soils that contain carbon nutrients which improves the fertility of the land i.e organic soil whereas inorganic soils containing minerals but does not contain carbon nutrients may not produce good yield.

Cassava, apart from being consumed as food, serves many other purposes. Cassava, according to [6] is processed into flour which on account of its low content of non-carbohydrate constituent might well be called Starch. [11] also collaborated that it is extremely rich in starch. It is used directly or made in a group of baked products or manufactured into glucose. In Malaysia, cassava starch is used in sweetened and unsweetened biscuits, cakes and in cream sandwiches. Its starch is used in the manufacture of many types of candies, toffee, hard candy and soft gums. Starch and starch products are used in many food and non-food industries and are used as chemical raw – material for many other purposes such as in plastics, and the tanning of leather. Attempts were made to develop waxy maize as a replacement for normal non cereal starch but the production of cassava starch has increased considerably in recent years.

Although starch is a major constituent of flours, bread making depends largely on the selection of flour with the proper glutten characteristic. Cassava in composite flours is used widely in bread making and is economically advantageous when compared to wheat flour and is at the same time, of good quality. It is widely used in most tropical areas for feeding animals like cattle, sheep and poultry. Dried peels of cassava roots are fed to sheep and goats and raw or boiled roots mixed with concentrates such as maize, sorghum, groundnut oil or oil palm kernel are used for livestock feeding. Cassava starch is used in the manufacture of paper.

Cassava starch and molasses (by-product of the sugar industry) are the major raw materials used in the manufacture of

Monosodium glutamate (MSG) used extensively as a flavouring agent in foods such as meats, vegetables, sources and gravies. It is also used in the production of glucose syrup and is preferred to other starch. Fructose obtained from cassava is used in industry for sweetening fizzy drinks.

It is used in cloth printing or producing certain designs in various colours on the smooth surface of a finished fabric.

Cassava is one of the richest fermentable substances for the production of alcohol. Ethanol produced from cassava can be used as biofuel when combined with additives.

Aside, the International Fund of Agricultural Development [7] offered that there is current research underway to test cassava as a type of gene therapy to treat certain kinds of cancer. Hence Cassava is highly needed for domestic consumption and export through the use of sustainable agriculture.

[1] in his research concluded that Cassava is not commonly used in herbal medicine but indigenous people doe employ it for various healing purposes

In Tanzania, cassava is ranked number one in three zones and second in only one zone. Tanzania realizing the importance of cassava has given cassava second priority ranking in its national research [5]. For industrialization to be meaningful and effective, raw materials must be available.

However, several factors affect the yield of cassava. [8] identified the factors to include: use of inferior low yielding varieties, lack of good planting materials, price of inputs, farm size, improper planting season, soil composition, poor utilization method. [5] stated that pests and diseases, shortage of planting materials, drought, poor soil fertility, use of varieties with low genetic potential and low adoption rates of research recommendations affect the yield of cassava. [12] in their study to determine the growth characteristics of improved and local varieties of cassava in Eastern Cameroun under repeated cultivation and also assessing the effects of different soils on cassava growth using randomized blocked design with six replicates showed that variety and site were significant whereas there was no significant interaction between variety of cassava and soil type. [3] opined that cassava varieties, soil nutrients, credit facilities, pests and diseases and socio-economic characteristics have negative impact on cassava productivity. This work will focus on the effect of cassava type, planting season and soil composition on the yield of cassava.

2. Methodology

Factorial design will be used since this is the design used in experiments involving several factors where it is necessary to study the joint effect of the factors on a response. The factorial design studies the effect of each factor on the response variable as well as the effects of interactions between factors on the response variable. A full factorial experiment is an experiment whose design consists of two or more factors each with discrete possible values or levels and whose experimental units take on all possible combinations of these levels across all such factors.

Here, the 2^k design would be employed where k factors each occurring at two levels would be studied. The factors are cassava type, planting season and soil composition, thus k = 3. The analysis involves forming initial model of the design, estimating the effects of each of the factors which are regarded as the main effects, estimating the effects of all possible two-factor interactions and the three-factor interactions, performing statistical testing using Analysis of Variance (ANOVA) and interpreting the result. This design was first used in 19^{th} century by John Benneth Lawes and Joseph Henry Gilbert of Rothamsted [13]. [4] argued that complex designs such as factorial designs were more efficient than studying one factor at a time. Factorial design is analyzed using Analysis of variance (ANOVA) or regression analysis. This work uses ANOVA. The factorial ANOVA for some statisticians does not only compare differences but also assumes a cause-effect relationship; this infers that one or more independent, controlled variables (the factors) cause the significant difference of one or more characteristics. The way this works is that the factors sort the data points into one of the groups, causing the difference in the mean value of the group.

The three factors are each investigated at two levels: cassava species was classified as sweet and bitter cassava, planting season categorized into early (March – May) and late planting (August – October), and soil composition into organic and inorganic soil. The effect of these factors on the yield of cassava is considered hence, we apply 2^k, k = 3 factorial design on the data i.e 3 factors each occurring at 2 levels. Since there are only two levels, we assume that the response is linear over the range of the factor levels chosen. Normally, one level is considered to be low (represented as '_ ') and the other high level (represented as ' + '. Six replicates of the experiment were considered. Let the 3 factors be A, B and C

Where A = cassava species

B = planting season

C = soil composition.

All the treatment combinations are (1), a, b, ab, c, ac, bc, abc, and are shown below in Table 1.

Table 1. *Treatment combinations.*

Factor A	Factor B	Factor C	Treatment combination
_	_	_	(1) all the factors are at low level
+	_	_	a, only factor A is at high level
_	+	_	b i.e only factor B is at high level
+	+	_	ab i.e. factors A and B are at high level or interaction of cassava species and planting season
_	_	+	c i.e only factor C is at high level
+	_	+	ac i.e. factors A and C are at high level or cassava species and soil composition interaction
_	+	+	bc i.e. factors B and C are at high level or bc interaction of planting season and soil composition
+	+	+	abc i.e. factors A, B and C are at high level or interaction of cassava species, planting season and soil composition

The following assumptions are made:

i. Factors are fixed
ii. Designs are completely randomized
iii. Normality

[9] gave the model of 2^3 design as

$$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + C_k + AC_{ik} + BC_{jk} + ABC_{ijk} + \varepsilon_{ijk}$$

where Y_{ijk} is the yield of the cassava during planting period on a specified soil type.

μ = Grand mean
A = Effect of cassava type
B = Effect of planting season
AB = Interaction effect of cassava type and planting season
C = Effect of soil composition
AC = Interaction effect of cassava type and soil composition
BC = Interaction effect of planting season and soil composition
ABC = Interaction effect of cassava type, planting season and soil composition
ε_{ijk} = random error component

Hypotheses to be tested are

H_0: A = B = C = AB = AC = BC = ABC = 0
H_I: at least one factor ≠ 0

i.e H_0: All the factors have zero effect on cassava yield
H_I: at least one factor has a non- zero effect on the yield of cassava.

Critical region: Reject H_0 if $F_{cal} > F_\alpha$

2.1. Data Collection

Data used were collected from Federal University of Agriculture, Umudike, Nigeria, and is a secondary data. It comprised of cassava yield based on type of cassava, planting period and the soil composition. It also consists of the data generated based on the combination of two or three of the factors. Six replicates of each factor level were also collected.

2.2. Population

The population of study consists of yield of cassava with consideration of planting season, cassava species and soil composition from inception of the farm in Umudike.

2.3. Sample

The sample here comprised of cassava yield from 2011 to date.

Data: Weight (tonnes/hectare) of two species of cassava root yield at different planting dates and soil composition.

Table 2. *Measurements of the experimental variables.*

Cassava Type Planting Season				
	Late planting		**Early planting**	
	Soil composition		**Soil composition**	
Cassava Type	**Inorganic**	**Organic**	**Inorganic**	**Organic**
Bitter	0.3	0.5	0.7	2.8
Cassava	0.5	1.7	3.2	2.1
	0.7	0.4	1.9	1.0
	1.3	1.0	1.2	0.9
	0.7	2.1	1.7	4.1
	1.9	0.8	0.6	3.5
	5.4 = (1)	6.4 = c	9.3 = b	14.4 = bc
Sweet	1.3	0.7	4.0	6.2
Cassava	2.0	1.9	3.3	3.5
	2.5	3.5	2.0	4.2
	2.3	3.8	3.5	4.9
	3.6	2.2	1.8	6.6
	1.6	5.2	1.5	4.8
	13.3 = a	17.3 = ac	16.1 = ab	30.2 = abc

Source: Physiology Department, Federal University of Agriculture, Umudike, Abia, State.

The sum of Squares are computed using

$$\text{TSS} = \Sigma\Sigma\sum yijk^2 - \frac{Y_{...}{}^2}{r2^k}$$

where r = number of replicates; k = number of factors.

$$\text{SS of any treatment combination} = \frac{(contrast)^2}{r2^k}$$

Contrast = (a+1)(b+1)(c+1)
Contrast A = (a – 1)(b + 1)(c + 1)

$$\text{SSA} = \frac{\{(a-1)(b+1)(c+1)\}^2}{r2^k} = \frac{(a+ab+ac+abc-(1)-b-bc-c)^2}{(6)2^3}$$

$$\text{SSB} = \frac{\{(a+1)(b-1)(c+1)\}^2}{r2^k} = \frac{(-a+ab-ac+abc-(1)+b+bc-c)^2}{(6)2^3}$$

$$\text{SSAB} = \frac{\{(a-1)(b-1)(c+1)\}^2}{r2^k} = \frac{(-a+ab-ac+abc+(1)-b-bc+c)^2}{(6)2^3}$$

$$\text{SSC} = \frac{\{(a+1)(b+1)(c-1)\}^2}{r2^k} = \frac{(-a-ab+ac+abc-(1)-b+bc+c)^2}{(6)2^3}$$

$$\text{SSAC} = \frac{\{(a-1)(b+1)(c-1)\}^2}{r2^k} = \frac{(-a-ab+ac+abc+(1)+b-bc-c)^2}{(6)2^3}$$

$$\text{SSBC} = \frac{\{(a+1)(b-1)(c-1)\}^2}{r2^k} = \frac{(a-ab-ac+abc+(1)-b+bc-c)^2}{(6)2^3}$$

$$SSABC = \frac{\{(a-1)(b-1)(c-1)\}^2}{r2^k} = \frac{(a-ab-ac+abc-(1)+b-bc+c)^2}{(6)2^3}$$

$$TSS = \Sigma\Sigma\Sigma_{yijk}{}^2 - \frac{Y_{...}{}^2}{r2^k}$$

SSE = TSS – SSA – SSB – SSAB – SSC – SSAC – SSBC – SSABC

The treatment combinations are

Table 3. *Treatment Combinations and Replication.*

Treatment	Replicates (yields)	Total
(1)	0.3, 0.5, 0.7, 1.3, 0.7, 1.9	5.4
a	1.3, 2.0, 2.5, 2.3, 3.6, 1.6	13.3
b	0.7, 3.2, 1.9, 1.2, 1.7, 0.6	9.3
ab	4.0, 3.3, 2.0, 3.5, 1.8, 1.5	16.1
c	0.5, 1.7, 0.4, 1.0, 2.0, 0.8	6.4
ac	0.7, 1.9, 3.5, 3.8, 2.2, 5.2	17.3
bc	2.8, 2.1, 1.0, 0.9, 4.1, 3.5	14.4
abc	6.2, 3.5, 4.2, 4.9, 6.6, 4.8	30.2
Total		112.4

Using the values, we compute the sum of squares below:

$$SSA = \frac{(13.3+16.1+17.3+30.2-5.4-9.3-14.4-6.4)^2}{(6)2^3}$$

$$= \frac{(41.4)^2}{48} = 35.7075$$

$$SSB = \frac{(-13.3+16.1-17.3+30.2-5.4+9.3+14.4-6.4)^2}{(6)2^3}$$

$$= \frac{(27.6)^2}{48} = 15.87$$

$$SSAB = \frac{(-13.3+16.1-17.3+30.2+5.4-9.3-14.4+6.4)^2}{(6)2^3}$$

$$= \frac{(3.8)^2}{48} = 0.3008$$

$$SSC = \frac{(-13.3-16.1+17.3+30.2-5.4-9.3+14.4+6.4)^2}{(6)2^3}$$

$$= \frac{(24.2)^2}{48} = 12.2008$$

$$SSAC = \frac{(-13.3-16.1+17.3+30.2+5.4+9.3-14.4-6.4)^2}{(6)2^3}$$

$$= \frac{(12)^2}{48} = 3.0000$$

$$SSBC = \frac{(13.3-16.1-17.3+30.2+5.4-9.3+14.4-6.4)^2}{(6)2^3}$$

$$= \frac{(14.2)^2}{48} = 4.2008$$

$$SSABC = \frac{(13.3-16.1-17.3+30.2-5.4+9.3-14.4+6.4)^2}{(6)2^3}$$

$$= \frac{(6)^2}{48} = 0.7500$$

$$TSS = 0.32 + \ldots + 6.62 + 4.82 - \frac{112.4^2}{(6)2^3}$$

$$= 380.7 - 263.2033 = 117.496$$

SSE = 117.4967 – 35.7075 – 15.8700 – 12.2008 – 0.3008 – 3.0000 - 4.2008 – 0.7500

= 48.4368

3. Analysis of Variance (Anova) Table

The table is computed based on the values obtained previously

Table 4. *Analysis of Variance table for the Esxperimental Design.*

Source of Variation	Degree of freedom	Sum of squares	Mean square	F – ratio
Cassava species (A)	1	35.7075	35.7075	29.4879
Planting Season (B)	1	15.87	15.87	13.1057
Soil composition (C)	1	12.2008	12.2008	10.0756
Cassava species and Planting Season interaction (AB)	1	0.3008	0.3008	0.2484
Cassava species and Soil composition interaction (AC)	1	3.0000	3.0000	2.48
Planting Season and Soil composition interaction (BC)	1	4.2008	4.2008	3.4691
Cassava species, Planting Season and Soil composition interaction (ABC)	1	0.7500	0.7500	0.6194
Error	40	48.4368	1.21092	
Total	47	117.4967		

The critical value, F_α, is read from the F – table when α = 0.05.

$$F_{0.05\ (1,40)} = 4.08$$

At α = 0.01

$$F_{0.01\ (1,40)} = 7.23$$

Decision rule: Reject H_0 if F- ratio $> F_\alpha$

Since F- ratio $> F_\alpha$ for factors A, B and C, we reject Ho and accept H_1. ∴ The main effects A, B and C are significant. i.e Cassava species, Planting Season and Soil composition have non-zero effect on the yield of cassava whereas their interactions, Cassava species and Planting Season interaction (AB), Cassava species and Soil composition interaction (AC), Planting Season and Soil composition interaction (BC) and Cassava species, Planting Season and Soil composition interaction (ABC) have negligible effects on the yield of cassava, that is, all the two-factor interactions and the three-factor interaction do not have significant effects on cassava yield.

4. Conclusion

From the ANOVA, the main effects (the main factors) are seen to be significant i.e Cassava Species, Planting Season and Soil Composition are seen to affect the yield of cassava. This agrees with the result obtained by [13].

These factors should be given due attention. Type of cassava is important for a good yield as such, cassava specie that is highly resistant to pests and diseases at the same time possessing abundant yield should be cultivated. Early Planting season should be adhered to especially at the early on- set of rains so as to allow the crop to thrive well and mature before the on- set of sun and harsh weather.

For soil composition, we know that cassava can be grown on most soil, the best being clay and loamy soil with water and nutrient holding capacity known as organic soil.

Thus this study advices the use of sweet cassava variety in combination of improved variety at early planting season on organic soil. (i.e various factors at high level). Nigerians should be enlightened and encouraged to embrace agriculture and embrace cassava planting. Government should supply fertilizers to farmers at reduced rate and follow up the delivery so that the actual farmers are not exploited. This will help to improve our poor and over-cultivated land. With adequate information and assistance to farmers in form of loan and incentives, in addition to the factors, greater yield of cassava will be achieved with its resultant usage and importance to individuals, industry, and general economy.

Hence cassava is highly needed for domestic consumption and export through the use of sustainable agriculture.

This will service and boost industrialization for job creation, wealth creation, poverty alleviation and infrastructural consolidation and expansion, which are the basis of every economic development.

References

[1] Anderson, R. (2009). Root Crops Agronomy. ECBS/Clasedon Press, Oxford.

[2] Balogun, J. (2011): A review of Cassava in Africa. A journal of the Federal Ministry of Agriculture and Natural Resources in Nigeria. Vol. 43, No. 6. john Wiley and sons, Ghana.

[3] Ezekiel, A. A., Olawuyi, S. O., Ganiyu, M. O., Ojedokun, I. K., Adeyemo, S. A. (2012): Effects of climate change on Cassava productivity in Ilesa – East LGA, Osun State. British Journal of Arts and Social Sciences. British Journal Publishing Inc. ISSN: 2046-9578, 10 (11).

[4] Fisher, R. (1926). The arrangement o Field Experiments (PDF). Journal of the Ministry of Agriculture of Great Britain, 33: 503-515.

[5] Food and Agricultural Organization (FAO) (1991). Cassava in Africa with country case studies on Tanzania and Nigeria. http://www.fao.org/../a0154e08.htm.

[6] Food and Agricultural Organization (FAO) (2011). Cassava Processing. Retrieved from http://www.fao.Org/docrep/x5032/x5032.e06.htm.

[7] International fund of Agricultural Development (IFAD) (2013) Cassava root cure Retrieved from http://www.IFAD.org/research/cassava.

[8] Kayode, A. and Owolade, E. (2012). Factors affecting continued use of Improved Cassava Technology in Ogun State, Nigeria. Journal of Agricultural Science and Policy Research, 2 (1).

[9] Montgomery, D. C (2005): Design and Analysis of Experiment. 6th Edition, John Wiley and Sons Inc. USA. ISBN 0–471–66159–7.

[10] Onwueme, I. C. (2002). Cassava in Asia and the Pacific, Production and Utilization. CABI Publisher, Wallingford, UK. Pg 55-66.

[11] Plotkin, P. (2001). Applied Statistics for Agriculture, 4th Edition, Richard D. Irwin Inc.

[12] Sarr, Papa Saliou, Araki, Shigeru and Njukwe, Emmanuel (2013): Interactions between Cassava varieties and Soil characteristics in Crop production in Eastern Cameroun. African Study Monographs, 34 (4), 187-202.

[13] Yates, F. and Mather, K. (1963): Ronald Ayimer Fisher PDF. Biographical Memoirs of Fellows of the Royal Society of London, 9: 91-120.