International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 2 Feb 2022, pp: 161-168 www.ijaem.net ISSN: 2395-5252

Multiple Comparison and Random Effect Model on Maize Production in North West Regions of Nigeria

Gerald Ike Onwuka[1], Wasiu Babayemi[2], and Ubaidullahi Isah[3]
[1,2,3]*Faculty of Physical Science, Department of Mathematics, Statistics Unit.*
Kebbi State University of Science and Technology, Aliero. Kebbi state, Nigeria.

Submitted: 25-01-2022 Revised: 05-02-2022 Accepted: 08-02-2022

ABSTRACT: The study analyses the production of maize in Nigeria from 1980 to 2020 .The study area (Jigawa, Katsina, Kaduna, Kano, Kebbi Sokoto and Zamfara states) were particularly chosen for this study because of their prime places in maize production in Nigeria. The descriptive statistics used to analyze the results showed that majority (56.33%) of maize produced in the country comes from North West region with the mean annual production of 142823.9 metric tonnes while the lowest production (0.5%) of maize comes from Jigawa state with mean annual production being 4897.00 metric tonnes. The ANOVA analysis revealed that there is significant difference(significance= 0.0001) between the mean production of maize in the country and further analysis using the multiple comparison (pair wise tests) also showed that the mean annual production of maize differ in terms of the seven states of maize production in thecountry. Multiple comparison to detect where the difference lies using the three the comparison tests in the study (Turkey, LSD, Scheffe and Bonfferoni) showed that the mean difference between Kaduna and Katsina states was not significant but the mean difference between Kaduna and Kano, Kebbi, Sokoto, Zamfara and Jigawa were significant with mean difference of 53679.23, 39441.73, 83654.48, 62654.78 and -54272.38respectively. Further analysis using mixed effect model also revealed that from 1980 production, all the seven states with the exception of Jigawa state experienced increasing maize production trend as time increased. Kaduna and Katsina regions had the highest production over the years. Random intercept with variance-covariance assumption also showed that the different states had variations in the mean maizeproduction.

KEYWORDS: Analysis of Variance, Multiple Comparisons, Random Effects, Models, Experimental Design.

I. INTRODUCTION

Maize (Zea mays) is a major cereal and one of the most important food crops in Nigeria. Its genetic plasticity has made it the most widely cultivated crop in the country from the wet evergreen climate of the forest zone to the dry ecology of the Sudan savanna. Being photoperiod insensitive, it can be grown any time of the year, giving greater flexibility to fitting into different cropping patterns. It is one of the dominant cereal crops in the Guinea and Sudan savannas in northern Nigeria.

Over the years, maize has become an important crop, taking over acreages from traditional crops such as millet and sorghum. In 2018, about 10.2 million tons of maize was produced from 4.8 million hectares, making Nigeria the highest producer in Africa (FAO, 2018). Research efforts by breeders and agronomists have led to the production of many technologies including the breeding of high yielding varieties that are tolerant to drought, diseases, low nitrogen, and Striga infestation (Kamara etal., 2014). Despite the availability of these varieties, yields are still low in the Nigerian savannas.

Maize over time does not only serve as the source of food for man and livestock but also as a source of income and foreign exchange. Ransom et al. (2003) reported that maize dominates the agricultural sector of Terai, employing 60% of the work force and 28% of the gross domestic product (GDP). In Nigeria, it is the third most important cereal after sorghum and millet (Ojo, 2000). Faranti (2005) reported that maize farming was profitable

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 2 Feb 2022, pp: 161-168 www.ijaem.net ISSN: 2395-5252

in Northern Nigeria with gross margin and net returns of N200,637.80 and N200,141.00 respectively in the previous farming year. Grains produced in Nigeria are maize, rice, cowpea, soybean, sorghum, millet and groundnut. The greater proportion of the grains produced in Nigeria is maize because of its ability to thrive under different ecological condition. Adekunle and Nabinta (2000) reported a sustained increase in the production of maize output. Maize is the most important staple food in Nigeria and it has grown to be local 'cash crop' most especially in the southwest part of Nigeria where at least 30% of the crop land has been devoted to small scale maize production under various cropping system (Ayeni, 1991). Ogunsumi (2005) established that growing maize by small scale farmers can overcome hunger in the households and the aggregate effect could double food production in Africa. According to FAO (2018), about 4.7 million tonnes of maize were produced on the average between 1980 and 2003 in Nigeria and the contribution of maize to total grains produced in Nigeria increased from 8.7% in 1980 to about 22% in 2003. About 561397.29 hectares of Nigerian land were planted with maize, which constitutes about 61% of total cultivable land in Nigeria. Economically, the price of maize increased from N2500 in 1980 to N36000/tones in 2003. This means, the price increased more than 14times of the price of 1980. All these data emphasised the importance of maize in the diet and the economy of Nigeria.

However one of the major tasks facing Nigerian agriculture is the provision of an adequate and well-stable food supply to meet the requirements of a growing population. One of such food crops is maize. The significance of maize to the modern society is first and foremost clearly reflected in the importance of the crop in the diet of man and animals throughout the world (Onwueme and Sinha, 1991). Abubakar (2018), ranked maize as the third most important cereal after wheat and rice globally.

In Nigeria, maize is produced across the country right from the mangrove region in the south to the Sahel Savannah in the North (Edache, 1999; Tauna, 1999; Olukosi and Raphael, 1997). Maize production in Nigeria has also been on the increase both in terms of hectarage and production. A seven-fold increase in production occurred between 1984 and 1994. Similarly production increased from 6,515,000.0 to 7,019,500.0 tonnes (7.75%) between 1999 and 2003 respectively (CBN Annual Report 2013).

In recent years however, production of maize in Nigeria has been declining due to low input usage. For example, in 2000 production was 6491MT as compared to 6515MT in 1999. Rapid population growth and increased pressure on land have led to a reduction in fallow periods to below the threshold needed for sustainability (FAO, 1985; Conways, 1997).

To compound the situation, essential inputs such as fertilizer, herbicides and pesticides were often scarce and costly at a time when economic reforms have compelled reductions in farm inputs subsidies. Maize is a heavy feeder that requires sustainable amount of nutrients uptake. In the Savannah region, the enormous potentials for maize production can be realized only with the use of high levels of fertilizer, improved seeds, hectare expansion and adequate weed control. With adequate supply of these inputs and the provision of adequate storage facilities, the rapid expansion of maize could be sustained.

The primary aim of this research is to develop a suitable model for maize production in Nigeria while the objectives are 1. To identify states that produce high or low maize yield in the region over the forty (40) years. 2. To identify factors responsible to the high or low production 3. To make a comparative analysis of maize production in the (7) states of North West region using suitable statistical tool. 4. To account for the variations in the maize yield production using random effect model. 5. To compare results obtained in (2) and (3) with other regions in Nigeria.

II. LITERATURE REVIEW

In Nigeria, maize is one of the most important crops for food and cash. Its dual role of feeding a fast increasing population and supporting a potentially buoyant agricultural industrialisation is well recognised. He further noted that by 1975 there was a projected demand of over one million metric tons against a supply of 931,239 tons, the deficit was met by importation of maize. With the expansion of the economy, particularly the poultry industry, the deficit has increased even more (Fajemisin, 1978).

Tauna (1999) in his study shows that maize is an important raw material for a number of agro – based industries, which are rapidly increasing in number and scope in the country. It is therefore necessary to tackle the problem of maize production with bolder measures.However, maize production in Nigeria has been on the increase both in terms of hectarage and production (Ajala and Kling, 1999).

Abalu (1984), in his study found that small scale farmers in Nigeria constitute the most

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 2 Feb 2022, pp: 161-168 www.ijaem.net ISSN: 2395-5252

significant population of those engaged in farming production. He also identified small-scale peasant farmers as the most effective means of meeting the food needs of the country.

Onucheyo (1998) asserted that the small-scale farmers hold the key to increased food production in Nigeria. It is therefore the responsibility of research scientists, government and extension agents to improve the status of maize production in Nigeria.

III. METHODOLOGY

ANOVA (Analysis Of Variance)

Given that $x_{\ell 1}, x_{\ell 2}, \ldots x_{\ell n_\ell}$ is a random sample from an N $(\mu_\ell \sigma^2)$ population, $\ell = 1,2, \ldots, g$, and that the random samples are independent.

Since populations usually corresponds to different sets of experimental conditions and therefore, it is convenient to investigate the deviation (τ_ℓ) associated with the ith population (production yield). In this case the decomposition become

$$\mu_\ell = \mu + \tau_\ell \qquad (3.1)$$

The response (x_{ej}), distribution as N $(\mu + \tau_\ell \sigma^2)$ can be expressed in the form

$$x_{ej} = \mu + \tau_\ell + x_{ej} \qquad (3.2)$$

Where x_{ej} are independent N $(0,\sigma^2)$ random variables

To define uniquely the model parameters and their estimates, it is customary to impose the constraints.

$$\sum_{\ell}^{g} = 1 n_\ell \tau_\ell = 0 \qquad (3.3)$$

Motivated by the decomposition in (3.2), the analysis of variance is based upon an analogous decomposition of the observation.

$$\bar{x}_{ej} = \bar{x} + (\bar{x}_\ell - \bar{x}) + (x_{ej} - \bar{x}_\ell) \qquad (3.4)$$

Where is an estimate of, $\bar{\tau}_\ell = (\bar{x}_\ell -$) is an estimate of τ_ℓ and $(x_{ej} - \bar{x}_\ell)$ is an estimate of x_{ej}.

The question of equality of means is answered by whether the contribution of the treatment array is large to the residuals. The size of an array is quantified by stringing the rows of the array out into a vector and calculating it's squared length. The quantity is called the sum of squares (SS).

The above is summarize in ANOVA table by attribution of g–1 degree of freedom (df) to the total degrees of freedom is

Table1:ANOVA Table for One Way Analysis

Source of variation	Sum of squares(SS)	Degree of freedom(d.f)
Treatments	$SS_{tr} = \sum_{\ell=1}^{g} n_\ell (\bar{x}_\ell - \bar{x})^2$	$g - 1$
Residual (Error)	$SS_{res} = \sum_{\ell=1}^{g} (x_{ej} - \bar{x}_\ell)^2$	$\sum_{\ell=1}^{g} n_\ell - g$
Total	$SS_{total} = \sum_{\ell=1}^{g} \sum_{j=1}^{n_\ell} (x_{ej} - \bar{x}_\ell)^2$	$\sum_{\ell=1}^{g} n_\ell - 1$

we can calculate F- statistics

$$F = \frac{SS_{tr}/_{(g-1)}}{SS_{res}/_{\sum_{\ell=1}^{g} n_\ell - g}} \quad (3.5)$$

The Null hypothesis $H_0 : \tau_1 = \tau_g = 0$ at a level if

$$F > F_{g-1,} \sum_{\ell=1}^{g} n_\ell \text{ - gat } (a)$$

IV. RESULTS AND DISCUSSION

The research had two variables taking into consideration: the year of maize production and annual regional yield of maize produced in the seven states of the region where maize is been produced in Nigeria. The factor or treatment was the Seven (7) states where maize has been produced in Nigeria. They are Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara North West region of Nigeria. Since the introduction of free mass spraying of maize in Nigeria; maize production has increased and the task is to identify whether there is any significant difference in the mean maize production. Data collected from central bank of Nigeria from 1980 production year to 2020 production year was assessed and analyzed using SAS system. The following were the results:

Table2: Summary statistics on yield per state

	Mean	Minimum	Maximum	Std Dev
Jigawa	3896.17	872.010	18322.00	3842.14
Katsina	88551.48	44928.00	145557.00	28084.25
Kano	55440.75	28756.00	119156.00	25914.14
Kebbi	34872.25	13782.00	59713.00	14113.85
Sokoto	4897.00	906.0000	22188.00	5632.68
Kaduna	142823.85	31113.00	419710.00	119433.19
Zamfara	49109.75	25372.00	86000.00	18223.00

From table 2 above it is shown that Kaduna state has the maximum mean of maize yield production over the forty (40) years of the study. It recorded a mean of 142823.85 metric tons of maize yield production with the maximum production of 419710.00 metric tons.

The maximum yield production was realized in 2016 production year and in that year there was an increase in yield production for the other states. In was also shown that the minimum mean of maize yield production was recorded inJigawa state with value 3896.17 metric tons. Jigawa state recorded the minimum maize yield production among the seven (7) states with yield production of 872.010 metric tons. In the summary statistics, the order of maize yield production among the seven (7) states over the 40 years in regard to quantity of yield produced over the years was in the order: Kaduna, Katsina, Kano, Zamfara, Kebbi, Sokoto and Jigawa. The table also analyzed to check the standard deviation in the means of yield produced among the sevevn states. It was seen that there were a lot of variations in the Kaduna state compared to the other states.

Table 3: ANOVA Table for Yield of Maize

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	4.57E11	9.15E10	33.72	<.0001
Error	273	6.35E11	2.71E10		
Corrected Total	279	1.09E12			
		R-Square	=0.418757		

From table 3:it can be seen that the F = 33.72 with an associated p-value of 0.000l. Hence, P< 0.01, we rejected the null hypothesis that all the seven states means are equal. We concluded that at least one of the group means is significantly different from the others.

The R-Square value of 0.418757 indicated that annual yield accounts for approximately 42% of the variance in the states of production. We tested using post hoc multiple comparisons when the null hypothesis was rejected to check where the difference lies.

Table 4: ANOVA Model for Year of Production

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	39	1.4062834E11	3.60585499E10	0.76	0.8483
Error	200	9.5222975E11	4.76114876E10		
Corrected Total	239	1.0928581E12			

Table 4.4 above also showed the model for the year of maize production from 1980 to 2020 production years. It was seen that the year of production was not significant since it had a p-value of 0.8483 which is far greater than the critical value of 0.01 which was also confirmed in the R-square value of 0.12879 meaning the year of production account for only 12% of the production of maize in the seven states and hence the year of maize yield production has no or little influence on the annual yield of maize production among the seven states all other things beingequal.

Table 5: Summary of the multiple comparison tests; Comparisons significant at 0.05 level are indicated as ***

Region Comparison	Difference Between Means	95% Confidence Limits						
		LSD		Tukey		Bonferroni		
6 – 1	54272	31319	77225	20795	87749	19722	88823	***
6 – 2	87383	64430	110336	53906	120860	52832	121934	***
6 – 4	93714	70761	116667	60237	127191	59163	128265	***

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 2 Feb 2022, pp: 161-168 www.ijaem.net ISSN: 2395-5252

6 – 7	107952	84999	130905	74475	141429	73401	142502	***
6 – 5	137927	114974	160880	104450	171404	103376	172478	***
1 – 2	33111	10158	56064	-366	66588	-1440	67661	***
1 – 4	39442	16489	62395	5965	72919	4891	73992	***
1 – 7	53679	30726	76632	20202	87156	19129	88230	***
1 – 5	83654	60702	106607	50177	117132	49104	118205	***
2 – 3	50544	27591	73497	17067	84021	15993	85094	***
4 – 6	44213	21260	67166	10736	77690	9662	78763	***

Table 5 shows the result of the Post Hoc tests. Since the assumption of normality has been met, we looked at the multiple Comparisons (pairwise) tests using the three (3) tests: Least significant Difference(LSD), Bonferroni and Tukey. From the table 5 it is noticed that there is a degree of redundancy, so we are only concentrated on the unique pair Comparisons. All the three tests started with the highest mean of production (Kaduna state) and then compared with the next regions of mean of production. The table revealed that Kaduna state (mean = 142823.85) is significantly different from Kano state (mean = 88551.48) at an alpha level of 0.05 significance with a mean difference of 54272 Metric tons ofproduction.

Kaduna state is significantly different from Kano state with a mean difference of 87383 metric tons. Kaduna state is also significantly different from Kebbi, Zamfara and Sokoto states with mean difference of 93714, 107952 and 137927 metric tons respectively.

Katsina state is significantly different from Kano with a mean difference of 33111 metric tons. This means that Katsina state produces more maize than Kano state.Katsina state is also significantly differently from Zamfara, kebbi, Sokoto and Jigawa with mean differences of 39,442, 53679, 72545 and 83654 metric tons respectively.Kano state has a significant difference of 50544 metric tons from Sokoto state.Kebbi state was also significantly different from Sokoto state by a value of29975 metric tons. Zamfara state was also significantly difference from Sokoto state by a value of 44213 metric tons. Sokoto state was also significantly diffirence from Jigawa by a value of 3420 metric tons. Among the three (3) multiple comparism tests it was seen that LSD gave the best confidence interval since it had narrow or smallintervals.

MIXED EFFECT MODEL

i. Random intercept with variance-covariance assumption (autoregressive of order 1) with linear time effect.

$$y_{ij} = \beta_0 + \beta_1 t_{ij} + \beta_2 t^2{}_{ij} + b_{oi} + \varepsilon_{ij}\varepsilon_{ij} \square N(0, \delta^2)$$

$$Y = 39816 + 1112.18t_{ij} + b_{oi} + b_{1i}t_{ij}$$

$i = 1, \ldots, 7\, states$ $\quad j = 1, 2, \ldots 40\, years$

ii. Random intercept with variance-covariance assumption (compound symmetry) with linear time effect.

$$y_{ij} = \beta_0 + \beta_1 t_{ij} + b_{oi} + \varepsilon_{ij}\varepsilon_{ij} \square N(0, \delta^2)$$

$$\bar{Y} = 39816 + 1112.18t_{ij} + b_{oi} + b_{1i}t_{ij}$$

$i = 1, \ldots, 7\, states$

iii. Random intercept and slope with variance – covariance assumption (a retrogressive of order 1) with linear time effect.

$$y_{ij} = \beta_0 + \beta_1 t_{ij} + b_{oi} + b_{1i}t_{ij}\varepsilon_{ij}\varepsilon_{ij} \square N(0, \delta^2)$$

$$\bar{Y} = 58291 + 1245.88t_{ij} + b_{oi} + b_{1i}t_{ij}$$

j = 1,2,...,40 years

$i = 1, \ldots, 7\, states$

iv. Random intercept with variance–covariance assumption (autoregressive of order i) with quadratic time effect.

$$y_{ij} = \beta_0 + \beta_1 t_{ij} + b_{oi} + \varepsilon_{ij}\varepsilon_{ij} \square N(0, \delta^2)$$

$$\bar{Y} = 39816 + 1112.18t_{ij} + b_{oi} + b_{1i}t_{ij}$$

$i = 1, \ldots, 7\, states$

j = 1, 2, . . . , 40 years.

v. Random intercept with variance covariance (compound symmetry) with quadratic time effect

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 2 Feb 2022, pp: 161-168 www.ijaem.net ISSN: 2395-5252

$$y_{ij} = \beta_0 + \beta_1 t_{ij} + \beta_2 t^2{}_{ij} + b_{oi} + \varepsilon_{ij} \varepsilon_{ij} \square N(0, \delta^2)$$

$$\bar{Y} = 73629 - 3987.53 t_{ij} + 127.63 t^2{}_{ij} + b_{oi}$$

$$i = 1, ..., 7 \, states$$

$$j = 1, ..., 40 \, years$$

Table 6: AIC values for the six (6) Random effect model Assumptions

Model	**AIC**
1. Random intercept with variance – covariance assumption (AR1) with linear time effect.	5398.0
2.Random intercept with variance –covariance assumption (compound symmetry) with linear time effect	5870.7
3. Random intercept and slope with variance – covariance (AR1) with linear time effect	5400.00
4. Random intercept and slope with variance – covariance (compound symmetry) with linear time effect	5872.7
5.Random intercept with variance-covariance (AR1) with quadratic time effect	5382.7
6. Random intercept with variance-covariance (compound symmetry) with quadratic time effect	5826.0

V. CONCLUSION

The broad objective of this study was to carry out a comparative analysis of maize production in the states. The specific objectives were to describe the state that produce high and lower maize yield and determine levels of production. The descriptive statistics used to analyze the results showed that majority (56.33%) of maize produced in the region comes from Kaduna state with the mean annual production of 142823.9 metric tons while the lowest production (0.5%) of maize comes from Jigawa state with mean annual production being 4897.00 metric tons.

The study also continued by establishing contrasts between first: Kaduna state and the other states. This revealed that the mean of maize production from Kaduna state differs from the means of maize production from other six (6) states. Secondly, establishing contrasts by geographical locations between the sector of (Kaduna, Kano and Jigawa) and the sector of (Katsina, Zamfara, Sokoto and Kebbi) revealed that there is no strong evidence to conclude that the mean of maize production from the sector differ from other.

Among the assumptions that were used in the mixed effect model, the model that best fit our analysis was random intercept with variance-covariance (AR1) with quadratic time effect. The AIC value for this assumption was 5382.7 which were the smallest among the six (6) assumptions. The quadratic time (year) was also significant.

From this model as time increases the quantity of maize produced in the country also increases.

In conclusion, as time increases there exist variations in the production among the states but these variations are constant and the variations weakens with time. Since variations are constant within states but different between states the policy by policy implementer for a specific year should be different for anotheryear.

VI. RECOMMENDATION

Based on the findings of the study, the following recommendations are made:

1. Investing in the maize industry in Jigawa state to raise its productivity especially among small holder farmers should be given the highest priority to increase revenue for both the government and the individualfarmers.
2. Government should strive to make maize agrochemicals available at the right time in both Kaduna Katsina and Kano state during the maize season and at subsidized prices. This would make it possible for the farmers to have access to input anytime they want to useit.
3. Maize diseases and pest control program should be established by government to meet the recommended fungicides application per maize season to boost maize productivity in Sokoto and Jigawastates.
4. There should also be improved extension linkage to sensitize maize farmers of the need to apply agrochemicals at the right proportion, recommended frequency per production season and at the right time. This will help to bridge the gap between potential and actual yield and hence, improve the level of efficiency andproductivity.
5. There should be critical intervention by relevant stakeholders in the current production technology available to maize farmers in order to increase production to hit the above target in next coming years.

Area for further Research

It's advised that other statistical approach such as multiple regression analysis should be applied to this area and compared the result; also it's advised that further researchers should broaden to the all states of Nigeria.

REFERENCES

[1]. Adekunle, O.A. & Nabinta, R.T. (2000). Indigenous storage structure of cereals, by women farmers in Kaltungo area of Gombe state, Nigeria. Journal of Rural Economics and Development 14(1):47-54.

[2]. Amos, T. T. (2007). An analysis of productivity and technical efficiency of smallholder cocoa farmers in Nigeria. Journal of Social Science, 15(2): 127 – 133.

[3]. FAO. (2018). Food and Agriculture Organization Statistics. FAOSTAT. Available:www.fao.org/faostat, accessed 27th December 2021.

[4]. FAO (1985). Available:http://faostat3.fao.org/home/index .html/ #DOWI, Accessed 26th November 2021.

[5]. Kamara, A.Y., S.U. Ewansiha, and A. Menkir. (2014). Assessment of nitrogen uptake and utilization in drought-tolerant and Striga resistant tropical maize varieties. Archives of Agronomy and Soil Science 60: 195–207. doi:10.1080 /03650340.2013.783204

[6]. Ojo, S.O. 2000. Factors productivity in maize production in Ondo state, Nigeria. Applied Tropical Agriculture. 1:57-63

[7]. Ransom, J. K., Paudyal, K. & Adhikari, K. 2003. Adoption of improved maize variety in the hill of Nepal: Agricultural Economics 29, pp. 299-305.