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

Abstract

It is pertinent to exploit 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 thus necessitating the study to determine the effect of these nutrients on growth, dry matter yield and nutrient uptake in maize. This study involved 3 pot experiments laid out in a completely randomized design with three replications concurrently at the university farm of the Federal University of Agriculture, Abeokuta, Nigeria. Soil sample was collected at the University farm, Federal University of Agriculture, Abeokuta at the depth of 0-20cm.Treatments included (0,30,60,90,120,150,180kgN) ,(0,30,60,90,120,150, 180kg P) and (0,30,60,90,120,150, 180kg K) for the 3 experiments respectively. Maize seeds were sown in pot containing 5kg sieved soil and treatments were applied two weeks after planting. Data were collected fortnightly on maize height, girth, leaf number, length, breadth, leaf area. for 8weeks and subjected to analysis of variance The result of the study showed that application of nitrogen at the rate of 120 kg N/ha led to a significant increase in plant height (66%), number of leaves (96%) and dry matter yield of maize while leaf area, phosphorus concentration (157%) increased with150 kg N/ha. Plant height (26%), stem girth, leaf area, leaf number (54%), shoot dry weight and nitrogen concentration was significantly increased with 60kg P. However applying potassium at 180kg significantly increased plant height (16%), girth(61%), number of leaves, leaf area, length (10%) and breadth and concentration and uptake of nitrogen and potassium. It is therefore concluded that application rate between 120 to 150 kg N/ha, 60kg P and 180kg K is useful for increasing maize agronomic parameters, dry matter yield and uptake for sustainable maize production.

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

1. INTRODUCTION

The demand for food is increasing as a result of increasing population; the problem of food scarcity is increasing. Maize (Zea mays L.) as an important crop in Nigeria is a better option since it is a high yielding crop that provides food and forage. It is the Nigeria's third most important cereal crop after sorghum and millet [11]. 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 its productivity and sustainability [24]. Longer cultivation has further depleted the soil organic-matter content and fertility [23].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 [1]. Increasing the nutrient status of the soil may be achieved by boosting the soil nutrient content either 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 [1]. Nitrogen, phosphorus and potassium and other nutrient elements play great physiological importance in formation of chlorophyll, nucleotides, phosphotides and alkaloids as well as in many enzymes, hormones and vitamins for optimum grain yield [17]. Nitrogen deficiency could exert a particularly marked effect on maize crop yield as the plant would remain small and rapidly turned yellow if sufficient nitrogen was not available for the construction of protein and chlorophyll [15].

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 [14]. 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. [3] noticed that nitrogen and phosphorus application increased the green fodder yield of maize. Phosphorus application enhanced the crop to reach 50% tasseling and silking earlier [8]. 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 [4]. Under K deficient conditions photosynthesis is depressed as a consequence of sucrose accumulation in the leaves and its effect on gene expression [12]. 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 exploit 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 ANALYSIS

The top soil a sample (0-20cm) 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 samples from the soils 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. Total nitrogen was digested and analysed using kjedahl method. Available phosphorus was extracted with Bray-1 and P was determined according to [18]. Exchangeable cations were extracted with 1N ammonium acetate, Na and Kin 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 randomised 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}. 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} Treatments for experiment

3 included 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}

2.3 SCREEN HOUSE EXPERIMENT

Five kilogrammes of soil sample was dispensed into each experimental pot with each treatment applied separately into the pot. The soil samples 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 tasseling. 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 roots and shoot were separated, cleaned, placed in to neatly labelled envelopes and dried to constant weight. The oven dried shoots were milled and analysed for potassium and nitrogen concentration. Similar procedure carried out in experiment 1 was also done simultaneously in experiment 2 and 3 only that nutrient analysed were different. In experiment 2, oven dried shoot were milled and analysed for phosphorus and nitrogen while milled shoots from experiment 3 were analyzed for potassium and nitrogen content.

2.4 STATISTICAL ANALYSIS

Data collected was analysed for their variance by using the software package SAS (1999). The significant treatment was separated using LSD at 5 % level of probability. Data collected was also subjected to Pearson's Correlation analysis.

3. RESULTS

3.1 SOIL CHARACTERISTICS

The soil has a pH of 6.20; total organic carbon of 0.65% total nitrogen is 0.04%. It also contains 3.01mgkg^{-1} available phosphorus while calcium, magnesium, sodium and potassium content of 4.41, 1.16, 0.64 and 0.24 cmolkg^{-1} (Table 1).

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

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

The application of phosphorus fertilizer at all rate except 30 and 60 kg increased maize height at 2WAP although significant increase was recorded with P rate of 60kg in comparison to 30 and 120kg P. Similar response was also reported at 4WAP where all P rate except 60kg did not lead to significant increase in maize height in respect to control. 30, 60 and 120kg P had similar effect of height of maize while a highest significant increase of 26% above 30kg P was recorded with 60kg P. The height of maize was similar for the control and P rates at 6WAP. A significant reduction in maize height was noted with control, 30kg P and 150kg P in comparison to 60kg P at 8WAP. All P rates except 60kg P had similar effect on height of maize at 8WAP. There was no significant difference in stem girth at 2WAP. Stem girth increased with increasing P till 60 kg while rate below 60 led to significant reduction in stem girth at 4WAP. The application of 60kg P led significant increase in stem girth when compared to other rates except 120 and 150kg but the highest significant increase was of 150% was recorded above the control. Similar response was observed at 6WAP only that widest stem girth produced with 60kg did not significantly differ from P rates above 60kg. At 8WAP all P rates did not differ from each other although significant increase in stem girth was produced by 120, 150 and 180kg P.

The application of 60kg K led to 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 2WAP (Table 2). At 4WAP significant increase in height was noted with K at 180kg even though this did not differ from 120kg and 150kg. There was no significant difference in maize height at 6WAP but highest increase was noted with 60kg and 90kg K. All potassium rates except 180kg K and the control stimulated similar maize height at 8WAP. However potassium rate at 180kg increased the height significantly above the other treatments, it recorded an increase of 16% over the control. The stem girth of maize was higher with the application of potassium even though significant difference was not recorded at 2WAI. Applying potassium at rate of 180kg K widened the stem girth of maize significantly at 2WAP in comparison to the control at an increase of 61%. The application of K at 30, 60, 90 kg K led to similar maize girth in comparison with the control at 2WAP also the stem girth of maize increases with increasing potassium rates. Maize stem girth did not significantly differ with potassium rate at 30kg K in comparison with the control at 6 and 8WAP. However maize stem widened with increasing potassium rates at 6 and 8WAP. The application of 180kg K led to the widest girth relative to other rates at 6 and 8WAP. 90 kg K and 120 kg K led to similar girth while 150kg K increased the girth than the later at 6WAP.

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

Leaf length of maize was significantly increased with the application of nitrogen fertilizer of 120kgN at 2WAP in comparison with the control while other rates did not differ (Table 3). At 4 and 6WAP, no significant difference in leaf length though application of fertilizer increased leaf length when compared to the control. The highest increase in leaf length was recorded with 90kg N and 150 kg N at 4 and 6WAP respectively. Significant increase in leaf length was recorded with the application 150kg N in respect to the control that had similar effect with 30kg N at 8WAP. Leaf breadth did not significantly differ with the application of nitrogen fertilizer at all weeks except a4WAP as shown in Table 3. The highest significant increase was brought about by N rate at 120 and 150kg that had similar effect on leaf breadth.

There was increase in leaf length of maize as the weeks progressed for all treatment. Though no significant effect was recorded within the treatments from 2-8WAP despite that the highest leaf length was produced with 60kg P for all the weeks and the lowest was recorded with P rate of 30kg for all weeks except 2WAP. Similar response was observed for the leaf breadth at all weeks only that maize grown in the control soil had the lowest leaf breadth and the highest leaf breadth for 2 and 6WAP was produced by 90kg P.

Table 3 shows that leaf length of maize was significantly longer by 10% with the application of 60 kg K in comparison to the control. However leaf length was similar for all potassium rates at 2WAI. Significant increase was only noted with 180 kg K in relation to other rates and even the control which did not differ from each other at 4WAP. All potassium rates led to significantly longer leaves than the control at 6WAP. A highest increase in leaf length was recorded with 150kg K even though it did not significantly differ from 180kg K at 6WAP. Increasing potassium rates also increased the leaf length at 8WAP in which the longest leaf was recorded with 180 kg K. All potassium rates recorded significantly longer leaf than the control while the highest increase was noted with 180kg K at 8WAP. Maize leaf breadth was similar for the control and all rates except 180kg K which led significantly shorter breadth than 90, 120 and 150 kg K at 2WAP. Application rate 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 180kg K in respect to the control even though the later did not differ from other rates except 30kg K at 6WAP and 30 and 60 kg K at 8WAP.

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

The leaf area of maize was highest with nitrogen applied at 120kg and lowest was recorded in the control according to Table 4, although no significant difference was recorded at 2 and 6WAP. At 4WAP applying nitrogen rate at 120kg increased the leaf area significantly by 96% of the control. However at 8WAP there was no difference in leaf area with 30kg N in comparison to the control. Significant increase was only noted with nitrogen rate of 150kg N when compared to the control. Other N rates did not differ from the control. Application of fertilizer did not lead to significant increase in leaf number at 2, 6 and 8WAP though the lowest number of leaves was recorded with 60kg N, 180kg N and 30kg N at 2, 6 and 8 WAP respectively. However at 4WAP, application of nitrogen rates of 90, 120 and 150kg N significantly increased the leaf number than the control, the highest increase of 51% was recorded with 120kg and 150kg above the control

The application of P fertilizer increased the leaf number from 2 to 8WAP. At 2WAP all P rate except 30kg increased the leaf number. Similar response was noted at 4WAP all P rates except 30kg had similar effect on leaf number. A highest increase of 54% was recorded with 90kg P in comparison with 30kg P. Significant increase in leaf number was recorded with the application of P fertilizer except 30kg at 6WAP with the lowest leaf number produced with the control. 60kg phosphorus significantly increased the leaf number when compared to the control and 30kg 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 60kg P at all weeks except at 8WAI.

There was no significant difference in the leaf number of maize as shown in Table 4 at 2WAP though similar number of leaf was recorded with the control and potassium rates except 60kg K. At 4WAP, similar leaf number was recorded with the control, 30, 90 and 180 kg K and a decrease was noted with application rates of 60 and 150kg K. The application of 180kg K recorded the highest leaf number at 6WAP. However significantly lower leaf number was noted in the control and potassium rates of 30 - 90kg K. Similar sequence was also observed at 8WAP. 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 90kg K. Applying potassium at 180kg K produced the highest leaf area at 4WAP though this did not differ from 60 and 90kg K. The control, 30kg K, 90kg K, 120kg K and 150 kg K significantly decreased the leaf area when compared to 180kg K. Maize leaf area was significantly increased at 6WAP with the application of potassium rates except 30kg K. At 8WAP 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 at 180kg.

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 increase was 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 that N uptake increased with increasing rate up to 150kg.However application of nitrogen also increased potassium concentration in plant though significant increase was only noted with 150kg 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 30kg P lead to significant increase in shoot dry weight when compared to the control. Shoot dry weight was significantly decreased with P at 30kg in respect to the control. The root dry weight was not significantly increased with the application of phosphorus. Phosphorus concentration was lowest in maize grown on control soil while the highest was recorded with 60kg P even though increase was not significant. Nitrogen concentration in plant was highest and only significant with P rate of 60kg in respect to the control and a decrease with increasing P at rate lower than 60kg was also observed in N concentration. Phosphorus and nitrogen uptake was not significantly affected with application of phosphorus though the greatest uptake of these nutrients was recorded with 60kg P.

Shoot dry weight was significantly increased with potassium rate at 180kg with respect to the control and rates below 90 kg. No significant difference in root dry weight even though highest was recorded with 180kg K. The application of potassium increased the nitrogen concentration significantly although all rate except 60kg K led to similar nitrogen content in maize. Potassium concentration was significantly higher with the 180kg and 90kg 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 90kg led to significant N uptake while a rate above 60kg increased K uptake significantly above the control.

4. DISCUSSION

The soil is slightly acidic, with low organic carbon and available phosphorus. It is also very low in total nitrogen. Its calcium, sodium and potassium content are low while its magnesium is medium. It is sandy in nature and of low nutrient status and 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. [3] reported 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 [2] 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 can be attributed to the fact that nitrogen promoted vegetative growth in maize. Similar results have been reported by [21]. Leaf area was also affected by levels of nitrogen application. There was increase in leaf area with increase rate of nitrogen. The application of 150kg N resulted in significantly higher leaf area and P concentration in the plant. This result is in agreement with the findings of [9] who reported that higher rate of nitrogen promotes leaf area during vegetative development and also 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 [19] that reported the increased P accumulation in leaves and kernels of both corn cultivars due to urea application.

Phosphorus fertilization led to increase in maize agronomic parameters, dry weight and nitrogen concentration. [22] Revealed that application of phosphorous fertilizer significantly plant height. However among all P rates, application of 60kg P significantly increased plant height, stem girth, leaf area and leaf number than the control. The significant increase in the above mentioned parametres could be because phosphorus is a major component of Adenosine triphosphate that is involved in respiration process thereby increasing the leaf area and rate of photosynthesis. [20] reported the 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 60kg P is in conformity with [5] who reported that dry matter yield increased with the increasing level of P up to 60 kg P/ha.

The significant increase in plant height, stem girth and leaf length of maize with the application 180kg K signifies that increased level of K led to higher plant height and girth. This could be attributed to the fact potassium is responsible for maintaining proper water potential and turgor pressure and promoting cell elongation in the leaves. This is supported by the findings of [10] who reported 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 180kg K and potassium rate below 180kg did not lead to significant increase. [13] reported that insufficient K levels reduced leaf area expansion leading to reduced leaf size in maize. The increased concentration and uptake of potassium with increasing potassium in soil could be due to the fact that the soil responded well to K fertilization thereby increasing the rate of K uptake from the soil. Increased potassium concentration as a result of K fertilization is also reported by [7]. Potassium influences the uptake and transport of nitrate within the plant [6]. This could have been the reason for the increased concentration and uptake of nitrogen with the application of 180kg K. [16] also demonstrated that the trans-port of amino acids is enhanced by higher K1 levels, especially the transport of amino acids to developing seeds.

5. CONCLUSION

It is therefore concluded that application rate between 120 to 150 kg N/ha, 60kg P and 180kg K is useful for increasing maize agronomic parameters, dry matter yield and uptake for sustainable maize production. Furthermore increased potassium rate led to increased plant height stem girth, concentration and uptake of N and K in maize.

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 on plant height and stem girth of maize

Treatment	**............**	**Plant**	**Height**	**(cm).**	**...........**	**Stem**	**Girth**	**(cm).**
(ha-1)	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**2WAP**	**4WAP**	**6WAP**	**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	21.0ab	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 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 on number of leaves and Leaf area of maize

Treatment (K ha-1)	**.......... 2WAP**	**Leaf 4WAP**	**number 6WAP**	**......... 8WAP**	**........... 2WAP**	**Leaf 4WAP**	**Area 6WAP**	**(cm^2) 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 on dry matter, nutrient concentration and uptake

Treatment (ha^{-1})	**Shoot dry wgt g/pot**	**Root dry wgt. g/pot**	**conc.**	**conc.**	**Uptake Per pot**	**Uptake Per pot**
			N (%)	**P(mg/kg)**	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(mg/kg)	**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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