

Original Research Article

Nitrogen (N) and Phosphorus (P) Fertilizer Application on Maize (*Zea mays* L.) Growth and Yield Performance at Ado-Ekiti, Southwest Nigeria

ABSTRACT

The effects of nitrogen (N) and phosphorus (P) fertilizer application rates on the performance of maize (*Zea mays* L.) were evaluated in field trials at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti. The treatments consisted of N at 0, 30, 60, 90kg N/ha and P at 0, 15, 30, 45kg P/ha arranged in a randomized complete block design with three replicates. Data collected included plant height, leaf area, stem diameter, cob length, cob diameter, seed weight and grain yield. The result showed that plant height, number of leaves plant⁻¹, stem diameter, leaf area plant⁻¹ were significantly increased as the fertilizer rate increase. Cob length, cob diameter, weight of 100 seed and grain yield, were all significantly (P=.05) affected by the application of different rates of nitrogen and phosphorus fertilizers. The treatment combination (90kg N/ha + 30kg P/ha) gave the highest significant (P=.05) grain yield of 3420kg/ha. It was therefore concluded that for maximum yield, this combination could be recommended for maize production at this location.

Keywords: Fertilizer, growth, maize, nitrogen, phosphorus.

INTRODUCTION

Cereals are the main crops grown in a wide range of environments in various parts of the world and can provide approximately 55% of proteins, 15% of fats, 70% of glucosides and 50-55% calories needed by man [1]; [2]. Maize is an important cereal crop in Nigeria, which is a useful ingredient in the formulation of livestock feed and other food preparations both at home and in hotels [3]. It is consumed fresh or processed, depending on the users' demand to provide raw materials for industrial preparation of several by-products like corn starch, corn oil, dextrose, corn syrup, corn flakes, cosmetics, wax, alcohol and tanning materials [4]. Thus, maize production and utilization are being promoted as viable ventures to farmers because of the numerous benefits and economic importance [5].

Maize is a heavy feeder of nutrients particularly nitrogen, phosphorus and potassium which are needed for good growth and high yield of crops [6]. The low fertility status of most tropical soils is a hindrance to production of maize, which removes a lot of nutrients from the soil. Thus, without an adequate nutrient supply, maize would fail to produce high grain yield [7]. Inorganic fertilizers supply the needed nutrients, and thus enhance plant luxuriant growth, development and yield [8].

Nitrogen is a major yield determining factor in maize production [9]. It is a critical component of protein, which controls the metabolic processes, required for optimum plant growth, and so, must be available in sufficient quantity throughout the growing season of plant [10] Unfortunately, the capacity of tropical soils to supply N declines rapidly as a result of agricultural activities, hence, the inherent quantity of N derived from soil organic matter must be supplemented by other external sources.

Phosphorus is also required by maize for growth, being an essential component of nucleic acid, phosphorylated sugar, lipids and protein and so, plays a vital role in grain production. It forms high-energy phosphate bonds with adenine, guanine and uridine, which act as carriers of energy for many biological reactions. It is important for seed and fruit formation and hastens crop maturation. Phosphorus hastens the ripening of fruits and can counteract the effects of excess N applied to the soil. Root growth and development are critical for early P uptake by plants, since it is relatively unavailable and immobile in many soils [11]. Thus, maize P requirement is high at the early stages of growth [12]. Adediran and Banjoko [13] reported positive and significant responses of maize to low P rates in the derived and southern guinea savanna zones of Nigeria. Thus, in order to achieve high yields of maize, there is need for balanced N and P nutrition of maize. Several fertilizer trials, carried out in different locations in Nigeria showed that responses of to applied N and P, in term of growth and grain

yield depend on maize varieties with hybrid cultivars requiring higher fertilizer rates for optimum yield. Therefore, in view of the importance of maize as a grain crop and the role of nitrogen and phosphorus in its high productivity, this study was designed to examine the effects of varying nitrogen and phosphorus fertilizer rates on growth and yield of maize at Ado-Ekiti, Southwest Nigeria.

2. MATERIALS AND METHODS

2.1 Site description

A field trial was conducted at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria, between 2010 and 2011 cropping seasons. The location experiences a tropical climate with distinct wet and dry seasons from late March to October and a dry spell in August. Mean annual rainfall, rainy days and temperature were 1,367mm, 112 and 27⁰C, respectively. The soil of the study site has been identified as an Alfisols [14] derived from granitic rocks of the basement complex, highly leached with low to medium organic matter content. The site had been under continuous cultivation for some years to some arable crops, among which are maize, cassava, cocoyam before it was left to fallow for three years, prior to the commencement of this study..

2.2 Soil Sampling and Laboratory Analysis

Prior to planting, ten core samples randomly collected from 0-15cm soil depth, were bulked to form a composite sample, which was analysed. The samples were thoroughly mixed, dried, crushed and sieved, using a 2 mm sieve. Particle size distribution was carried out by the hydrometer method. Soil pH was determined in soil solution ratio 1:2 in 0.01M CaCl₂. Organic carbon was determined by the Walky and Black [15] method and the total N by the micro kjeldahl digestion method [16]. Available P was determined by Bray and Kurtz [17] method, while exchangeable cations were determine by extracting with neutral IM NH₄OAC in a

solution ratio of 1:10 and measured by flame photometer. Magnesium was determined with an atomic absorption spectrophotometer. Effective cation exchange capacity (ECEC) was obtained by summation method (i.e. sum of Ca, K, Mg, Na and exchangeable acidity). The determination of exchangeable acidity was by the extraction-titration method.

2.3 Treatments and Experimental Design

The treatments consisted four rates of N (0, 30, 60, 90 kg N/ha and also four rates of P (0, 15, 30, 45 kg P/ha), arranged in a randomized complete block design with three replicates. The source of N was urea (46% N) while that of P was single super phosphate (18% P_2O_5). A basal application of K (50 kg K_2O /ha) in form of muriate of potash (KCl) was carried out in all treatment plots. Three seeds of early maturing maize variety were sown per hole at 75 x 25 cm spacing in a 3x5 m treatment plot and later thinned to one seedling per stand at one week after emergence giving a population of 53,333 maize plants per hectare. Weeds were controlled manually by hand at 3 weeks after planting.

2.4 Data Collection

Data were collected on growth parameters of randomly selected maize plants in each plot. Plant height was measured from soil level up to the tip of highest leaf with a tape meter rule. Stem diameter was measured with the aid of Vernier Caliper from top middle and bottom portion of the same stem and the averages calculated. The leaf area per plant was calculated as the product of leaf length and widest middle portion of the leaf and then multiplied by a correction factor 0.75 [18]. Yield parameters included ear height, cob length, cob diameter, weight of 100 seeds and grain yield which was determined at 12.5% moisture content.

2.5 Data Analysis

All data collected on growth and yield parameters were subjected to analysis of variance (ANOVA) using statistical analysis system [19]. The differences between treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% probability.

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical properties of the Soil used.

The physical and chemical properties of the soil prior to cropping are shown in Table 1. The soil were slightly acidic loamy sand with a pH of 4.8, 3.61g kg⁻¹ organic carbon, 0.21g kg⁻¹ total N and 4.06 mg.kg⁻¹ available P for 2010 and a pH of 4.6, 2.24g kg⁻¹ organic carbon, 0.26g kg⁻¹ total N and 4.56 mg.kg⁻¹ available P for 2010 and 2011 respectively which were below the critical level values obtained for soils in Southwest Nigeria, as reported by Adeoye and Agboola [20]. The low N and P values can be explained in the light of the low organic matter content of the soil such that maize would be expected to benefit from added N and P fertilizers.

Table 1. The physical and chemical properties of soil of the study site prior to cropping

Parameters	2010	2011
Ph	4.82	4.60
Organic carbon (g kg ⁻¹)	3.41	2.24
Total nitrogen (g kg ⁻¹)	0.21	0.26
Available phosphorus (mg kg ⁻¹)	4.06	5.60
Exchangeable Bases (cmol kg ⁻¹)		
K	0.17	0.20
Ca	2.28	2.42
Mg	0.92	0.45
Na	0.43	0.60
Exch. Acidity	0.17	0.16
Effective cation exchange capacity	3.97	3.83
Particle size analysis (g kg⁻¹)		
Sand	786	813
Silt	128	132
Clay	140	54
Textural class	Loamy sand	Sandy loam

3.2 Effects of N and P fertilizer application on growth parameters of maize.

The result of this study showed that N and P individually had significant ($P=0.05$) effects on plant height. Plant height has been described as a measure of growth related to the efficiency in exploitation of environmental resources [4]. This growth character is directly linked with the productive potentials of plants in terms of fodder and grain yield [21]. The highest N dose in this study (Table 2) resulted in the tallest plant (139.8cm) which was 9.5 % increase over the control. Grazia *et al*, [22] noted that plant height can be increased with N application. Also, increase in plant height with nitrogen and phosphorus application has been reported by [23,24]. This observation is also in agreement with the findings of [5] who reported that increasing level of fertilizer application was observed to increased growth and yield of crops. Law-Ogbomo and Law-Ogbomo [25] on the performance of *Zea mays* as influenced by NPK fertilizer application reported that plant height was increased with successive increment in fertilizer application rate up to 600 kg / ha. Stem girth, leaf area and number of leaves also increased significantly ($P=0.05$), it increase with N application to maximum values of 2.92cm, 692cm² respectively. Phosphorus applications increased maize plant height, stem girth, leaf area and number of leaves but the values for 15kg and 30kgP/ha in plant height and leaf area were not different (Table 2). Plant height increased from 110.79cm in the control to 154.80cm at 45kg/ha P. The increase in leaf number was not significant with P application.

Ear height is strongly influenced by soil, water, nutrients, light situation and plant competition due to plant density whose optimization is necessary to maximize the genetic potential of maize cultivars. Ear height increased with N rates from 71.3cm in the control up till 80.9cm at 60kg N/ha and decreased thereafter. However, this maximum ear height was not significantly different from 30kg N/ha rate. P application did not significantly increase ear

height (Table 3) but the maximum value (79.3cm) obtained at 45kg P/ha was only 4.2% increase over the control.

Table 2. Effect of N and P fertilizers rate on growth parameters of maize.

Treatments	Plant height (cm)	Stem girth (cm)	Leaf area (cm ²)	Number of leaves plant ⁻¹
Nitrogen (kg/ha)				
0	126.48c	2.73b	624.63	12.83b
30	130.57b	2.60c	665.16	12.91b
60	139.27a	2.72b	748.16	14.30a
90	139.83a	2.92a	692.30	12.75b
Phosphorus (kg/ha)				
0	110.79c	2.40c	588.98c	12.58a
15	135.27b	2.65b	672.58b	12.83a
30	135.22b	2.80ab	683.54b	13.00a
45	154.80a	2.92a	754.90a	13.02a
Mean				
SE±	70.5	0.23	62.4	0.31

Means with the same letter(s) in each column for each variable are not significantly different at P<0.05 (DMRT).

3.3 Effects of N and P fertilizer application on yield component of maize.

Cob length and cob diameter increased significantly (P=0.05) with N application. The maximum cob length (17.68cm) and cob diameter (3.92cm) were recorded at 90kg N/ha. The least cob length (15.19cm) and cob diameter 3.45cm) were recorded in control plot. However, 30kg N/ha and 60kg N/ha rates were not significantly different which gave (16.20cm and 16.73cm) and (3.57 and 3.6cm) respectively for cob length and cob diameter. The significant response may probably be due to adequate supply of N which enhanced more photosynthetic activities of the plant. [26] had stated that N is an essential requirement for cob and kernel growth in maize. Also, [27] had observed significant increases in cob diameter and cob length with increase rates of nitrogen from different N sources.

Phosphorus application did not significantly affect cob length of maize even though the maximum value (17.60cm) was obtained with 45kg P/ha which is 12% increase over the

control. The highest dry cob yield (12.61t/ha) were obtained at 60kgN/ha treated plants whilst the control plant had the least (4.42t/ha). The dry cob yields obtained with the application of 30, 60 and 90kg/ha were 51, 64 and 62% increase relative to the untreated plant respectively. Also, for P, application of 45kg/ha gave the highest dry cob yield (13.4t/ha) which was 72% increase over the untreated plants.

3.4 Effects of N and P fertilizer application on 100 grain weight of maize.

The 100 grain weight is an important yield determining factor; it expresses the magnitude of seed development for deriving the grain quality and yield per hectare [28]. The effects of N and P rates on 100-seed weight showed that N application resulted in significant ($P=0.05$) increase as the rate increase and for P, it increase up to 30kg/ha after which there was reduction. This suggests a linear relationship between maize seed weight and increase rate of N and quadratic relationship with P application. [29] had reported a linear increase in the weight of 1000 grains in two varieties of maize and this was attributed to increase in nitrogen which plays very important roles in several physiological processes in plants.

3.5 Effects of N and P fertilizer application on grain yield of maize.

Grain yield is an important economical part of the plant which is available to man and livestock. It is affected by environmental factors and genetic potential of plant. Grain yield was significantly affected by both N and P application as indicated in Table 3. Sole application of N at 90kg/ha gave the highest grain yield (3102.1kg) compared to (1853.0kg) in the control. [30] had reported that the use of nitrogen gives significant increases in maize grain yield. The increase in yield from application of N was mainly due to greater plant height, stem diameter and leaf area plant^{-1} [31]. [32] had stated that the rapid growth rate may have promoted photosynthetic activities in maize plants with resultant high carbohydrate production during fruiting, based on the premise that the growth of plant is positively correlated with their yields. Also, increase in fodder yield with N and P application has also been reported by [23, 33, 24].

Phosphorus fertilizer rate at 30kg/ha produced grain yield of 3091.2kg and beyond which there was a significant reduction while the least value was recorded in the control plot.

Table 3. Effect of N and P fertilizers rate on yield and yield components of maize.

Treatments	Ear height (cm)	Cob length (cm)	Cob diameter (cm ²)	Dry cob weight (t/ha)	Weight of 100 seeds (g)	Grain yield (Kg/ha)
Nitrogen kg/ha						
0	71.26c	15.19c	3.45c	4.42d	20.45c	1853.6d
30	78.74a	16.20b	3.57b	9.10c	25.10b	2403.2c
60	80.98a	16.73b	3.60b	12.61a	26.30b	2901.7b
90	76.26ab	17.68a	3.92a	11.93b	28.71a	3102.5a
Phosphorus kg/ha						
0	75.19a	16.32b	3.01b	3.64d	19.34d	1990.7d
15	75.13a	17.30a	3.38b	8.32c	21.60c	2521.4b
30	79.17a	17.50a	4.32a	11.45b	24.21a	3091.5a
45	79.34a	17.60a	4.73a	13.40a	23.60b	2106.3c
Mean						
SE±	0.026	0.23	0.036	1.38	4.50	76.8

Means with the same letter(s) in each column for each variable are not significantly different at $P < 0.05$ (DMRT).

3.6 Interaction Effects of N x P fertilizer application on maize.

Nitrogen and phosphorus and their interaction ($p < 0.05$) effect were significant on 100 grain weight and grain yield (Table 4). Since the interaction of $N \times P$ rate was significant; mean values for each treatment combination are presented in Table 4. Means Comparison of interaction effect indicated that among all interactions, the highest grain yield (3420 kg) was recorded in the combination of 90 kg N/ha with phosphorus application of 30 kg P/ha followed by the combinations of similar nitrogen level with lower rate of 90 kgN +15 kg P_2O_5 /ha . This combination produced 21% and 34% more yield than when N or P were applied alone and more than 78% the yield obtained from control plots. Irrespective of N rate, increase levels of P application significantly increase both 100 grain weight and grain yield except for the control plots where no fertilizer was applied.

4. CONCLUSION

The applications of N and P fertilizer thus have a profound significant influence on the growth and performance of maize. From this study, it may be concluded that application of the combination of N at 90kg/ha and P at 30kg/ha producing the highest grain yield of maize in this area be regarded as the optimum for N and P and should not be applied beyond this rates for maximum yield.

Table 4. Effects of N x P interactions on grain yield of maize

Fertilizer (kg/ha)		100 grain weight (g)	Grain yield (kg/ha)
Nitrogen	Phosphorus		
0	0	20.5f	1921h
	15	20.7f	2321f
	30	21.0f	2534e
	45	21.4f	2106g
30	0	23.2e	2412ef
	15	24.3d	2607d
	30	24.8d	2532e
	45	23.6e	2710c
60	0	25.6c	2423ef
	15	26.3c	2650d
	30	26.9b	2734c
	45	25.7c	2801b
90	0	26.9b	2825b
	15	27.6b	3102b
	30	28.8a	3420a
	45	28.5a	2905bc
SE±		3.22	77.6

Means with the same letter in each column for each variable are not significantly different (P<0.05) using DMRT.

REFERENCES

1. FAO, (2007). Food and Agriculture Organisation yearbook Volume 60.
2. Normohammadi, G., Siadat, A. and Kashani, A., 2001. Agronomy (Cereal), First Edn, Ahvaz, Iran, Shahid Chamran University publication, p. 468.
3. Akintoye, H.A. and A.B. Olaniyan (2012).Yield of sweet corn in response to fertilizer sources. *Global Advanced Research Journal of Agricultural Science Vol. 1(5) pp. 110-116*
4. Alimohammadi Mehrzad, Mohsen Yousefi and Peiman Zandi (2011). Impact of Nitrogen rates on growth and yield attributes of Sweet Corn grown under different Phosphorus levels. *Journal of American Science, 7(10): 201-206*
5. Babatola, I. A. (2006). Effects of NPK 15:15:15 fertilizer on the performance and storage life of okra (*Abelmoschus esculentus*). Proceedings of the Horticultural Society of Nigeria Conference, pp. 125-128.

- 228 6. Onasanya, R. O, O. P Aiyelari, A Onasanya, S, Oikeh, F. E Nwilene and O. O Oyelakin
229 (2009) Growth and yield response of maize (zea mays) to different rates of nitrogen and
230 phosphorus fertilizers in Southern Nigeria. *World Journal of Agricultural Science* 5 (4):
231 400-407.
- 232 7. Adediran, J. A. and V. A. Banjoko (2003). Comparative effectiveness of some compost
233 fertilizer formulations for maize in Nigeria. *Nig. J. Soil Sci.*, 13:42-48.
- 234 8. Stefano P, Dris R, Rapparini F (2004). Influence of growing conditions and yield and
235 quality of cherry. II. *Fruit J. Agric. And Envi*, 2: 307-309.
- 236 9. Reddy, K.J., 2006. Nutrient stress. In: *Physiology and Molecular Biology of Stress*
237 *Tolerance in Plants*, Madhava Rao KV, Raghavendra A S. and Janardhan Reddy K, (Eds.).
238 Springer, pp. 187-217.
- 239 10. Lombin G (1983). Evaluating the micronutrient fertility of Nigeria's semiarid savanna
240 soils. 2. Zinc. *Soil Sci.*, 136: 42-47.
- 241 11. Mollier A, Pellerin S. 1999. Maize root system growth and development as influenced by
242 phosphorus deficiency. *Journal of Experimental Botany* 50, 487-497.
- 243 12. Ahn, P.M. (1993). Tropical soils & fertilizer use. TAP, Malaysia, pp.128-130 & 163-171.
- 244 13. Adediran, J.A. and V.A. Banjoko, (1995). Response of Maize to Nitrogen, Phosphorus and
245 Potassium fertilizers in the savanna zone of Nigeria. *Commun. Soil Sci. Plant Anal.*,
246 26:593-606.
- 247 14. Fasina A. S, Aruleba, J. O. Omolayo, F. O, Omotoso, S. O, Shittu, O. S. and Okusami, T.
248 A. (2005). Properties and classification of five soils formed on granitic parent material in
249 Ado- Ekiti, Southwestern Nigeria, *Nigerian Journal of Soil Science* 15 (2): 21 – 29.
- 250 15. Walkley A, Black I. A (1934). An examination of the Degtjareff method for determining
251 soil organic matter and a proposed modification of the chronic acid titration method.
252 *Soil Science* 37: 29-39.
- 253 16. Bremner J.M, Mulvaney C. S (1982). Nutrient Total In: *Methods of soil*
254 *analysis* 2nd ed. A. L. Page et al., (Eds) Pp. 595-624 ASA, SSA Medison Winsconsin.
- 255 17. Bray, R.H. and L.T. Kurtz, 1945. Determination of total organic and available forms of
256 phosphorus in soils. *Soil Sci.*, 59: 39-45.
- 257 18. Rajeshwari, R. S., N. S, Hebsur, H. M Pradeep and T. D Bharramagoudar, (2007). Effect
258 of integrated nutrient management on growth and yield of maize. *Karnataka J. Agric. Sci.*,
259 20:399-400
- 260 19. SAS, Institute Lac, (2006). *SAS/STAT User's Guide: Version 6, Fourth Edition*, vol 2,
261 Carry, N C., SAS institute Inc, 2006. 846pp.
- 262 20. Adeoye G.O and Agboola A. A (1985). Critical level of soil plant available N, P, K, Zn,
263 Mg, Cu and Mn on Maize leaf content in Sedimentary Soil of Southwestern Nigeria. *Fert.*
264 *Res.*, 6: 60-71.
- 265 21. Saeed, I. M, Abbasi R, Kazim M (2001). Response of maize (Zea mays) to nitrogen and
266 phosphorus fertilization under agro-climatic condition of Rawalokol, Azad Jammu and
267 Kaslim and Kashmir, Pak. *J. Biological Sci*, 4: 949-952.
- 268 22. Grazia, J.de., Tittonell, P.A., Germinara, D. and Chiesa, A., (2003). Short communication:
269 Phosphorus and nitrogen fertilization in sweet corn (*Zea mays* L. var.saccharata Bailey).
270 *Span J Agric Res.*, 1(2), 103-107.
- 271 23. Ayub, M., A. Tanveer, R. Ahmad and M. Tariq, 1997. Fodder yield and quality of two
272 maize varieties at different nitrogen levels. *Andhra Agric. J.*, 47: 7-11.

24. Cheema, H.N.A, (2000). Yield and quality response of maize (*Zea mays* L.) fodder grown on different levels of phosphorus and seedling densities. M. Sc. Thesis, Department Agronomy University Agriculture Faisalabad Pakistan.
25. Law-Ogbomo, K. E and J. E.Law-Ogbomo (2009). The Performance of *Zea mays* as Influenced by NPK Fertilizer Application. *Notulae Scientia Biologicae. 1 (1):59-62*.
26. Crawford, T.W., V.V. Rending and F.E. Broadbent.1982. Sources; fluxes and sinks of nitrogen during early reproductive growth of maize (*Zea mays* L.). *Plant Physiology*, 70:1654-1660.
27. Akhtar, M. and J.A. Silva. (1999). Agronomic traits and productivity of sweet corn affected by nitrogen and intercropping. *Pak. J. Soil Sci.*, 16:49-52.
28. Haseeb-Ur-Rehman, Asghar Ali, Muhammad Waseem Asif Tanveer, Muhammad Tahir, Muhammad Ather Nadeen and Muhammad Shahid Ibni Zamir (2010). Impact of N application on growth and yield of maize (*Zea mays* L.) grown alone and in combination with cowpea (*vigna Unguiculata* L.). *American-Eurasian Journal of Agric. And Environmental Science*. 7(1):43-47.
29. Ma, B. L., L. M. Dwyer and E. G. Gregorich (2004). Soil nitrogen amendment effects on nitrogen uptake and grain yield of maize. *Agron. J.*, 9: 650– 656.
30. Falhi, G. H., (1999). Crop growth and nutrient. *Jahade Daneshgahi Publications*, p. 372.
31. Husnain, M.A., 2001. Effects of nitrogen application on fodder yield and quality of sorghum harvested at different times. M.Sc. Thesis, University Agriculture Faisalabad Pakistan.
32. Nyende, P; Tenywa, J.O and Kidoido, M. (2001). Weed profiles and management assessment for increase finger millet production in Uganda. *African Crop Science Journal*, 9 (3): 507-516.
33. Ali, S., 2000. Effects of different levels of nitrogen and seedling rates on growth, yield and quality of sorghum fodder. M.Sc. Thesis, Department of Agronomy University Agriculture Faisalabad, Pakistan.