**OPTIMIZING PRODUCTION OF PUMPKIN (*Cucurbita maxima* L.) VARIETIES THROUGH NUTRIENTS MANAGEMENT AND INTRA-ROW SPACING AT KANO, SUDAN SAVANNA, NIGERIA**

**ABSTRACT**

Field trials were conducted in 2017 and 2018 rainy seasons at Teaching and Research Farm of Faculty of Agriculture, Bayero University Kano (Lat: 110 58' N and Long: 8◦ 33' E, 475 m above sea level) situated in the Sudan Savanna ecological zone of Nigeria. The study evaluated the performance of two varieties of Pumpkin (*Cucurbita maxima* L.) to integrated nutrient and intra-row spacing. The objectives of the trials were to determine the effect of integrated poultry manure (PM) and inorganic fertilizer rates, and the appropriate pumpkin intra-row spacing for optimum growth and yield of pumpkin. Treatments comprised of six levels of integrated nutrients as shown below; Untreated control (N1), NPK at 120:60:60 kg (N2), PM at 15 t ha-1(N3), NPK at 30:15:15 kg + PM at 10 t ha-1 (N4), NPK at 60:30:30 kg + PM at 5 t ha-1 (N5) and NPK at 60:30:30 kg + PM at 10 t ha-1 (N6), three intra-row spacing (100, 150 and 200 cm) and two varieties (Yar-Madina and Ex–Ajiwa) of pumpkin. The experiment was laid out in Split-Split Plot Design (SSPD) replicated three times with varieties allocated to the main plot while the spacing and the integrated fertilizer were assigned to the sub and the sub-sub plots, respectively. Based on the results of this experiment application of integrated nutrient at N4, N5 and N6 had significant edge over sole inorganic fertilizer at N2 or PM at N3. The results also showed that pumpkin intra-row spaced at 200 cm recorded significantly higher growth and yield characters and the varieties are similar with respect to almost all the parameters evaluated.

**Keywsords;** Pumpkin; Integrated Nutrient; Poultry Manure; Intra-row Spacing,

**INTRODUCTION**

Pumpkin (*Cucurbita maxima* L.) is an important vegetable crop which belongs to the genus *Cucurbita* and family *Cucurbitaceae* which also include; Squash, Watermelon, Cucumber and Muskmelons (Alekar *et al*., 2015). Pumpkin is a widely cultivated crop across the world but up to date global production figures is not available. However, according to FAO (2018) global production from 1994 to 2017 was more than 27 million tones with China and India among the top producers.

The seeds and the fruits are used in various ways either by animals or human being. The seeds are used to feed animals and the fruits are eaten either raw or cooked (Stephen, 2014). Pumpkin beer is made from fermented pumpkin; it is a cherished alcohol of Indians and Pulp Kenyans (Abbaspour, 2014). It is also used for baking and pie filling or to thicken soups and compliment expensive condiments such as tomato especially at off seasons (Lawal, 2009).

In view of the importance of this vegetable in the life of people, it has become necessary to conduct research on ways of increasing its production because of the increasing demand for the crop. One of the major problems limiting crop production is soil fertility (Ogbonna, 2008). The use of integrated organic and inorganic fertilizers as sources of nutrients for vegetable production is necessary because of its importance and production sustainability (Mahajan and Gubta, 2009). Organic fertilizers apart from releasing nutrients to the soil also improve its physical properties, which enhance plant growth and development. Furthermore, organic fertilizers last longer in the soil compared to the inorganic fertilizers which are often lost rapidly by leaching in our porous soil. Frequent uses of inorganic fertilizers have resulted to some environmental pollution. Also the inorganic fertilizer has become expensive and scarce in Nigeria. Therefore, the main aim of integrated plant nutrient management is to minimize the use of chemical fertilizers without sacrificing the yield.

The rate at which field operations are carried out, weed crop competition and yield are influenced by the spatial arrangement on the field. This is because the crop competes for water, space, nutrients and solar radiation (Gani, 2014). Pumpkin is characterized by a spreading and trailing growth habit, with large and expansive leaves. In view of these, there was need to conduct a study on the proper spacing that increases the photosynthetic efficiency which gives optimum growth and yield of pumpkin. This study, therefore, investigated the effect of organic and inorganic fertilizer rates, and appropriate plant intra-row spacing for optimum growth and yield of pumpkin varieties.

**MATERIALS AND METHODS**

**Experimental Location**

Field experiment was conducted during 2017 and 2018 rainy seasons at the Teaching and Research Farm of Faculty of Agriculture, Bayero University, Kano (Lat: 110 58' N and Long: 80 33' E, 475 m above sea level) located in the Sudan Savanna of Nigeria. The meteorological information during the production period was collected for both seasons. The soils in the study area are reddish-brown described texturally as sandy and sandy loam with low organic matter content (Ogigirigi, 1993). It is characterized by natural vegetation with sparse trees usually between 5 - 9 m tall being dominated by widely spaced shrubs and grasses (Abubakar, 2002). The study area has a short period (3 – 4 months) of rainfall (645.9 mm/annum), usually falling between the months of June and September; dry season minimum and maximum temperature range from 35 - 40 0C while humidity is recorded to be constantly below 40% in the dry season (Nov./May) but can rise up to 70% during wet season (Kowal and Kassan, 1978).

**Treatments and Experimental Design**

The treatments consisted of 6 levels of integrated fertilizer as shown below:

N1 = NPK at 0:0:0 kg + PM at 0 t ha-1, N2 = NPK at 120:60:60 kg + PM at 0 t ha-1, N3 = NPK at 0:0:0 kg + PM at 15 t ha-1, N4 = NPK at 30:15:15 kg + PM at 10 t ha-1, N5 = NPK at 60:30:30 kg + PM at 5 t ha-1 and N6 = NPK at 60:30:30 kg + PM at 10 t ha-1), three levels of intra-row spacing (100, 150 and 200 cm) and two varieties (Yar-Madina and Ex–Ajiwa) of pumpkin. The experiment was laid out in Split-Split Plot Design (SSPD) with three replications. Varieties were allocated to the main plot while the intra-row spacing and the integrated nutrients were assigned to the sub and the sub-sub plots, respectively.

**Land Preparation and Crop Management**

The lands were harrowed and ridged 0.75 m apart divided into gross plots (54 m2) and net plots (18 m2) separated by alley ways of 1.5 m between the sub, sub-sub and main plots and 2.25 m between replicates. Thus gross plots consisted of 6 rows of 6 m long of pumpkin with 1.5m inter row spacing while the 2 inner rows constituted the net plot. Prior to land preparation, soil samples were collected randomly within the experimental plots at the depths of 0 – 30 cm. These were appropriately labeled, bulked, air dried and subjected to routine analysis as suggested by Blake and Hartge, (1986). Similarly, the poultry manure used in both locations was analysed.

The seeds were treated with Apron Star (20% w/w thimethoxan, 20% w/w metalaxyl-m and 2% w/w difenoconazole) at the rate 10 g per 5 kg of seed against fungicides and insecticides before planting. Three seeds per hill were sown which were later thinned to two pumpkins per stand after germination. The seeds were sown on 7th and 13th July, 2017 at Kano and Danbatta respectively.

Basal application of inorganic fertilizer N, P2O5 and K2O using NPK 15:15:15 was applied as per treatment at 2 weeks after sowing (WAS) while the remaining half dosage of N was applied at 4 WAS using urea (46% N). Similarly, poultry manure was weighed and applied as per treatment 7 days prior to sowing of seeds. The plots were weeded manually using hoes at 3 and 5 WAS, and at 7 WAS a single hand pulling was conducted. Three plants were tagged within each net plot for the purpose of data collection.

**Data Collection and Analysis**

Data were collected on the following parameters;

**Crop growth rate (CGR) per plant (g wk-1):** This refers to the increase of plant material per unit of time. The CGR was determined at 8 WAS using the formula suggested by Watson, (1958). Thus; CGR = W2 - W1= gwk-1

 t2 - t1

Where W2 and W1 represent total dry matter per plant at time t2 and t1, respectively.

**Leaf area index (LAI):** LAI is the ratio of leaf surface area per unit of land surface. This was determined in accordance with the formula of Duncan and Hasketh (1968).

LAI = A

LA Where A = Leaf area and LA = Land area

**Days to 50% flowering (Anthesis):** The number of days from sowing to when 50% of the plants within a net plot have produced flowers was recorded for each plot.

**Number of fruits per plant:** Number of fruits harvested per plant within the net plots was recorded at each harvest and the cumulative number of fruits harvested per plant computed.

**Fruit circumference (cm):** Five fruits per plot were sampled at random from the net plot. The circumferences at the middle of the fruits were measured using measuring tape and the mean computed.

**Fruit yield per hectare (t ha-1):** Harvested fruits per net plot were weighed and extrapolated to per hectare basis, thus;

Fruit yield per hectare = weight per net plot x 10,000

 net plot area

The data collected were subjected to statistical analysis of variance (ANOVA) and was analysed using GenStat 17th Edition Version. Treatment means were compared using Student-Newman-Keuls (SNK) test at 0.05 probability level.

**RESULTS AND DISCUSSION**

**Results**

**Effect of Integrated Nutrient and Intra-Row Spacing on Growth Parameters of pumpkin**

Table 1 show the effect of integrated nutrient and intra-row spacing on crop growth rate (CGR), leaf area index (LAI) and days to 50% flowering of Pumpkin varieties during 2017 and 2018 rainy seasons at Kano. In both seasons the effect of integrated nutrient was significant on the CGR of pumpkin. The result showed that in 2017 rainy season, application of integrated nutrient at N3, N4 and N6 recorded similar CGR which was significantly higher than other treatment levels. However, application of F5 resulted in significantly higher growth rate than the untreated control but comparable to N2. In 2018 application of integrated nutrient at N4 recorded higher CGR which was comparable to N2 and N6. However, the control recorded the least CGR but similar to application of N3 and N5.

The influence of intra-row spacing of pumpkin on CGR was significant in 2018. The increase in intra-row spacing of pumpkin from 100 to 150 cm had no significant effect on CGR. Further increase in spacing from 150 to 200 cm resulted in significant increase in this character. Although varietal influence was not significant with respect to the CGR of pumpkin in 2017 but there was a significant interaction of N and S in 2018.

The LAI was also significantly affected by treatments in both years. In 2017 application of nutrient at N6 recorded higher but comparable LAI to N3, N4 and N5 which were higher than the control but at par to N2. However, in 2018 nutrient application at N4 recorded higher but comparable LAI to N6 which was higher than the control but at par to N2, N3 and N5. Furthermore, the influence of intra-row spacing in both seasons showed that each increase in spacing resulted in significant decrease in LAI. There were no varietal differences recorded with respect to this parameter.

The results further showed that in the two seasons, the effect of integrated nutrient was significant on days to 50% flowering while intra-row spacing was only significant in 2017 where plots intra-row spaced at 100 cm flower late compared to those spaced at 150 and 200 cm which were comparable. Generally, application of fertilizer at N4, N5 and N6 resulted in statistically similar and longer days to 50% flowering than other treated plots. Similarly, pumpkin treated with N2 and N3 were statistically comparable but higher than the untreated control with respect to this character. There was no significant interaction and varietal influence observed with respect to the days to 50% flowering in both years.

**Table 1:** Effect of Integrated Nutrient and Intra-Row Spacing on Crop Growth Rate (CGR), Leaf Area Index (LAI) and Days to 50% Flowering of Pumpkin Varieties During 2017 and 2018 Rainy Seasons at Kano, Sudan Savanna, Nigeria.

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments |   **CGR (g w-l)** | **LAI** | **Days to 50% flowering** |
|   |   2017 | 2018 | 2017 | 2018  | 2017 | 2018 |
| **Integrated nutrient (N)** |  |  |  |  |  |
| **NPK(kg), PM (t ha-l)**  |  |  |  |  |  |
| N1 (NPK 0:0:0 + PM 0) | 37.27c | 29.17b | 1.50c | 1.43c | 47.00c | 46.01c |
| N2 (NPK 120:60:60 + PM 0) | 46.49bc | 36.23ab | 1.75b | 1.88b | 49.50b | 48.40b |
| N3 (NPK 0:0:0 + PM 15) | 88.13a | 30.30b | 1.93ab | 1.87b | 51.06b | 50.11b |
| N4 (NPK 30:15:15 + PM 10) | 83.51a | 38.34a | 2.01ab | 2.14a | 53.83a | 52.42a |
| N5 (NPK 60:30:30 + PM 5) | 55.04b | 28.75b | 1.93ab | 1.74b | 54.28a | 52.99a |
| N6 ( NPK 60:30:30 + PM 10) | 77.33a | 32.40ab | 2.18a | 1.95ab | 54.67a | 53.72a |
| SE ± | 6.780 | 2.940 | 0.099 | 0.087 | 0.902 | 0.877 |
| Probability level  |  0.001 | 0.006 | 0.001 | 0.001 | 0.001 | 0.001 |
| **Intra-row spacing (S) cm** |  |  |  |  |  |
| 100 |  69.37 | 29.14b | 2.00a | 1.97a | 50.44b | 51.23 |
| 150 |  61.37 | 31.18b | 1.89b | 1.84b | 52.87a | 52.74 |
| 200 |  68.15 | 37.29a | 1.75c | 1.70c | 53.11a | 51.89 |
| SE ± | 3.650 | 2.281 | 0.051 | 0.048 | 0.671 | 0.612 |
| Probability level |  0.120 | 0.048 | 0.003 | 0.001 | 0.047 | 0.309 |
| **Variety (V)** |  |  |  |  |  |
| Yar-Madina |  65.60 | 32.80 | 1.87 | 1.85 | 51.31 | 50.09 |
| Ex-Ajiwa |  67.00 | 32.20 | 1.89 | 1.82 | 52.15 | 51.20 |
| SE ± |  1.750 | 1.517 | 0.092 | 0.092 | 0.497 | 0.433 |
| Probability level  |  0.510 | 0.075 | 0.172 | 0.217 | 0.229 | 0.313 |
| **Interaction** |  |  |  |  |  |  |
| F x S | NS | NS | NS | NS | NS | NS |
| F x V | NS | NS | NS | NS | NS | NS |
| S x V | NS | NS | NS | NS | NS | NS |
| F x S x V | NS | NS | NS | NS | NS | NS |

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. NS = Not significant, \* = Significant at 5% and \*\* = Significant at 1%. PM = Poultry manure,

**Effect of Integrated Nutrient and Intra-Row Spacing on Yield Parameters of Pumpkins**

Table 2 shows the effect of integrated fertilizer and intra-row spacing on number of fruits per plant, fruit circumference and yield per hectare in 2017 and 2018 rainy seasons. Generally, integrated nutrient N6 recorded the highest number of fruits while the untreated control recorded the least. In both seasons, number of fruits recorded at N6 was comparable to N3 and N4 but at par with the untreated control. Similarly, in 2018 N5 was at par with other rates. Influence of variety on number of fruits was not significant at both locations and seasons but variation at intra-row spacing recorded significant difference in this character. In both seasons pumpkin spaced at 200 cm produced significantly many fruits than other treated plots which were at par.

Furthermore, the result on fruit circumference in both years showed that application of integrated nutrient resulted in significantly higher fruit circumference than the untreated control (N1). In both years application of fertilizer at N6 recorded higher fruit circumference which in 2017 was comparable to N2, N3 and N4 which were at par to F5. However, in 2018 N6 was comparable to only N4 which were at par with other treated plants.

The influence of variation in spacing was significant on fruit circumference in both years. In 2017 plants spaced at 200 cm recorded significantly broader fruits than those spaced at 100 cm while in 2018 each increase in spacing resulted in significant increase in the fruit circumference of pumpkin. There was no significant difference between treatment interactions but varietal difference was observed in both years with Ex-Ajiwa having significant edge over Yar-Madina with respect to the fruit circumference.

The result on fruit yield showed that in 2017 highest yield per hectare was observed on application of integrated fertilizer at N6 which was statistically comparable to N4 and N5 but in both years, the untreated control recorded lower yield compared to all treated rates. However, during 2018 rainy season, plants treated with nutrient at N4, N5 and N6 recorded significantly higher and similar fruit yield compared to other treated rates (N2 and N3) which were at par. The varietal influence on yield per hectare was not significant in both years however, each increase in intra-row spacing resulted in significant increase in yield per hectare. Interaction between integrated nutrient and intra-row spacing on fruit yield during 2017 rainy season was recorded.

 Table 3 shows the interaction between integrated nutrient (N) and intra-row spacing (S) on fruit yield per hectare during 2017 rainy season at Kano. The result indicated that higher yield was recorded at integrated nutrient treatment N6 at 200 cm intra-row spacing while the lower fruit yield was recorded at the untreated control at 100 cm intra-row spacing. Within the same vein, fruit yield recorded by the control at 100 cm was comparable to other spaced pumpkin evaluated.

**Discussion**

The results of this research showed that all the growth and yield characters evaluated

responded positively to integrated fertilizer rates. This indicated that the application of nutrients recorded higher growth (LAI and days to 50% flowering) and yield (fruit circumference and fruit yield) characters compared to the control treatments. The significant effect of both PM and inorganic fertilizer on the characters evaluated might be attributed to low fertility of the experimental sites which corroborated Dauda *et al*. (2008) that crops respond more to fertilizer application in soils with low nutrients content than soils with high nutrients.

The results further showed that application of integrated nutrients delays days to flowering hence it takes longer days for the fruits to develop. It had been reported that properly fertilized pumpkin requires many days for the fruit set (Lawal *et al*., 2009).

The higher growth and yield characters recorded at the nutrients combination of organic and inorganic might be as a result of some micro-nutrients being released by PM which are lacking in inorganic fertilizers (Azam *et al*., 2012) and leads to vigorous plants and consequently higher yield (Ali *et al*. 2021).

. The effect of intra-row spacing on growth and yield characters of pumpkin was significant in this study. The vegetative growth of pumpkin was significantly influenced by intra-row spacing. Higher CGR and longer days to flowering recorded by pumpkin intra-row spaced at 200 cm. Furthermore, pumpkin spaced at 200 cm recorded significantly broader fruit and higher fruit yield per hectare. El-Hameed and Elwan (2011) earlier reported that densely populated (close spacing) pumpkin competes for nutrients and solar radiation thus reducing growth and yield. It might also be due to higher competition for natural resources such as solar radiation and nutrients in the soil (Dean *et al*., 2004). It has been suggested that the space available to plants is an important determinants for growth and yield of crops (Hussain *et al*., 2014).

This study has shown that the response of varieties to most of the characters evaluated were not significant. However, there were few significant differences with Ex-Ajiwa having significant edge over Yar-Madina with respect to the fruit circumference of pumpkin. Despite the aforementioned difference, the varieties were statistically comparable with respect to all the growth and yield characters evaluated. The similarities in most of the characters evaluated indicated that the improved (Yar-Madina) variety had no significant advantage over the local (Ex-Ajiwa) variety with respect to these characters. It may also be due to adaptability of the indigenous variety to the environment Lawal *et al*., (2009); Lassa and Wali, (2015) or cross pollination as reported by Bernard *et al*. (2018) that cross pollination would take place if different varieties of pumpkin are planted on plots of less than 250 m apart.

**Table 2:** Effect of Integrated Nutrient and Intra-Row Spacing on Number of Fruits, Fruit Circumference and Fruit Yield (t ha-l) of Pumpkin Varieties During 2017 and 2018 Rainy Seasons at Kano, Sudan Savanna, Nigeria.

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments |   **Number of fruits** | **Fruit circumference (cm)** | **Fruit yield (t ha-l)** |
|   |  2017 | 2018 | 2017 | 2018  | 2017 | 2018 |
| **Integrated nutrient (N)** |  |  |  |  |  |
| **NPK(kg), PM (t ha-l)**  |  |  |  |  |  |
| N1 (NPK 0:0:0 + PM 0) | 1.44b | 1.43b | 48.47c | 41.41c | 11.49c | 7.93c |
| N2 (NPK 120:60:60 + PM 0) | 1.55b | 1.50b | 54.90ab | 48.59b | 16.11b | 12.14b |
| N3 (NPK 0:0:0 + PM 15) | 1.72ab | 1.78ab | 55.47ab | 48.42b | 15.56b | 12.27b |
| N4 (NPK 30:15:15 + PM 10) | 1.94ab | 1.78ab | 57.34ab | 51.74ab | 18.18ab | 15.01a |
| N5 (NPK 60:30:30 + PM 5) | 1.66b | 1.61ab | 53.90b | 50.29b | 17.87ab | 14.22a |
| N6 ( NPK 60:30:30 + PM 10) | 2.17a | 2.07a | 58.83a | 54.46a | 20.24a | 15.55a |
| SE ± | 0.188 | 0.199 | 1.618 | 1.562 | 1.297 | 0.729 |
| Probability level |  0.004 | 0.039 |  0.001 | 0.001 | 0.001 | 0.001 |
| **Intra-row spacing (S) cm** |  |  |  |  |  |
| 100 | 1.61b | 1.47b |  50.55b | 46.85c | 13.36c | 11.32c |
| 150 | 1.61b | 1.61b |  53.29ab | 48.50b | 16.64b | 13.99b |
| 200 | 2.03a | 2.01a |  55.62a | 51.61a | 20.22a | 15.46a |
| SE ± | 0.093 | 0.105 |  1.559 | 0.770 | 1.192 | 0.624 |
| Significance |  0.003 | 0.003 |  0.034 | 0.001 | 0.001 | 0.001 |
| **Variety (V)** |  |  |  |  |  |  |
| Yar-Madina |  1.68 | 1.68 |  50.86b | 47.48b | 16.88 | 13.42 |
| Ex-Ajiwa | 1.81 | 1.70 |  53.44a | 49.83a | 16.61 | 13.76 |
| SE ±` | 0.067 | 0.049 |  0.233 | 0.245 | 1.132 | 0.444 |
| Probability level |  0.192 | 0.742 |  0.017 | 0.019 | 0.834 | 0.527 |
| **Interaction** |  |  |  |  |  |  |
| F x S | NS | NS | NS | NS | \* | NS |
| F x V | NS | NS | NS | NS | NS | NS |
| S x V | NS | NS | NS | NS | NS | NS |
| F x S x V | NS | NS | NS | NS | NS | NS |

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. NS = Not significant, \*= Significant at 5% and \*\*= Significant at 1%. PM = Poultry manure,

**Table 3**: Interaction Between Integrated Nutrients and Intra-Row Spacing on Fruit Yield (t ha-1) of Pumpkin During 2017 Rainy Season at Kano, Nigeria.

|  |
| --- |
| Integrated nutrient (N) |
|   | N1 | N2 | N3 | N4 | N5 | N6 |
| Intra-row spacing (cm) |  |  |  |  |  |  |
| 100 | 10.35h | 11.13gh | 12.38fh | 18.95be | 11.13gh | 14.67eh |
| 150 | 14.37eh | 15.45ef | 16.57df | 18.68be | 17.47ce | 17.38ce |
| 200 | 12.13fh | 18.72be  | 20.97ad | 21.73ac | 22.43ab | 24.93a |
| SE ± |  |  | 2.430 |  |  |  |

Means within and across column followed by the same letter(s) are not significantly different at 5% level of probability using Fisher's protected least significant difference test. PM = Poultry manure, N1 = Control), N2 = NPK 120:60:60 kg ha-l, N3 = PM 15tha-1, N4 = NPK 30:15:15 kg + PM 10 t ha-1, N5 = NPK 60:30:30 kg + PM 5 t ha-1 and N6 = NPK 60:30:30 kg + PM 10 t ha-1

**CONCLUSION**

From the results of this research, it could be concluded that the application of integrated nutrient at NPK 30:15:15 kg + PM at 10 t ha-1 (N4), NPK 60:30:30 kg + PM 5 t ha-1(N5) and NPK 60:30:30 kg + PM 10 t ha-1 (N6)had significant edge over sole inorganic fertilizer at NPK 120:60:60 kg ha-l (N2) or PM at PM 15 t ha-1 (N3). The results also showed that pumpkin intra-row spaced at 200 cm recorded significantly higher growth and yield characters. Based on the findings of this experiment, it is recommended to apply nutrient at NPK 30:15:15 kg + PM at 10 t ha-1 (N4) and intra-row spacing at 200 m for optimum pumpkin production.

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