EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM APPLICATION ON AGRONOMIC PARAMETERS, YIELD AND UPTAKE IN MAIZE: A GREEN HOUSE EXPERIMENT

Abstract

It is important to explore varying supply of nitrogen, phosphorus and potassium for sustainable production of maize in screen house environment. This necessitated the study to determine the effect of these nutrients on growth, dry matter yield and nutrient uptake in maize. The study involved three pot experiments laid in a completely randomized design with three replications carried out concurrently in the screen house at Federal University of Agriculture, Abeokuta, Nigeria. Treatments included (0, 30, 60, 90, 120, 150, 180 kg N ha^{-1}), (0, 30, 60, 90, 120, 150, 180 kg P ha^{-1}), (0, 30, 60, 90, 120, 150, 180 kg K ha^{-1}) for the first, second and third experiments respectively. Maize seeds were sown in pots and treatments were applied two weeks after planting. Data were collected fortnightly on maize height, stem girth, leaf number, leaf length, breadth and area for 8 weeks, dry matter yield and uptake were determined at the end of the experiments. The result showed that application of N at a rate of 120 kg ha^{-1} significantly increased height (66 %), leaf number (96 %) and dry matter yield of maize whereas leaf area and P conc. (157 %) significantly increased with a rate of 150 kg N ha^{-1}. Significant increase in height (26 %), stem girth, leaf area, leaf number (54 %), shoot dry weight and N concentration was observed with 60 kg P ha^{-1}. However applying K at 180 kg ha^{-1} increased height (16 %), stem girth (61 %), leaf number, leaf area, length (10 %), breadth, concentration and uptake of N and K. It is concluded that maize growth, dry matter yield and uptake is greatly influenced by nitrogen, phosphorus and potassium application. 120 to 150 kg N ha^{-1}, 60 kg P ha^{-1} and 180 kg K ha^{-1} should be adopted.

Keywords: Agronomic parameters, sustainable, nutrient concentration and uptake, Fertilizer, dry matter

1. INTRODUCTION

The demand for food is increasing because of increasing population; the problem of food scarcity is increasing. Maize (*Zea mays L.*) as an important crop in Nigeria is a better option as it is a high yielding crop that provides food and forage. It is Nigeria's third most important cereal crop after sorghum and millet [1]. However, a major reason for low yields in maize production is the poor organic matter and available nutrients of most soils in the humid tropics since they are continuously cropped leading to reduction in productivity and sustainability [2]. Longer cultivation has further depleted the soil organic-matter content and fertility [3]. This phenomenon is amidst other constraints like drought, poor crop management, diseases and pest. Efforts aimed at obtaining high yield of maize would necessitate the augmentation of the nutrient status of the soil to meet the crop's requirements for optimum productivity and maintain soil fertility [4]. Increasing the nutrient status of the soil may be achieved by boosting the soil nutrient content with the use of inorganic fertilizers such as NPK.

The maize crop requires an adequate supply of nutrients particularly nitrogen, phosphorus and potassium for optimum growth and yield [4]. Nitrogen, phosphorus, potassium, and other nutrient elements play great physiological importance in formation of chlorophyll, nucleotides, phosphotides and alkaloid as well as in many enzymes, hormones and vitamins for optimum grain yield [4]. Nitrogen deficiency could exert a particularly marked effect on maize crop yield as the plant would remain small and rapidly turn yellow if sufficient nitrogen is not available for the construction of protein and chlorophyll [6].

Phosphorus is also required by maize for growth, being an essential component of nucleic acid, phosphorylated sugar, lipids and protein plays a vital role in grain production [7]. It is important because it forms phosphate bonds with adenine, guanine and uridine, which act as carriers for biological process. In plants, phosphorus is a common component of organic compounds. It was noticed [8] that nitrogen and phosphorus application increased the green fodder yield of maize while Phosphorus application enhanced the crop to reach 50% tasseling and silking earlier [9].

Potassium is one of the important macronutrients next to N and P. This nutrient is one of the essential nutrients whose deficiency affects the crop growth and production. Potassium is an activator of many plant enzymes. Potassium has important functions in plant water relations where it regulates ionic balances within cells. Potassium regulates the leaf stomata opening and subsequently the rate of transpiration and gas exchange. Plants also need K for the formation of sugars and starches, for the synthesis of proteins, and for cell division. It increases the oil content of pistachios and contributes to its cold hardiness [10]. Under K deficient conditions photosynthesis is depressed as a consequence of sucrose accumulation in the leaves and its effect on gene expression [11]. Maize is the most important cereal in the world after wheat, its nutritional values cannot be over emphasized and the rate at which it is being consumed and used industrially is increasing daily thereby making its production throughout the year a major concern. It is therefore pertinent to explore varying supply of nutrients particularly nitrogen, phosphorus and potassium needed for good growth and high yield of maize for sustainable production in screen house environment. This necessitated the study to determine the effect of nitrogen, phosphorus and potassium on growth, dry matter yield and nutrient uptake in maize.

2. MATERIALS AND METHODS

2.1 SOIL COLLECTION AND SOIL ANALYSIS

The top soil (0-20 cm) was collected from the University farms, Federal university of Agriculture Abeokuta, Ogun state. The soil was air dried, and sieved with 2mm mesh sieve. Sub sample from the soil was collected and analyzed for the following properties: Soil pH was estimated in 1:2 (soil : water) using glass electrode pH meter. Particle size was determined according to hydrometer method. Soil was digested and total nitrogen content was analyzed using kjedahl method. Available phosphorus was extracted with Bray-1 and P was determined according to [12]. Exchangeable cations were extracted with 1N ammonium acetate, Na and K in the extract were determined by flame photometry, and Ca and Mg were determined by atomic absorption spectrophotometer.

2.2 EXPERIMENTAL DESIGN

The experiments were laid out in completely randomized design with three replications. Treatments for experiment 1 included varying levels of nitrogen (0, 30, 60, 90, 120, 150 and 180 kg K ha^{-1}) and constant levels of potassium and phosphorus at 90 kg N ha^{-1} and 15 kg P ha^{-1} respectively. Treatments for experiment 2 included varying levels of phosphorus (0, 30, 60, 90, 120, 150 and 180 kg K ha^{-1}) and constant levels of nitrogen and potassium at 90 kg N ha^{-1} and 15 kg P ha^{-1} respectively.

Treatments for experiment 3 were varying levels of potassium (0, 30, 60, 90, 120, 150 and 180 kg K ha^{-1}) and constant levels of nitrogen and phosphorus at 90 kg N ha^{-1} and 15 kg P ha^{-1} respectively.

2.3 **SCREEN HOUSE EXPERIMENT**

Five kilogram's of soil was dispensed into each experimental pot with each treatment applied separately into the pot. The soil in the pots were watered and maize seeds (Swam 1) were sown at 3 seeds per pot. The plants were thinned to one plant per pot after two weeks. The plants were watered in the screen house for eight weeks i.e. at tassel stage. Agronomic data including plant height, stem girth, leaf length, leaf breadth, number of leaves were taken forth nightly. The leaf area was also measured. Maize plants were harvested at the end of the 8th week. The root and shoot were separated, cleaned, placed in to neatly labeled envelopes and dried to constant weight. The oven dried shoots were milled and analyzed for potassium and nitrogen concentration. Similar procedure carried out in experiment 1 was done simultaneously in experiments two and three only that nutrient analyzed were different. In experiment 2, oven dried shoot were milled and analyzed for phosphorus and nitrogen while milled shoots from experiment 3 were analyzed for potassium and nitrogen content.

2.4 STATISTICAL ANALYSIS

Data collected were analyzed for their variance by using the software package SAS (1999). The significant treatments were separated using LSD at 5 % level of probability.

3. RESULTS

3.1 SOIL CHARACTERISTICS

The soil had a pH of 6.20, organic carbon, total nitrogen and available P of 0.65 % and 0.04 % and 3.01$mgkg^{-1}$ respectively. It contained 4.41 $cmolkg^{-1}$, 1.16 $cmolkg^{-1}$, 0.64 $cmolkg^{-1}$ and 0.24 $cmolkg^{-1}$ of calcium, magnesium, sodium and potassium respectively (Table 1).

3.2 EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM APPLICATION ON PLANT HEIGHT AND STEM GIRTH OF MAIZE

Table 2 shows that application of nitrogen did not lead to significant increase in plant height at 2 and 6 WAP (weeks after planting) though the tallest plants were recorded with nitrogen rate at 150 kg ha^{-1} and 120 kg ha^{-1}. At 4 WAP, maize height was significant with a highest increase of 66 % above the control with 150kg N ha^{-1}. There was no difference among the control, 30 kg and 180 kg N at 4 WAP. Application of 120 kg N ha^{-1} led to increase in maize height at 8 WAP in comparison to the control and other rates. 120 kg N ha^{-1} significantly increased maize height by 134 % when compared to 30 kg N. Maize stem girth was narrowest with N rate of 30 kg ha^{-1}. There was no difference in control, 30 kg N ha^{-1} and 180kg N ha^{-1} in terms of stem girth at 2 WAP. However, at 4 WAP stem girth was wider with 150kg N ha^{-1} in comparison to the control although significant differences were not observed with other rates. Stem girth was similar for all the treatments at 6 and 8 WAP despite that the widest girth at 6 and 8WAP were recorded with 90kg N ha^{-1} and 120 kg N ha^{-1}.

Application of phosphorus at rates except 30 kg ha^{-1} and 120 kg ha^{-1} increased maize height at 2 WAP even though increases were not significant with respect to the control. Similar responses were reported at 4 WAP. However, 30 kg P ha^{-1}, 60 kg P ha^{-1} and 120 kg P ha^{-1} had similar effect on maize height despite that a highest significant increase of 26 % was recorded with 60 kg P ha^{-1} relative to 30 kg P ha^{-1}. The height of maize was similar for the control and P rates at 6 WAP. A significant reduction in maize height was noted in control, 30 kg P ha^{-1} and 150 kg P ha^{-1} in comparison to 60 kg P ha^{-1} at 8 WAP. All P rates except 60 kg P ha^{-1} had similar effect on height of maize at 8 WAP. There was no significant difference in stem girth at 2 WAP. Stem girth increased with increasing P until 60 kg ha^{-1} while rate below 60 kg ha^{-1} led to significant reduction in stem girth at 4 WAP. The application of 60 kg P ha^{-1} led to significant increase in stem girth when compared to other rates except 120 kg P ha^{-1} and 150 kg P ha^{-1} but the highest significant increase was of 28 % was recorded above the control. Similar response was observed at 6 WAP only that widest stem girth produced with 60 kg P ha^{-1} did not significantly differ from P rates above 60 kg ha^{-1}. At 8 WAP all P rates did not differ from each other although significant increase in stem girth was produced by 120 kg P ha^{-1}, 150 kg P ha^{-1} and 180 kg P ha^{-1}.

The application of 60 kg K ha^{-1} produced significantly taller plants than the control although there was no difference in the height of maize with the application of potassium at the varying rates at 2 WAP (Table 2). At 4 WAP significant increase in height was noted with K at 180 kg ha^{-1} even though this did not differ from 120 kg ha^{-1} and 150 kg ha^{-1}. There was no significant difference in maize height at 6 WAP but highest increase was noted with 60 kg K ha^{-1} and 90 kg K ha^{-1}. All potassium rates except 180 kg K ha^{-1} and the control stimulated similar maize height at 8 WAP. However potassium rate at 180 kg ha^{-1} significantly increased height, an increase of 16 % more than the control was observed. The stem girth of maize was higher with the application of potassium; significant difference was not recorded at 2 WAP. Applying potassium at rate of 180 kg K ha^{-1} widened the stem of maize at 2 WAP in comparison to the control at an increase of 61 %. The application of K at 30 kg K ha^{-1}, 60 kg K ha^{-1}, 90 kg K ha^{-1} led to similar maize girth when compared with control at 2 WAP, stem girth of maize increased with increasing potassium rates. At 6 and 8 WAP, there was no significant difference in stem girth with the application of K at 30 kg ha^{-1}. However maize stem widened with increasing potassium rates at 6 and 8WAP. The application of 180 kg K ha^{-1} produced the widest girth relative to other rates at 6 and 8WAP. 90 kg K ha^{-1} and 120 kg K ha^{-1} had similar effect on girth while 150 kg K ha^{-1} increased the girth than 120 kg K ha^{-1} at 6 WAP.

3.3 EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM APPLICATION ON LEAF LENGTH AND BREADTH OF MAIZE

Leaf length of maize significantly increased with the application of nitrogen fertilizer of 120 kg N ha^{-1} at 2 WAP in comparison with the control while other rates did not differ (Table 3). At 4 and 6 WAP, no significant increase was observed in leaf length though application of fertilizer increased leaf length when compared to the control. The highest increase in leaf length was recorded with 120 kg N and 90 kg N ha^{-1} at 4 and 6WAP respectively. Significant increase in leaf length was recorded with the application 150 kg N ha^{-1} relative to control at 8WAP. Leaf breadth did not significantly differ after application of nitrogen fertilizer at all weeks except at 4 WAP as shown in Table 3. At 4 WAP the highest significant increase was brought about by N rate at 120 kg N ha^{-1} and 150 kg N ha^{-1} in respect to the control.

There was increase in leaf length of maize as the weeks progressed for all phosphorus treatments. Though no significant effect was recorded among the treatments from 2-8 WAP despite the highest leaf length was produced with 60 kg P ha^{-1} for all the weeks and the lowest was recorded with P rate of 30 kg ha^{-1} for all weeks except 2 WAP. Similar response was observed for leaf breadth during the period of observation only that maize grown in the control soil had the lowest leaf breadth, highest leaf breadth for 2 and 8WAP was produced by 90 kg P ha^{-1}.

Table 3 shows that leaf length of maize was significantly longer by 10 % with the application of 60 kg K in comparison with the control. However, leaf length was similar for all potassium rates at 2 WAP. Significant increase was only noted with 180 kg K ha^{-1} in relation to other rates and control at 4 WAP. All potassium rates led to significantly longer leaves than the control at 6 WAP. A highest increase in leaf length was recorded with 150 kg K ha^{-1} even though it did not significantly differ from 180 kg K ha^{-1} at 6 WAP. Increasing potassium rates also increased the leaf length at 8WAP when the longest leaf was recorded with 180 kg K ha^{-1}. All potassium rates produced significantly longer leaf than the control and a highest increase in leaf length was created with 180kg K at 8 WAP. Maize leaf breadth was similar for control, 30 kg K and 60 kg K. 180 kg K 120 kg K ha^{-1} significantly reduced leaf breadth when compared with 90, 120 and 150 kg K 120 kg K ha^{-1} at 2 WAP. Application rates of 60 kg and 180 kg K led to similar leaf breadth which was significantly higher than the control and other rates at 4WAP. Significantly, wider leaf was recorded with the application of 150 kg K and 180 kg K relative to the control even though 180 kg K did not differ from other rates except 30 kg K at 6WAP and 30 and 60 kg K at 8 WAP.

3.4 EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM APPLICATION ON LEAF NUMBER AND LEAF AREA

The leaf area of maize increased with nitrogen applied at 120 kg ha^{-1} and a decrease was recorded for the control (Table 4), no significant differences were recorded at 2 and 6 WAP. At 4 WAP, applying nitrogen rate at 120 kg ha^{-1} increased the leaf area significantly by 96 % above control. However, at 8 WAP there was no difference in leaf area with 30 kg N ha^{-1} in comparison with the control. Significant increase was only noted with nitrogen rate of 150 kg N ha^{-1} when compared to the control while other N rates did not differ from the control. Application of N fertilizer did not lead to significant increase in leaf number at 2, 6 and 8 WAP though the lowest number of leaves was recorded with 60 kg N, 180 kg N and 30 kg N at 2, 6 and 8 WAP respectively. However at 4 WAP, application of nitrogen rates of 90 kg ha^{-1}, 120 kg ha^{-1} and 150 kg N significantly increased the leaf number than the control. Highest increase of 51 % was recorded with 120 kg N and 150 kg N above the control.

The application of P fertilizer increased the leaf number from 2 to 8 WAP. At 2 WAP, all P rates except 30 kg and 150 kg ha^{-1} increased the leaf number. Similar response was noted at 4WAP in which all P rates except 30 kg and 120 kg ha^{-1} had similar effect on leaf number. A highest increase of 54 % was recorded with 90 kg P in comparison with 30 kg P at 4 WAP. Significant increase in leaf number was recorded with the application of P fertilizer except 30 kg ha^{-1} at 6 WAP with the lowest leaf number produced with the control. 60kg ha^{-1} P significantly increased the leaf number when compared with the control and 30 kg P. An increase was observed in the leaf area of maize with increasing weeks though no significant effect was recorded with the application of phosphorus fertilizer at all the weeks. The highest leaf area was produced in maize grown on soil applied with 60 kg P at all weeks except at 8 WAP.

There was no significant difference in the leaf number of maize (Table 4) at 2 WAP though similar number of leaf was recorded with the control and potassium rates except 60 kg K. At 4 WAP, similar leaf number was recorded with the control, 30 kg K, 90 kg K and 180 kg K while a decrease was noted with application rates of 60 kg K ha^{-1} and 150 kg K ha^{-1}. The application of 180 kg K ha^{-1}, 150 kg K ha^{-1} recorded the highest leaf number at 6 WAP. However significantly lower leaf number was produced by the control and potassium rates of 30 – 90 kg K ha^{-1}. The leaf area was similar for all potassium rates , moreover the application of potassium increased the area of leaf significantly above the control with the highest leaf area recorded with 90 kg K for 2 WAP. At 4 WAP, applying potassium at 180 kg K produced the highest leaf area at 4 WAP though this did not differ from 60 and 90 kg K. The control, 30 kg K, 90 kg K, 120 kg K and 150 kg K significantly decreased the leaf area when compared to 180 kg K at 4 WAP. Maize leaf area was significantly increased at 6 WAP with the application of potassium rates except 30 kg K. At 8 WAP maize leaf area increased with increasing potassium in which significantly lower area was observed in the control. Highest leaf area was recorded with K rate of 180 kg ha^{-1}.

3.5 EFFECT OF POTASSIUM ON DRY MATTER, NUTRIENT CONCENTRATION AND UPTAKE

Shoot dry weight and root dry weight increased with the application of nitrogen fertilizer though increases were not significant as presented on Table 5. The highest dry weight was produced with N rate of 120kg. Nitrogen concentration in maize shoot and uptake from soil did not significantly differ for all the rates and even the control despite N uptake increased with increasing rate up to 150 kg ha^{-1}. However, application of nitrogen also increased potassium concentration in plant though significant increase was only noted with 150 kg N with the highest increase of 157 % over the control.

The application of phosphorus fertilizer had significant effect on the shoot dry weight. All phosphorus rates except 30 kg P ha^{-1} led to significant increase in shoot dry weight when compared to the control. Shoot dry weight was significantly decreased with P at 30 kg ha^{-1} in respect to the control. The root dry weight did not significantly increased with the application of phosphorus. Phosphorus concentration was lowest in maize grown on control soil while the highest was recorded with 60 kg P ha^{-1} even though increase was not significant. Nitrogen concentration in plant was highest and only significant with P rate of 60 kg in respect to the control, N concentration was observed to decrease with increasing P at rate lower than 60 kg ha^{-1}. Phosphorus and nitrogen uptake were not significantly affected with application of phosphorus though the greatest uptake of these nutrients was recorded with 60 kg P ha^{-1}.

Shoot dry weight was significantly increased with potassium rate at 180 kg ha^{-1}with respect to the control and rates below 90 kg ha^{-1}. No significant difference in root dry weight even though highest was recorded with 180 kg K. The application of potassium increased the nitrogen concentration significantly although all rate except 60 kg K led to similar nitrogen content in maize. Potassium concentration was significantly higher with the 180 kg K in comparison to other rates and control. It was also observed that the more the potassium applied, the more the concentration in plant. Applying potassium at a rate above 90 kg led to significant N uptake while a rate above 60 kg ha^{-1} increased K uptake significantly above the control.

4. DISCUSSION

The soil used for the experiment was slightly acidic. It was low in organic carbon, available phosphorus, calcium, sodium and potassium. Its total nitrogen was very low and while magnesium was medium. It was a sandy soil with poor nutrient status: hence would respond well to fertilizer application.

The result obtained from this study showed that different levels of nitrogen significantly improved maize growth, dry matter yield and nutrient uptake. It was reported [8] that nitrogen and phosphorus application increased the green fodder yield of maize. Growth was mostly supported with application levels of 120 kg N ha^{-1}. This was evident in the plant height, number of leaves and dry matter yield of maize production. These results were similar to the findings of [13] who reported that increasing supply of N improved growth of corn. It was also observed that number of leaves per plant tended to increase as nitrogen rate increased. Maximum numbers of leaves were produced with the application of 120 kg N ha^{-1}. This could be attributed to the fact that nitrogen promoted vegetative growth in maize. Some researchers [14] have reported similar results. Leaf area was also affected by levels of nitrogen application. There was increase in leaf area with increased rate of nitrogen. The application of 150 kg N ha^{-1} resulted in significantly higher leaf area and P concentration in the plant. This result is in agreement with the findings of [15] who reported that higher rates of nitrogen promote leaf area during vegetative development and help to maintain functional leaf area during the growth period. The significant increase in phosphorus concentration with increased N fertilization could be attributed to the fact that nitrogen plays a major role in the formation of nucleotides and phosphotides thereby increasing the concentration of phosphorus in the plant. This is in agreement with the findings of [16] who reported that increased P accumulation in leaves and kernels of two corn cultivars were due to urea application.

Phosphorus fertilization led to increase in maize agronomic parameters, dry weight and nitrogen concentration. It was revealed [17] that application of phosphorous fertilizer significantly increased plant height. However, among all P rates, application of 60 kg P significantly increased plant height, stem girth, leaf area and leaf number than the control. The significant increase in the above-mentioned parameters could be because phosphorus is a major component of Adenosine triphosphate involved in respiration process thus increasing the leaf area and rate of photosynthesis. Furthermore, application at 60 kg P ha^{-1} could have initiated the actions of microorganisms directly involved in nutrient mineralization and availability thereby increasing plant growth (plant height, stem girth, leaf area and leaf number). This supports the findings of [18] that solubility of insoluble phosphates by phosphorus solubilizing microorganisms and the secretion of growth enhancers such as auxin, gibberellins and cytokinin by such organisms increased the root growth and consequently the crop growth. The significant increase in shoot dry weight with the application of 60 kg P ha^{-1} is in conformity with [19] who reported that dry matter yield increased with the increasing P up to 60 kg P ha^{-1}.

The significant increases in plant height, stem girth and leaf length of maize with the application of 180 kg K ha^{-1} signifies that increased level of K led to higher plant height and girth. This could be attributed to the fact that potassium is responsible for maintaining proper water potential, turgid pressure and promoting cell elongation in the leaves. This supports the findings of [20] that one of the more visually obvious consequences on plant growth from insufficient levels of plant potassium is a reduction in plant stature. Maize leaf area was significantly increased with the application of 180 kg K, potassium rate below 180 kg ha^{-1} did not lead to significant increase. Insufficient K levels reduced leaf area expansion leading to reduced leaf size in maize [21]. The increased concentration and uptake of potassium with increasing potassium in soil could be because soil responded well to K fertilization thereby increasing the rate of K uptake from the soil. This is in conformity with the findings of [22] that potassium concentration increased because of K fertilization. Potassium influences the uptake and transport of nitrate within the plant [23]. This could have been the reason for the increased concentration and uptake of nitrogen with the application of 180 kg K. The transport of amino acids was reported to be enhanced by higher K levels, especially the transport of amino acids to developing seeds [24].

5. CONCLUSION

Agronomic parameters (plant height, number of leaves, leaf area), dry matter yield and phosphorus concentration were affected by N application. However, nitrogen concentration, shoot dry matter and agronomic parameters except leaf area and breadth were greatly influenced by P fertilization. Application of potassium to maize grown in screen house affected maize height, girth, leaf number area, length and breadth. Furthermore increasing potassium rate was equivalent to increasing those parameters, concentration and uptake of N and K in maize.

It is therefore recommended that nitrogen, phosphorus and potassium application should be encouraged for sustainable maize production in screen house. Additionally, application rate between 120 to 150 kg N ha $^{-1}$, 60 kg P ha $^{-1}$and 180 kg K ha $^{-1}$ should be adopted.

Table 1. Some chemical characteristics of experimental soil

	pH	Ca	Mg	Na	K	Avail P	Total N	Total C	Texture
		.... cmolkg^{-1}				mgkg^{-1}	............%............		
Soil	6.20	4.41	1.16	0.64	0.24	3.01	0.04	0.65	Sandy

Table 2. Effect of Nitrogen, Phosphorus and Potassium application on plant height and stem girth of maize

Treatment (ha-1)	**........... 2WAP**	**Plant 4WAP**	**Height 6WAP**	**(cm). 8WAP**	**.......... 2WAP**	**Stem 4WAP**	**Girth 6WAP**	**(cm). 8WAP**
0 kg N	16.2a	19.2d	23.8a	31.2ab	0.2bcd	0.35b	0.27a	0.49a
30 kg N	15.5a	22.3bcd	25.4a	27.5b	0.13d	0.39b	0.33a	0.45a
60 kg N	15.9a	27.4abc	30.3a	50.0ab	0.28ab	0.61ab	0.39a	0.69a
90 kg N	17.3a	30.7a	39.9a	54.3ab	0.23abc	0.53ab	0.52a	0.77a
120 kg N	18.5a	30.1ab	46.3a	64.3a	0.29a	0.59ab	0.45a	0.83a
150 kg N	19.9a	31.9a	40.0a	52.7ab	0.18cd	0.72a	0.47a	0.67a
180 kg N	16.5a	20.5cd	29.7a	34.3ab	0.22abc	0.53ab	0.33a	0.41a
0 kg P	15.5ab	21.0b	29.0ab	42.7c	0.13a	0.20d	0.26c	0.35b
30 kg P	13.7b	21.17b	26.8a	44.1c	0.14a	0.22cd	0.27bc	0.47ab
60 kg P	19.67a	26.8a	37.0a	67.5a	0.15a	0.50a	0.57a	0.65a
90 kg P	15.7ab	22.3b	33.5a	62.4abc	0.17a	0.25bcd	0.40abc	0.63ab
120 kg P	14.7b	21.5b	31.5a	55.0abc	0.15a	0.27bcd	0.35abc	0.63ab
150 kg P	17.50ab	24.3ab	30.8a	48.0bc	0.16a	0.45ab	0.55a	0.70a
180 kg P	17.0ab	23.7ab	31.2a	51.7abc	0.12a	0.42abc	0.50ab	0.77a

0 kg K	30.0b	80.3d	100.0a	116.6b	0.15a	0.24d	0.60e	0.64e
30 kg K	31.3ab	82.3cd	103.3a	122.6b	0.15a	0.28cd	0.63e	0.67e
60 kg K	33.0a	84.0bc	110.0a	116.6b	0.17a	0.28cd	0.69d	0.75cd
90 kg K	30.6ab	84.0bc	110.0a	123.3b	0.17a	0.30cd	0.76c	0.80c
120 kg K	32.3ab	87.0ab	103.3a	120.0b	0.17a	0.33c	0.78c	0.94b
150 kg K	31.6ab	86.6ab	100.0a	117.6b	0.17a	0.55b	0.85b	0.98ab
180 kg K	31.0ab	87.6a	103.3a	135.6a	0.16a	0.70a	0.91a	1.07a

Mean with the same alphabet in each treatment section did not differ significantly across the column at (*P* = .05)

WAP- weeks after planting

Table 3. Effect of Nitrogen, Phosphorus and Potassium application on Leaf length and Leaf breadth of maize

Treatment	**..........**	**Leaf**	**Length**	**(cm)**	**..........**	**Leaf**	**Breadth**	**(cm)**
(K ha^{-1})	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**2WAP**	**4WAP**	**6WAP**	**8WAP**
0kg N	25.4b	32.2a	45.9a	72.0b	4.0a	3.6b	4.0a	5.0a
30kg N	35.6ab	46.4a	63.4a	74.6b	4.3a	4.3ab	4.0a	4.0a
60kgN	72.6ab	78.9a	104.3a	101.9ab	3.3a	5.0ab	4.7a	6.7a
90kgN	77.6ab	97.1a	120.5a	131.8ab	4.0a	5.3a	5.0a	8.0a
120kgN	90.3a	98.9a	120.1a	146.6ab	4.3a	5.7a	5.0a	8.0a
150kg N	66.0ab	83.7a	117.1a	176.9a	4.3a	5.7a	5.0a	6.7a
180kg N	47.4ab	60.7a	91.4a	92.8ab	4.3a	4.0ab	3.7a	5.0a
0kg P	19.0a	38.3a	44.6a	46.8a	1.55a	1.70a	2.1a	2.2a
30kg P	19.0a	33.7a	40.2a	44.3a	1.50a	1.80a	2.2a	2.6a
60kg P	19.7a	54.7a	65.6a	67.3a	1.73a	2.4a	3.0a	3.2a
90kg P	18.7a	49.1a	58.0a	64.3a	1.83a	2.4a	2.7a	3.6a
120kg P	17.7a	39.5a	48.5a	54.6a	1.63a	2.1a	2.6a	2.7a
150kg P	17.5a	41.1a	52.0a	54.7a	1.65a	2.5a	2.8a	2.6a
180kg P	19.3a	48.4a	56.6a	61.5a	1.63a	2.0a	3.2a	2.2a
0 Kg K	29.6b	56.67b	67.6d	77.0f	1.9ab	4.1b	5.5c	5.6c
30 kg K	31.0ab	58.0ab	69.6c	80.0e	2.1ab	4.3ab	5.6bc	5.7bc
60 kg K	32.6a	58.0ab	72.3ab	83.0d	2.1ab	4.5a	5.7ab	5.8a
90 kg K	31.3ab	57.6ab	71.6b	85.3c	2.2a	4.4b	5.7ab	5.8ab
120 kg K	32.3ab	56.0b	72.3ab	88.0b	2.3a	4.1b	5.6ab	5.6c
150 kg K	31.6ab	57.3ab	73.6a	88.3b	2.3a	4.1b	5.8a	5.8a
180 kg K	30.3ab	59.0a	73.3a	90.6a	1.7b	4.5a	5.8a	5.9a

Mean with the same alphabet in each treatment section did not differ significantly across the column at (*P* = .05) WAP- weeks after planting

Table 4. Effect of Nitrogen, Phosphorus and Potassium application on number of leaves and Leaf area of maize

Treatment	....	Leaf	number	....	....	Leaf	Area	(cm^2)
(K ha-1)	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**2WAP**	**4WAP**	**6WAP**	**8WAP**
0 kg N	4.0a	3.7b	4.0a	5.0a	32.2a	25.4b	45.9a	72.1b
30kg N	4.3a	4.3ab	4.0a	4.0a	46.4a	32.6ab	63.4a	74.6b
60kg N	3.3a	5.0ab	4.6a	6.7a	78.9a	72.6ab	104.3	101.9ab
90kg N	4.0a	5.3a	5.0a	8.0a	97.1a	77.6ab	120.5	131.8ab
120kg N	4.3a	5.6a	5.0a	8.0a	98.9a	90.3a	120.1a	146.6ab
150kg N	4.3a	5.6a	5.0a	6.7a	83.7a	66.0ab	117.1a	176.9a
180kg N	4.3a	4.0ab	3.7a	5.0a	60.7a	47.0ab	91.4a	92.8ab
0kg P	3.5ab	4.5c	3.5c	6.0b	21.7a	46.6a	68.8a	76.6a
30kg P	3.0b	3.7b	4.3bc	6.0b	21.3a	45.8a	64.9a	87.0a
60kg P	4.0a	5.0abc	5.7ab	8.0a	25.7a	100.2a	150.3a	163.2a
90kg P	4.0a	5.7a	5.7ab	7.3ab	21.7a	88.0a	119.2a	171.6a
120kg P	4.0a	4.7a	6.0a	7.7ab	21.7a	64.0a	96.1a	112.7a
150kg P	3.5ab	5.5ab	5.0ab	7.5ab	21.7a	76.8a	108.9a	128.1a
180kg P	4.0a	5.0abc	5.7ab	8.0a	24.3a	78.2a	142.1a	182.a
0 Kg K	4.0a	6.3a	9.0c	9.7b	43.5b	175.7c	282.5d	321.5d
30 kg K	4.0a	6.0ab	9.3bc	10.0ab	50.5a	187.1bc	290.8cd	340.0c
60 kg K	3.7a	5.0c	9.0c	9.3b	50.6a	197.2ab	311.0ab	363.2b
90 kg K	4.0a	6.0ab	9.0c	9.7b	52.5a	188.7abc	306.3ab	371.3b
120 kg K	4.0a	5.7b	9.7ab	10.0ab	50.4a	180.6c	301.9bc	367.3b
150 kg K	4.0a	5.0c	10.0a	11.0a	50.5a	177.8c	318.6a	386.5a
180 kg K	4.0a	6.0ab	10.0a	11.0a	38.8a	200.6a	314.2ab	399.0a

Mean with the same alphabet in each treatment section did not differ significantly across the column at (*P* = .05)

WAP- weeks after planting

Table 5. Effect of Nitrogen, Phosphorus and Potassium application on dry matter, nutrient concentration and uptake

Treatment (ha^{-1})	Shoot dry wgt $gpot^{-1}$	Root dry wgt. $gpot^{-1}$	conc.	conc.	Uptake Per pot	Uptake Per pot
			N (%)	P ($mgkg^{-1}$)	N(g)	P(mg)
0kg N	1.07a	0.36a	0.36a	70.0b	0.27a	90.0a
30kg N	0.94a	0.44a	0.44a	70.0b	0.28a	90.0a
60kg N	2.10a	0.31a	0.31a	100.0ab	0.31a	250.0a
90kg N	2.98a	0.42a	0.42a	130.0ab	0.55a	400.0a
120kg N	3.45a	0.48a	0.48a	150.0ab	0.82a	610.0a
150kg N	3.00a	0.44a	0.43a	180.0a	0.93a	590.0a
180kg N	1.70a	0.27a	0.27a	90.0ab	0.34a	210.0a
			P ($mgkg^{-1}$)	N (%)	P (g)	N (g)
0kg P	4.50c	0.55a	400.8a	1.76b	0.73a	0.79a
30kg P	3.67d	0.33a	687.1a	3.60ab	1.97a	1.32a
60kg P	5.00abc	0.75a	1164.3a	5.95a	7.03a	2.97a
90kg P	5.67a	0.72a	458.1a	4.24ab	2.02a	2.40a
120kg P	4.67bc	0.53a	668.0a	3.60ab	1.93a	1.68a
150kg P	5.50ab	0.54a	1145.2a	3.65ab	3.36a	2.00a
180kg P	5.00abc	0.87a	591.7a	3.18ab	2.05a	1.59a
			K (%)	N (%)	K(g)	N(g)
0 Kg	6.66bc	0.84ab	2.34c	0.9c	0.15c	0.06b
30 kg	6.05c	0.82b	2.61c	1.06ab	0.15c	0.07b
60 kg	6.39c	0.81b	2.84bc	0.98bc	0.18bc	0.06b
90 kg	8.41abc	0.97ab	3.57ab	1.10a	0.30ab	0.09ab
120 kg	10.37ab	1.10ab	2.90bc	1.15a	0.30ab	0.12a
150 kg	10.39ab	1.10ab	3.07abc	1.15a	0.33a	0.12a
180 kg	10.58a	1.14a	3.77a	1.06ab	0.38a	0.11a

Mean with the same alphabet in each treatment section did not differ significantly across the column at (*P* = .05)

wgt.- weight conc. - concentration

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