

The Performance of *Zea mays* as Influenced by NPK Fertilizer Application

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Abstract

Field trials were made to estimate the effect of NPK 15:15:15 fertilizer on the growth and yield of maize were conducted over a two year period. NPK fertilizer applications significantly increase plant height, stem girth, number of leaves, leaf area, leaf area index, dry matter accumulation and yield. The optimum level of NPK 15:15:15 fertilizer for successful production of maize grains was 400 (60 kg N + 27.16 kg P + 49.80 kg K) kg / ha compound fertilizer based on the fact that it had the greatest dry cob yield (12.44 t / ha), grain yield (7.95 t / ha), relative grain yield (2.26) and 100-seeds weight (11.62 g).

Keywords: Growth, NPK fertilizer, plant height, stem girth and yield

Introduction

Wheat, rice and maize are the most important cereal crops in the world but maize is the most popular due to its high yielding, easy of processing, readily digested and costs less than other cereals (Jaliya *et al.*, 2008). Maize as a major source of carbohydrate is used as food, in livestock diet, in the textile industry and also in the pharmaceutical industry.

Maize has immense potential in the tropics and yield of up to 7.5 t / ha can be obtained if the crop is properly managed. Unfortunately, yields are still generally below 5 t / ha (FAO, 2007) and this had cause inadequacy of maize for its numerous usages. Yield differences between temperate and tropical areas have been attributed to low nutrient status of tropical soils especially nitrogen, phosphorus and potassium resulting from the practice of slash and burn farming system associated with bush fallow and with excessive leaching of the soil nutrients. This system is presently unsustainable due to high population pressure and other human activities which have resulted in reduced fallow period (Steiner, 1991).

The low fertility status of most tropical soils hindered maize production as maize has a strong exhausting effect on the soil. It was generally observed that maize fail to produce good grain in plots without adequate nutrients (Adediran and Banjoko, 2003). Inorganic fertilizer exert strong influence on plant growth, development and yield (Stefano *et al.*, 2004). The availability of sufficient growth nutrients from inorganic fertilizers lead to improved cell activities, enhanced cellk multiplication and enlargement and luxuriant growth (Fashina *et al.*, 2002). Luxuriant growth resulting from fertilizer application leads to larger dry matter production (Obi *et al.*, 2005) owing better utilization of solar radiation and more nutrient (Saeed *et al.*, 2001).

The use of inorganic fertilizers on crops increased yield as Adediran and Banjoko (2003) observed that there was substantial depletion of nutrients with the yields where no NPK fertilizer was applied. This position was reported by Uyovbisere *et al* (2001) who reported that there was substantial depletion of nutrients when no NPK fertilizer was applied and nitrates and available phosphorus were substantially reduced with cropping in humid zone of South-western Nigeria. Conflicting results about the benefits and adverse effects of fertilizer have however been found in literatures. Ayoola and Adeniyen (2006) had reported that the use of inorganic fertilizer has not been helpful under intensive agriculture because it is often associated with reduced yield, nutrient imbalance, leaching and pollution of groundwater (Sridhar and Adeoye, 2003). This is not unexpected due to lack of uniformity over a wide range of ecological conditions, especially soil type, under which maize is grown. This could also be likely due to differences in the pre-cropping nutrient status and partly due to difficulty in interpreting the results of soil analysis. Plant analysis is a useful supplement to soil analysis where the soil analysis presents difficulties in assessing available nutrients.

In view of inconsistency in the fertilizer and increasing cost of production associated with its usage, field trials were conducted in 2005 and 2006 to determine the appropriate NPK 15:15:15 rate that will produce the optimum yield.

Materials and Methods

Field trials were carried at Teaching and Research Farms, Benson Idahosa University, Benin City (5°04' N and 5°45' E) between March and June in 2005 and 2006. The site is a typical humid forest environment with loam sand characterized with low nutrient reserve and derives

from coastal plain sand classified as ultisols. The site had been cultivated in previous years; there was no record of fertilizer application.

Soil was well drained, of gentle slope. The composite soil sample (0-30 cm depth) taken from the site and analysed for routine soil physical and chemical properties using standard laboratory procedures outlined by Mylavapus and Kennelley (2002). The routine analysis showed that it had pH (H₂O) 5.99, total nitrogen (%) 0.16, organic carbon (%) 1.80, available phosphorus (mg / kg) 4.19, exchangeable K (cmol / kg) 0.06, exchangeable Ca (cmol / kg) 0.75, exchangeable Mg (cmol / kg) 0.12, exchangeable Na (cmol / kg) 0.10, clay (%) 4.00, silt (%) 14.00 and sand (%) 82.00.

The trials were laid down in a randomized complete block design. The treatments included four NPK fertilizer rates viz. 0 (0 kg + 0 kg P + 0 kg K), 200 (30 kg + 13.58 kg P + 24.90 kg K), 400 (60 kg + 27.16 kg P + 49.80 kg K) and 600 (90 kg + 40.70 kg P + 74.70 kg K) kg / ha of compound fertilizer.

Three seeds of maize variety DMSRW (Downy Mildew Streak Resistant White) sourced from IITA (International Institute for Tropical Agriculture), Ibadan were sowed on the field at a spacing of 75 x 25 cm in March in both years. The resulting seedlings were thin to one per stand, two weeks after planting (WAT). Weeding commenced at 2 WAT and subsequently weeding was carried out as at when due. Recommended practices for disease and insect pest control were followed.

The application of fertilizer of NPK 15:15:15 fertilizer was carried out at two equal splits at 2 and 4 WAT using ring method. Eight plants were randomly selected per plot for determination of growth and yield parameters. The growth parameters assessed included plant height (cm), stem girth (cm), number of leaves, leaf area per plant and leaf area index (LAI) and total dry matter (t ha⁻¹). At harvest, the cobs were harvested fresh and weighed. The cobs were dried and re-weighed. The grain on the cobs were shelled and equally weighed. Total dry matter (TDM) was determined by oven dried in brown envelope at 75°C until constant weight was attained (ISTA, 1993).

Analysis of variance was carried out on each of the observations recorded for each year of study, followed by combined analysis over two years using SAS-GLM procedure (SAS Institute, 2004). The Least Significant Difference (LSD P < 0.05) test was used for detecting differences between means.

Results and discussion

The effect of NPK fertilizer application on plant height and stem girth is showed in Tab. 1. NPK fertilizer application significantly affected plant height and stem girth (Tab. 1). Plant height was increased with successive increment in fertilizer application rate up to 600 kg / ha. Maize plants were tallest in those plants that received 600

Tab. 1. Effects of NPK 15:15:15 fertilizer on the height and stem girth of maize (*Zea mays*)

Fertilizer rate (kg ha ⁻¹)	Plant height (cm)			Stem girth (cm)		
	4 WAP	6 WAP	8 WAP	4 WAP	6 WAP	8 WAP
0	35.19	119.18	148.20	6.10	6.25	6.34
200	38.44	128.40	158.30	6.30	6.38	6.45
400	45.24	135.55	161.15	6.96	6.60	7.90
600	49.35	138.25	168.35	6.75	7.40	7.67
Mean	42.06	130.35	158.98	6.53	6.66	7.10
LSD (P<0.05)	2.63	6.13	9.25	0.48	0.68	0.79

kg NPK ha⁻¹ than those that received lower rate of application during all the sampling periods (Tab. 1). This observation is in agreement with the findings of Babatola et al (2002) who reported that increasing level of fertilizer application was observed to increased growth and yield of crops. The significant increase in plant height reflects the effect of fertilizer nutrients, N, P and K. The untreated plants were almost stunted in growth as they had to rely on the native soil fertility which, from the result of chemical analysis was deficient in these nutrients. The height of plant is an important growth character directly linked with the productive potential of plants in terms of grains. An optimum plant height is claimed to be positively correlated with productivity of plant (Saeed *et al.*, 2001).

NPK fertilizer application increased the stem girth (Tab. 1). The maize plants that received 600 kg / ha had the greatest stem girth irrespective of the sampling period. Uptake and utilization of applied fertilizer in both years witness better responses in terms of stem girth compared with the non-fertilized plants. Increase in stem girth is a reflection of retention of appreciable amount of assimilates in the stem for leaf production.

The number of leaves per plant during the three sampling periods was dependent on fertilizer rate as it increased with increase in fertilizer rate at 4, 6 and 8 WAP (Tab. 2). Plants fertilized with 600 kg NPK\ha had the highest number of leaves in all sampling periods in both years which were 100%, 62% and 277% increase over the unfertilized plants at 4, 6 and 8 WAP, respectively. The number of leaves was significantly correlated with fertilizer rate at 6 WAP (r = 0.72) and at 8 WAP (r = 0.60). These findings are in lined with the view of Stefano *et al* (2001) who reported that fertilizer application resulted in luxuriant growth with excessive leaves. Higher number of leaves on fertilizer treated plants contributes to a better canopy and suppression of weeds.

There was significant difference among treatment means in response to leaf area per plant (LA) at the three sampling periods (4, 6 and 8 WAP) (Tab. 2) in both cropping seasons. Plants fertilized with 600 kg NPK ha⁻¹ had the greatest LA at 4, 6 and 8 WAP (Tab. 2). At all sampling periods, the LA was significantly correlated with the

Tab. 2. Effects of NPK 15:15:15 fertilizer application on the growth of maize (*Zea mays*)

Fertilizer rate (kg ha ⁻¹)	Number of leaves			Leaf area/ plant (cm ²)			Leaf area index		
	Weeks after planting			Weeks after planting			Weeks after planting		
	4	6	8	4	6	8	4	6	8
0	2.50	5.25	8.50	5.20	12.97	46.75	0.003	0.007	0.025
200	2.50	7.50	14.20	11.40	57.90	352.16	0.006	0.031	0.188
400	5.00	8.25	25.00	50.35	161.87	1225.00	0.027	0.086	0.653
600	5.00	8.50	32.10	62.15	171.28	1600.00	0.033	0.091	0.853
Mean	3.75	7.38	19.95	32.28	101.01	805.98	0.017	0.054	0.430
LSD (P<0.05)	ns	ns	5.231	3.215	5.526	21.635	0.0021	0.0031	0.0143

number of leaves with $r = 0.66$ and 0.57 at 6 and 8 WAP, respectively.

The unfertilized plants had lower LA due to less number of leaves resulting from premature leaf fall and early vine senescence (Okwuowulu, 1995). The higher LAI associated with the fertilized plants was probably due to higher number of leaves.

The leaf index increased as fertilizer rate increased with correlation coefficient of 0.66 at 6 WAP in both years. Plants fertilizer with 600kg/ha had the greatest LAI which was 1200% higher than the unfertilized plants. This pattern of distribution was maintained at 8 WAP. There was significant correlation between number of leaves and LAI ($r = 0.68$). This is a pointer to the fact that changes in numbers of leaves are bound to alter the overall performance of the plant as the leaf serves as the photosynthetic organ of the plant.

TDM was higher in plants that received 600kg NPK/ha than those that received 0 and 400kg ha^{-1} (Tab. 3). The dry matter production at 600kg ha^{-1} was higher in TDM than at 400 , 200 and 0kg ha^{-1} by 11.76% , 19.49% and 115% , respectively. This trend has earlier been reported by Olufolaji *et al.* (2002) in a comparative evaluation on soil and foliar applied fertilizer on growth and yield of *Celocia argentea* reported increase in TDM. This may be attributed to NPK being part of the essential nutrients required for the production of the meristematic and physiological activities such as leaves, roots, shoots, dry matter production, etc leading to an efficient translocation of water and nutrients, interception of solar radiation and carbon dioxide. This activities promote greater photosynthetic activi-

ties of adequate assimilates for subsequent translocation to various sinks and hence the production of higher TDM (Jaliya *et al.*, 2008).

The effect of NPK fertilizer application on fresh cob yield followed the same trend as in TDM (Tab. 3). As observed in TDM, NPK increased significantly fresh cob as the rate increases. The untreated plants produced the least value. Fresh cob yield was significantly higher in plants treated with 600kg ha^{-1} than those treated with 400 , 200 and 0kg ha^{-1} by 24.46% , 53.35% and 282.5% , respectively. The highest (12.44t/ha) dry yields were obtained at 400kg ha^{-1} treated plants, whilst the untreated plants had the least (4.07t ha^{-1}). The dry cob yields obtained with the application of 600 , 400 and 200kg/ha were 191.15% , 205.65% and 160.20% greater than the untreated control, respectively.

The grain yields were significantly affected by NPK fertilizer application at all levels. The pattern of response was very clear, with lowest grain yield obtained from plants treated without fertilizer treatment, whilst the highest grain yields were obtained at 400kg/ha (Tab. 3). These findings are in lined with the view of Adediran and Banjoko (2003) but contrary to that of Ayoola and Adeniyani (2006) who reported that the use of inorganic fertilizer is associated with reduced crop yield. Based on pooled analysis between the two years, there was no significant difference on yield. The results of this trial showed that NPK application increased fresh grain yield. From this study, the average yield varied from 3.52 to 7.95t ha^{-1} between 0 and 400kg ha^{-1} suggests that the 400kg ha^{-1} may be regarded as the optimum level of the nutrient elements while the

Tab. 3. Total dry matter and yield attributes as affected by different levels NPK 15:15:15 fertilizer application on maize (*Zea mays*)

Fertilizer rate (kg ha ⁻¹)	TDM (t ha ⁻¹)	Fresh cob yield (t ha ⁻¹)	Dry cob yield (t ha ⁻¹)	Grain yield (t ha ⁻¹)	Relative grain yield	Weight of 100 ^{seeds} (g)
0	4.82	5.32	4.07	3.52	1.00	9.43
200	8.67	13.27	10.59	7.01	1.99	10.56
400	9.27	16.35	12.44	7.95	2.26	11.62
600	10.36	20.35	11.85	5.85	1.66	10.75
Mean	8.28	13.82	9.74	6.08	1.73	10.59
LSD (P<0.05)	1.30	2.16	0.56	1.22	0.56	0.58

600 kg ha⁻¹ may be said to be toxic level, since it retarded growth (dry matter accumulation) and grain yield. Such excessive inorganic fertilizer application can induce nutrient imbalance, acidity, pollution of ground water resulting from leaching and reduce palatability (Sridher and Adeoye, 2003). This could be as a result of interference in the absorption and utilization of other elements that would have improved yield (Uguru, 1996). The plants without fertilizer treatment had the lowest yield which could have been partly due to deficiency of nutrients as revealed by low nutrient status of the soil. The difference in the optimum levels of NPK fertilizer rate in both years may be attributed to differences in the nutrient reserve in the soils.

The effect of NPK fertilizer on relative grain yield and 100-seeds weight followed the same trend as observed in grain yield (Tab. 3). NPK fertilizer treated plants produced significantly higher relative grains and 100-seeds weight than the untreated plants at levels of application. The least values for the two parameters were produced by the untreated plants (1.00 for relative grain yield and 9.43g for the weight of 100-seed. The relative grain yields were greatest (2.26) for plants treated with 400 kg ha⁻¹. This is a reflection of the fact that there is positive relationship between grain yield improvement and economic viability in maize production. For the weight of 100-seeds, 400 kg / ha treated plants had the greatest (11.62 g). This implies that NPK fertilizer application has significant effect on the seed size and then and then made it bigger as the level of application increases.

This investigation revealed that NPK 15:15:15 fertilizer rates have a profound effect on the overall performance of maize. Application of NPK fertilizer at the different levels used in this study had significantly effect on the growth and yield of maize. Fertilizer application level of 400 (60 kg N + 27.16 kg P + 49.80 kg K) kg / ha is effective for the optimum growth and yield of maize.

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