

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 (N), phosphorus (P) and potassium (K) 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~~ number of leaves, leaf length, ~~breadth~~ width 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 increases in height (26%), stem girth, leaf area, leaf number (54 %), shoot dry weight and N concentration ~~was~~ were observed with 60 kg P ha⁻¹. However, the application of applying K at 180 kg ha⁻¹ increased the plant height (16%), stem girth (61%), leaf number, leaf area (?%), leaf length (10 %), leaf width (?%) breadth, concentration and uptake of N and K. It ~~is~~ was concluded that maize growth, dry matter yield and uptake is greatly influenced by nitrogen, phosphorus and potassium applications ~~at~~ 120 to 150 kg N ha⁻¹, 60kg P ha⁻¹, and 180kg 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 to mitigate the threat of food shortage, 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 a result of continuously cropping, and consequently, leading to~~ reduction in unsustainable soil productivity ~~and sustainability~~ [2]. ~~Longer~~ Long term cultivation has further

depleted the [soil](#)-organic-matter content and fertility [status of the soils](#)[3]. This phenomenon is amidst other constraints like drought, poor crop management, diseases and pest. Efforts aimed at obtaining [higher yields](#) of maize would necessitate the augmentation of the nutrient status of the soil to meet the crop's requirements for optimum productivity, and [also](#) maintain [the soil's](#) 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 [\[8, 9\]](#).

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 of~~ maize.

2. MATERIALS AND METHODS

2.1 SOIL COLLECTION AND SOIL ANALYSIS

The top soil (0-20cm) was collected from the University farms, Federal university of Agriculture Abeokuta, Ogun state. The soil was air dried, and sieved ~~with~~ through 2mm mesh sieve. Sub samples ~~from of~~ the soil ~~was were~~ collected and analyzed for the following properties: Soil pH was estimated in 1:2 (~~soil: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 ~~Kjeldahl~~ Kjeldahl 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 kilograms 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, width, and number of leaves were taken recorded forth nightly. The leaf area was also measured. Maize plants were harvested at the end of the 8th week. The root and shoot components 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 concentrations. Similar procedure as carried out in experiment 1 was done simultaneously in experiment two and three, only that the target nutrients analyzed were different, phosphorus and nitrogen in experiment 2, and potassium and nitrogen in experiment 3. 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. Mean comparison among the treatments was performed 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 3.01mgkg⁻¹ respectively. It contained 4.41cmol₊kg⁻¹, 1.16 cmol₊kg⁻¹, 0.64 cmol₊kg⁻¹ and 0.24 cmol₊kg⁻¹ of calcium, magnesium, sodium and potassium, respectively (Table 1).

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

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All the Application rates of phosphorus at rates except with the exception of 30 kg ha⁻¹ and 120 kg ha⁻¹ resulted in increased maize height at 2WAP, even although increases were not significant with respect to the control. Similar responses were reported at 4WAP. However, the application rates of 30 kg P ha⁻¹, 60 kg P ha⁻¹ and 120kg P ha⁻¹ had similar effect on maize height despite the fact that a highest significant increase of 26% was recorded with from the application 60kg P ha⁻¹ relative to 30

134 kg P ha⁻¹. The height of maize was similar for the control and P application rates at 6WAP. A
 135 significant reduction in maize height was noted in control, 30kg P ha⁻¹ and 150kg P ha⁻¹ ~~in~~
 136 ~~comparison compared to~~ 60kg P ha⁻¹ at 8WAP. All P rates except 60kg P ha⁻¹ had similar effect on
 137 height of maize at 8WAP. There was no significant difference in stem girth at 2WAP. Stem girth
 138 increased with increasing P ~~until up to~~ 60 kg ha⁻¹, ~~while whereas application rates~~ below 60 kg ha⁻¹ led
 139 to significant reduction in stem girth at 4WAP. The application of 60kg P ha⁻¹ led to significant
 140 increase in stem girth when compared to other rates except 120 kg P ha⁻¹ and 150kg P ha⁻¹, but the
 141 highest significant increase ~~was~~ of 28% was recorded ~~above the control~~. Similar response was
 142 observed at 6WAP only that widest stem girth produced with 60kg P ha⁻¹ did not significantly differ
 143 from P rates above 60kg ha⁻¹. At 8WAP all P application rates did not differ from each other although
 144 significant increases in stem girth ~~was were~~ produced by 120 kg P ha⁻¹, 150 kg P ha⁻¹ and 180kg P ha⁻¹.
 145 The application of 60kg K ha⁻¹ produced significantly taller plants than the control although there was
 146 no difference in the height of maize with the application of potassium at the varying rates at 2WAP
 147 (Table 2). At 4WAP, significant increase in height was noted with K at 180kg ha⁻¹, even though this did
 148 not differ from 120kg ha⁻¹ and 150kg ha⁻¹. There was no significant difference in maize height at
 149 6WAP but highest increase was noted with 60 kg K ha⁻¹ and 90kg K ha⁻¹. All the potassium application
 150 rates except 180kg K ha⁻¹ and the control stimulated similar maize height at 8WAP.
 151 However, ~~potassium application rate of at~~ 180kg ha⁻¹ significantly increased the plant height ~~to an~~
 152 ~~increase of 16% more than of~~ the control ~~was observed~~. The stem girth of maize was higher with the
 153 application of potassium; significant difference was not recorded at 2 WAP. Applying potassium at a
 154 rate of 180kg K ha⁻¹ widened the stem of maize at 2WAP in comparison to the control ~~at an increase~~
 155 ~~of by~~ 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 response
 156 in stem girth when compared ~~with to the~~ control at 2WAP, however, stem girth of ~~maize was~~
 157 ~~observed to~~ increased with increasing application rates of potassium rates. At 6 and 8 WAP, there
 158 was no significant difference in stem girth with the application of K at 30 kg ha⁻¹. However, maize
 159 stem widened with increasing potassium rates at 6 and 8WAP. The application of 180kg K ha⁻¹

160 ¹produced the widest stem girth relative to the application other rates at 6 and 8WAP. Application of
161 90 kg K ha⁻¹ and 120 kg K ha⁻¹ had similar effect on stem girth, while 150kg K ha⁻¹ increased
162 the produced a wider stem girth than 120 kg K ha⁻¹ at 6WAP.

163 3.3 EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM APPLICATION ON LEAF LENGTH AND 164 BREADTH OF MAIZE

165 Leaf length of maize significantly increased with the application of nitrogen fertilizer of 120kgN ha⁻¹
166 ¹at 2WAP in comparison with the control, while the other application rates did not differ
167 considerably (Table 3). At 4 and 6WAP, no significant increase was observed in leaf length, although
168 application of fertilizer increased leaf length when compared to the control. The highest increase in
169 leaf length was recorded with 120 kg N and 90 kg N ha⁻¹ at 4 and 6WAP, respectively. Significant
170 increase in leaf length was recorded with the application 150kg N ha⁻¹ relative to control at 8WAP.
171 With the exception of the observation made at 4 WAP, Leaf breadth-width did not significantly differ
172 after following the application of nitrogen fertilizer at all weeks except at 4WAP as shown in Table 3.
173 At 4 WAP, the highest significant increase was brought about by N application rate of at 120 kg N ha⁻¹
174 ¹and 150kg N ha⁻¹ in respect to of the control.

175 There was increase in leaf length of maize as the weeks progressed for all phosphorus treatments.
176 Though a No significant effect was recorded among the treatments from 2-8WAP, despite the
177 highest leaf length was produced with from the application of 60kg P ha⁻¹ for all the weeks and the
178 lowest was recorded with P rate of 30kg ha⁻¹ for all weeks except 2WAP. Similar response was
179 observed for leaf breadth-width during the period of observation only that maize grown in the
180 control soil had the lowest leaf breadthwidth, highest leaf breadth for 2 and 8WAP was produced by
181 90kg P ha⁻¹.

182 Table 3 shows that leaf length of maize was significantly longer by 10% with the application of 60 kg K
183 ha⁻¹ in comparison with relative to the control. However, leaf length was similar for all the application

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184 rates of potassium ~~rates~~ at 2 WAP. Significant increase was only noted with the application of 180 kg
 185 K ha⁻¹ in relation to the other application rates and the control at 4WAP. All the application rates of
 186 potassium ~~rates led to~~ resulted in significantly longer leaves than the control at 6WAP. ~~A~~ The highest
 187 increase in leaf length was recorded ~~with following the application of~~ 150 kg K ha⁻¹, even though it did
 188 not significantly differ from that of 180 kg K ha⁻¹ at 6WAP. Increasing potassium rates also increased
 189 the leaf length at 8WAP ~~when where in~~ the longest leaf was recorded ~~with under the~~ 180 kg K ha⁻¹
 190 treatment. All potassium rates produced significantly longer ~~leaf leaves~~ than the control, ~~with and~~
 191 ~~at the~~ highest increase in leaf length ~~was created observed with from the application rate of~~ 180 kg K ha⁻¹
 192 ¹ at 8WAP. Maize leaf ~~breadth width~~ was similar for the control, 30 kg K ha⁻¹ and 60 kg K ha⁻¹.
 193 Application of 180 kg K ha⁻¹ 120 kg K ha⁻¹ significantly reduced leaf breadth when compared with 90,
 194 120 and 150 kg K 120 kg K ha⁻¹ at 2WAP. Application rates of 60 kg K ha⁻¹ and 180 kg K ha⁻¹ ~~led~~
 195 ~~to resulted in~~ similar leaf ~~breadth width~~, which was significantly higher than the control and the other
 196 application rates at 4WAP. Significantly, wider ~~leaf was leaves were recorded observed~~ with the
 197 application of 150 kg K ha⁻¹ and 180 kg K ha⁻¹ relative to the control, even though 180 kg K ha⁻¹ did not
 198 differ from the other application rates except for 30 kg K ha⁻¹ at 6WAP, and 30 and 60 kg K ha⁻¹ at
 199 8WAP.

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200 3.4 EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM APPLICATION ON LEAF NUMBER AND 201 LEAF AREA

202 The leaf area of maize increased with nitrogen applied at 120 kg ha⁻¹ and a decrease was recorded for
 203 the control (Table 4), no significant differences were recorded at 2 and 6WAP. At 4WAP, applying
 204 nitrogen rate at 120 kg ha⁻¹ increased the leaf area significantly by 96% above control. However, at
 205 8WAP there was no difference in leaf area with 30 kg N ha⁻¹ in comparison with the control.
 206 Significant increase was only noted with nitrogen rate of 150 kg N ha⁻¹ when compared to the control
 207 while other N rates did not differ from the control. Application of N fertilizer did not lead to
 208 significant increase in leaf number at 2, 6 and 8WAP though the lowest number of leaves was
 209 recorded with 60 kg N, 180 kg N and 30 kg N at 2, 6 and 8 WAP respectively. However, at 4WAP,

210 application of nitrogen rates of 90 kg ha⁻¹, 120 kg ha⁻¹ and 150kg N significantly increased the leaf
211 number than the control. Highest increase of 51% was recorded with 120kg N and 150kg N above
212 the control.

213 The application of P fertilizer increased the leaf number from 2 to 8WAP. At 2WAP, all P rates except
214 30kg ha⁻¹ and 150 kg ha⁻¹ increased the leaf number. Similar response was noted at 4WAP in which all
215 P rates except 30kg ha⁻¹ and 120 kg ha⁻¹ had similar effect on leaf number. A highest increase of 54%
216 was recorded with 90kg P ha⁻¹ in comparison with 30kg P ha⁻¹ at 4 WAP. Significant increase in leaf
217 number was recorded with the application of P fertilizer except 30kg ha⁻¹ at 6WAP with the lowest
218 leaf number produced with the control. Application rate of 60kg ha⁻¹ P significantly increased the
219 leaf number when compared with the control and 30kg P ha⁻¹. An increase was observed in the leaf
220 area of maize with increasing weeks though no significant effect was recorded with the application
221 of phosphorus fertilizer at all the weeks. The highest leaf area was produced in maize grown on soil
222 applied with 60kg P ha⁻¹ at all weeks except at 8WAP.

223 There was no significant difference in the leaf number of maize (Table 4) at 2WAP though similar
224 number of leaf was recorded with the control and potassium rates except 60kg K ha⁻¹. At 4WAP,
225 similar leaf number was recorded with the control, 30 kg K ha⁻¹, 90 kg K ha⁻¹ and 180 kg K ha⁻¹ while a
226 decrease was noted with application rates of 60 kg K ha⁻¹ and 150kg K ha⁻¹. The application of 180kg K
227 ha⁻¹, 150kg K ha⁻¹ recorded the highest leaf number at 6WAP. However significantly lower leaf
228 number was produced by the control and potassium rates of 30 – 90kg K ha⁻¹. The leaf area was
229 similar for all potassium rates, moreover the application of potassium increased the area of leaf
230 significantly above the control with the highest leaf area recorded with 90kg K ha⁻¹ for 2 WAP. At 4
231 WAP, applying potassium at 180kg K ha⁻¹ produced the highest leaf area at 4WAP though this did not
232 differ from 60 and 90kg K ha⁻¹. The control, 30kg K ha⁻¹, 90kg K ha⁻¹, 120kg K ha⁻¹ and 150 kg K ha⁻¹
233 significantly decreased the leaf area when compared to 180kg K ha⁻¹ at 4 WAP. Maize leaf area was
234 significantly increased at 6WAP with the application of potassium rates except 30kg K ha⁻¹. 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 of 180kg 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 ha⁻¹. 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 150kg ha⁻¹. However, application of nitrogen also increased potassium concentration in plant though significant increase was only noted with 150kg N ha⁻¹ 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 ha⁻¹ led to significant increase in shoot dry weight when compared to the control. Shoot dry weight was significantly decreased with P at 30kg ha⁻¹ in respect to the control. The root dry weight did not significantly increase with the application of phosphorus. Phosphorus concentration was lowest in maize grown on control soil while the highest was recorded with 60kg P ha⁻¹ 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, N concentration was observed to decrease with increasing P at rate lower than 60kg ha⁻¹. Phosphorus and nitrogen uptake were not significantly affected with application of phosphorus though the greatest uptake of these nutrients was recorded with 60kg P ha⁻¹.

Shoot dry weight was significantly increased with potassium rate at 180kg 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 180kg K ha⁻¹. The application of potassium increased the nitrogen concentration significantly although all rate except 60kg K ha⁻¹ led to similar nitrogen content in maize. Potassium

259 | concentration was significantly higher with the 180kg K ha^{-1} in comparison to other rates and control.
260 | It was also observed that the more the potassium applied, the more the concentration in plant.
261 | Applying potassium at a rate above 90kg led to significant N uptake while a rate above 60kg ha^{-1}
262 | increased K uptake significantly above the control.

Comment [DT5]: Consider the suggestions made in the other sub sections and do same for these sections

263 | 4. DISCUSSION

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

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

284 concentration of phosphorus in the plant. This is in agreement with the findings of [16] who
285 reported that increased P accumulation in leaves and kernels of two corn cultivars were due to urea
286 application.

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

301 The significant increases in plant height, stem girth and leaf length of maize with the application of
302 180 kg K [ha⁻¹](#) signifies that increased level of K led to higher plant height and girth. This could be
303 attributed to the fact that potassium is responsible for maintaining proper water potential, turgid
304 pressure and promoting cell elongation in the leaves. This supports the findings of [20], [who](#)
305 [reported](#) that one of the more visually obvious consequences on plant growth from insufficient
306 levels of plant potassium is a reduction in plant stature. Maize leaf area was significantly increased
307 with the application of 180 kg K [ha⁻¹](#); potassium rate below 180 kg [ha⁻¹](#) did not lead to significant
308 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 180kg K ha^{-1} . The trans-port 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~~ 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~~ 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

329 Mean with thesame alphabet in each treatment section did not differ significantly across the column
330 at ($P = .05$)

331 WAP- weeks after planting

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

Treatment (K ha ⁻¹)	..... 2WAP	Leaf 4WAP	Length 6WAP	(cm) 8WAP	..... 2WAP	Leaf 4WAP	Breadth 6WAP	(cm) 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

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

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

Treatment (K ha-1)	..... 2WAP	Leaf 4WAP	number 6WAP	..... 8WAP	..... 2WAP	Leaf 4WAP	Area 6WAP	(cm²) 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

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

341 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

344 Mean with thesame alphabet in each treatment section did not differ significantly across the column
345 at ($P = .05$)

346 wgt.- weight conc. - concentration

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