Original Research Article

Nitrogen Uptake and Yield of Maize as Influenced by Nitrogen and Phosphorus Levels during Kharif Season

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Abstract

Present investigation was carried out during two consecutive kharif seasons of 2014 and 2015 to evaluate the nitrogen uptake and yield of maize as influenced by different nitrogen (200, 250 and 300 kg ha\(^{-1}\)) and phosphorus (40, 60, and 80 kg ha\(^{-1}\)) levels. The uptake of nitrogen was found to increase with each successive increase in N level from 200 to 300 kg ha\(^{-1}\) and phosphorus up to 60 kg ha\(^{-1}\) with increase in age of the crop with higher uptake of nitrogen with 300 kg N ha\(^{-1}\) and 60 kg P\(_2\)O\(_5\) ha\(^{-1}\). During both the years, the highest and lowest grain and stover yields were recorded with N level of 300 kg ha\(^{-1}\) and 200 kg ha\(^{-1}\) and with P level of 60 kg ha\(^{-1}\) and 40 kg ha\(^{-1}\) respectively.

Keywords
Nitrogen, Uptake, Maize, Grain, Stover, Yield

Introduction

Maize (Zea mays L.) is an important cereal food crop cultivated both in tropical and temperate regions of the world with the highest production and productivity as compared to rice and wheat. In the world, maize is cultivated in an area of 146 million hectares with a production of 685 million tonnes and an average productivity of 4.7 t ha\(^{-1}\). It is the third most important cereal after rice and wheat for human food by contributing to 9 per cent of India’s food basket and 5 per cent to World’s dietary energy supply (Saikumar et al., 2012). India is the sixth largest producer of maize with 22.36 million tonnes of production from 9.40 million hectares, with a productivity of 2.4 t ha\(^{-1}\). In Andhra Pradesh, it is cultivated in an area of 0.23 million hectares with a production of 1.41 million tonnes and productivity of 6.1 t ha\(^{-1}\) (ASG, 2016).

The demand for maize owing to burgeoning growth rate of poultry, livestock, fish and wet and dry milling industries is expected to increase from current level of 22.36 million tonnes to 45 million tonnes by 2030 (DMR, 2011). Among the factors limiting the amount of possibly obtainable higher yield, there are frequently highlighted those with regard to plant specific requirements like mineral nutrient imbalances. Maladjustment of the fertilization system to plant quantitative needs and especially to nutrient uptake dynamics in field crops, results in disturbances in the functions of individual nutrients, low rates of their utilization by plants as well as an
increased risk of environmental pollution (Roberts, 2008). The fulfillment of the fundamental goal of maize fertilization, i.e. obtaining high and stable yields, requires a suitable supply of N and P to the plant, maintained at a level with no impedimental effects. In support of the maximum crop response, nitrogen needs and adequate phosphorus levels as well as prospective N–P interactions in plant uptake. The aim of the present study was to assess nutrient contents in maize as well as their accumulation in this crop at all the stages of crop growth, under differentiated rates of mineral fertilization with N and P.

Materials and Methods

Field trial was conducted at College Farm of Agricultural College, Mahanandi campus of Acharya N. G. Ranga Agricultural University, situated at 15.51°N latitude, 78.61°E longitude and at an altitude of 233.5 m above the mean sea level, in the Scarce Rainfall Zone of Andhra Pradesh during kharif seasons of 2014 and 2015. The soil was sandy loam in texture, neutral in reaction (pH of 7.34), low in organic carbon (0.45%) and available nitrogen (275 kg ha\(^{-1}\)), medium in available phosphorus (153 kg ha\(^{-1}\)) and high in available potassium(670 kg ha\(^{-1}\)), during beginning of experimentation.

The trials were laid down in a randomized block design with factorial concept. The treatments included three nitrogen levels (200 kg ha\(^{-1}\) (N\(_1\)), 250 kg ha\(^{-1}\) (N\(_2\)) and 300 kg ha\(^{-1}\) (N\(_3\))) and three phosphorus levels (40 kg ha\(^{-1}\) (P\(_1\)), 60 kg ha\(^{-1}\) (P\(_2\)) and 80 kg ha\(^{-1}\) (P\(_3\))). The test variety of maize was P-3396 a single cross hybrid. Recommended practices for disease and insect pest control were followed. Nitrogen was applied at graded levels as per the treatments in three splits i.e., one third at basal, one third at knee high stage and the remaining one third at tasseling stage. Entire quantity of P\(_2\)O\(_5\) as per the treatments and K\(_2\)O (60 kg K\(_2\)O ha\(^{-1}\)) was applied as a basal dose. The sources of nitrogen, phosphorus and potassium were urea, single super phosphate and muriate of potash respectively. The split dose of nitrogen fertilizer was applied by placement at 5 cm away and 5 cm below the seed rows. Five plants from the destructive sampling area were cut to the base at 30 days interval and at harvest, sun dried and then oven dried at 60°C till a constant weight was obtained. The above samples were then ground into fine powder and used for estimation of nitrogen, employing the standard procedures as outlined by Jackson (1973) and the nutrient content of maize crop was expressed. The grain on the cobs was dried after shelling and was weighed.

The data recorded on hybrid maize for nitrogen uptake in the course of investigation were statistically analyzed following the method of analysis of variance for randomized block design with factorial concept. Wherever the treatmental differences were found significant (‘F’ test), critical difference was worked out at 0.05 probability level and the values are furnished. Treatmental differences that were non-significant are denoted as NS.

Results and Discussion

Nitrogen uptake at 30 DAS

Significantly higher nitrogen uptake was recorded with 300 kg N ha\(^{-1}\) (N\(_3\)) which was however on par with 250 kg N ha\(^{-1}\) (N\(_2\)) (Table. 1). The lowest nitrogen uptake was observed with the application of 200 kg N ha\(^{-1}\) (N\(_1\)), during the first year. Similar trend was observed in the second year also but the difference was not significant among different nitrogen levels. Higher and lower nitrogen uptake was recorded with 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_2\)) and 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_1\)) respectively and all the treatments recorded on par values of nitrogen uptake during both the years.
Nitrogen uptake at 60 DAS

Significantly higher nitrogen uptake was recorded with 300 kg N ha\(^{-1}\) (N\(_3\)) which was however on par with 250 kg N ha\(^{-1}\) (N\(_2\)) (Table. 1). The lowest nitrogen uptake was observed with the application of nitrogen at 200 kg ha\(^{-1}\) (N\(_1\)), during both the years.

Higher and lower nitrogen uptake was recorded with 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_2\)) and 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_1\)) respectively and all the treatments recorded on par values of nitrogen uptake at 60 DAS during both the years.

Nitrogen uptake at 90 DAS

Significantly higher nitrogen uptake was recorded with 300 kg N ha\(^{-1}\) (N\(_3\)) which was however on par with 250 kg N ha\(^{-1}\) (N\(_2\)) (Table. 1). The lowest nitrogen uptake was observed with 200 kg N ha\(^{-1}\) (N\(_1\)), during both the years. The higher nitrogen uptake was recorded with 80 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_3\)) during the first year and 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_2\)) during the second year, while the lower uptake in both the years was recorded with 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_1\)). However all the treatments recorded on par values of nitrogen uptake at 90 DAS during both the years.

Nitrogen uptake by stover

During first year higher nitrogen uptake was recorded with 300 kg N ha\(^{-1}\) (N\(_3\)) which was statistically on par with 250 kg N ha\(^{-1}\) (N\(_2\)) (Table. 1). Similarly during second year of study higher nitrogen uptake was recorded with 300 kg N ha\(^{-1}\) (N\(_3\)) which was significantly superior over 250 kg (N\(_2\)) and 200 kg N ha\(^{-1}\) (N\(_1\)). The lowest nitrogen uptake was observed with 200 kg N ha\(^{-1}\) (N\(_1\)), during both the years of study. During second year of study higher nitrogen uptake was recorded with 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_2\)) which was statistically on par with 80 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_3\)). Similarly during second year of study higher nitrogen uptake was recorded with 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_2\)) which was significantly superior over 80 kg (P\(_3\)) and 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_1\)). The lowest nitrogen uptake by grain was observed with the application of phosphorus at 40 kg ha\(^{-1}\) (P\(_1\)), during both the years of study.

The nitrogen uptake due to interaction effect of nitrogen and phosphorus levels was significant during both the years (Table. 2). During the first year, at lower levels of phosphorus, increase in nitrogen level from 200 kg (N\(_1\)) to 300 kg ha\(^{-1}\) (N\(_3\)) increased the grain nitrogen uptake but not significantly, while the difference was significant at 80 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_3\)). However, at 200 kg ha\(^{-1}\) (N\(_1\)) nitrogen level, there was significant decrease in nitrogen uptake with increase in P level from 60 kg (P\(_1\)) to 80 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_3\)) and at 250 kg ha\(^{-1}\) (N\(_2\)) nitrogen level, there was significant increase in nitrogen uptake from 40 kg (P\(_1\)) to 80 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_3\)).
Fig. 1 Uptake of nitrogen (kg ha\(^{-1}\)) by *kharif* maize as influenced by nitrogen and phosphorus levels

*Kharif, 2014*

*Kharif, 2015*
Fig. 2 Grain and stover yield (kg ha$^{-1}$) of maize as influenced by nitrogen and phosphorus levels during *kharif*. 

**Kharif, 2014**

**Kharif, 2015**
Table 1. Uptake of nitrogen (kg ha\(^{-1}\)) by *kharif* maize at different stages as influenced by nitrogen and phosphorus levels

| Treatments                  | 30 DAS   | 60 DAS   | 90 DAS   | Stover Uptake | Grain Uptake |
|-----------------------------|----------|----------|----------|---------------|--------------|
|                             | 2014     | 2015     | 2014     | 2015          | 2014         |
|                             | 2014     | 2015     | 2014     | 2015          | 2014         |
| Nitrogen levels (kg ha\(^{-1}\)) |          |          |          |               |              |
| \(N_1: 200\)               | 19.9     | 14.7     | 116.2    | 107.2         | 156.4        |
| \(N_2: 250\)               | 21.2     | 15.2     | 130.7    | 116.6         | 175.4        |
| \(N_3: 300\)               | 26.4     | 16.5     | 141.3    | 125.1         | 194.3        |
| SEM±                        | 2.08     | 1.37     | 4.38     | 5.60          | 6.59         |
| CD (P = 0.05)               | 6.2      | NS       | 13.1     | 16.8          | 19.7         |
| Phosphorus levels (kg ha\(^{-1}\)) |          |          |          |               |              |
| \(P_1: 40\)                | 21.24    | 14.9     | 116.7    | 112.2         | 160.4        |
| \(P_2: 60\)                | 26.04    | 15.3     | 129.4    | 127.8         | 163.6        |
| \(P_3: 80\)                | 25.80    | 15.0     | 124.7    | 117.6         | 177.5        |
| SEM±                        | 2.08     | 1.37     | 4.38     | 5.60          | 6.59         |
| CD (P = 0.05)               | NS       | NS       | NS       | NS            | NS           |
| Interaction                 |          |          |          |               |              |
| SEM±                        | 3.59     | 2.37     | 7.59     | 9.70          | 11.41        |
| CD (P = 0.05)               | NS       | NS       | NS       | NS            | NS           |
Table 2 Nitrogen uptake (kg ha\(^{-1}\)) by maize grain as influenced by interaction effect of nitrogen and phosphorus levels

| Interaction between N and P levels in 2014 | P\(_1\) | P\(_2\) | P\(_3\) | Mean |
|------------------------------------------|--------|--------|--------|------|
| N\(_1\)                                  | 76.5   | 94.0   | 65.2   | 78.6 |
| N\(_2\)                                  | 79.8   | 96.6   | 114.6  | 97.0 |
| N\(_3\)                                  | 92.4   | 108.8  | 106.9  | 101.1|
| Mean                                     | 82.9   | 98.1   | 95.6   |      |

SEm± 6.28  
CD (P = 0.05) 18.8

| Interaction between N and P levels in 2015 | P\(_1\) | P\(_2\) | P\(_3\) | Mean |
|------------------------------------------|--------|--------|--------|------|
| N\(_1\)                                  | 94.2   | 100.7  | 87.4   | 94.1 |
| N\(_2\)                                  | 98.0   | 139.5  | 136.8  | 124.7|
| N\(_3\)                                  | 133.6  | 141.2  | 130.0  | 134.9|
| Mean                                     | 108.6  | 127.1  | 118.0  |      |

SEm± 3.85  
CD (P = 0.05) 11.5

Table 3 Grain and stover yield of maize as influenced by nitrogen and phosphorus levels during kharif season

| Treatments                              | Grain yield (kg ha\(^{-1}\)) | Stover yield (kg ha\(^{-1}\)) |
|-----------------------------------------|-------------------------------|------------------------------|
| **Nitrogen levels (kg ha\(^{-1}\))**   | 2014                          | 2015                         |
| N\(_1\): 200                            | 6885                          | 8170                         |
| N\(_2\): 250                            | 7832                          | 9116                         |
| N\(_3\): 300                            | 8231                          | 9146                         |
| **SEm±**                                | 124.4                         | 125.5                        |
| CD (P=0.05)                             | 373                           | 376                          |
| **Phosphorus levels (kg ha\(^{-1}\))** | 2014                          | 2015                         |
| P\(_1\): 40                             | 7271                          | 8714                         |
| P\(_2\): 60                             | 7983                          | 8936                         |
| P\(_3\): 80                             | 7693                          | 8781                         |
| **SEm±**                                | 124.4                         | 125.5                        |
| CD (P=0.05)                             | 373                           | NS                           |

**Interaction**

| **SEm±** | 215.4 | 217.3 | 438.0 | 696.8 |
| CD (P=0.05) | NS   | 651   | NS    | NS    |
Table 4 Grain yield (kg ha\(^{-1}\)) of maize as influenced by nitrogen and phosphorus levels during kharif season

| Interaction between N and P levels during 2015 | P\(_1\) | P\(_2\) | P\(_3\) | Mean |
|---------------------------------------------|--------|--------|--------|-------|
| N\(_1\)                                     | 8071   | 8319   | 8120   | 8170  |
| N\(_2\)                                     | 8986   | 9307   | 9055   | 9116  |
| N\(_3\)                                     | 9087   | 9183   | 9169   | 9146  |
| Mean                                        | 8714   | 8936   | 8781   |       |
| SEm±                                        |        |        | 217.3  |       |
| CD (P = 0.05)                               |        |        | 651    |

Finally there was no effect of phosphorus on nutrient uptake at higher level of nitrogen i.e. 300 kg ha\(^{-1}\) (N\(_3\)). During second year at any level of phosphorus, increase in nitrogen level from 200 kg (N\(_1\)) to 300 kg ha\(^{-1}\) (N\(_3\)) increased the grain nitrogen uptake which was significant between 250 kg (N\(_2\)) and 300 kg N ha\(^{-1}\) (N\(_3\)) at 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_1\)) and between 200 kg (N\(_1\)) and 250 kg N ha\(^{-1}\) (N\(_2\)) at 60 (P\(_2\)) and 80 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_3\)).

Uptake of nitrogen increased significantly with each successive increment in nitrogen at all the stages of crop growth (Fig. 1). The higher nitrogen uptake was observed with 300 kg ha\(^{-1}\) than the other lower nitrogen doses tested. The lowest was recorded with 200 kg N ha\(^{-1}\). This might be due to increased root development leading to increased absorption of nitrogen under high nitrogen doses with split application. Application of nitrogen increases root cation exchange capacity, which might have enhanced the absorption of the nutrients. The results are in accordance with the findings of Al-Kaisi and Yin (2003), Reddy et al., (2012) and Zakkam et al., (2012).

Phosphorus applied at the rate of 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_2\)) recorded more uptake of nitrogen over lower and higher P\(_2\)O\(_5\) levels, but the differences were not significant at all the stages of crop growth. Paramasivan et al., (2013) and Nsanzabaganwa et al., (2014) also reported similar results of nitrogen uptake in maize.

Grain Yield

During the first year, application of 300 kg N ha\(^{-1}\) (N\(_3\)) resulted in higher grain yield, which was statistically superior to that of 250 kg (N\(_2\)) and 200 kg N ha\(^{-1}\) (N\(_1\)) (Table. 3). The lowest grain yield was associated with 200 kg N ha\(^{-1}\) (N\(_1\)). During the second year nitrogen applied at 300 kg ha\(^{-1}\) (N\(_3\)) resulted in highest grain yield, which was statistically on par with that of 250 kg N ha\(^{-1}\) (N\(_2\)). The lowest grain yield was associated with 200 kg N ha\(^{-1}\) (N\(_1\)). This might be due to favourable effect at higher nitrogen level leading to better crop growth and increase in yield attributes which was reflected in kernel yield of maize. In physiological terms, the grain yield of maize was largely governed by source and sink relationships as it is directly related to nitrogen. These results are in accordance with the findings of Nsanzabaganwa et al., (2014), Om et al., (2014) and Thimmappa et al., (2014).

Maize supplied with 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_2\)) resulted in higher grain yield, which was however statistically on par with 80 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_3\)). Significantly lowest grain yield was obtained with 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) (P\(_1\)) in the first year. Similar trend was observed during the second year but all the three phosphorus
levels recorded statistically on par values of grain yield. Grain yield of maize increased significantly up to 60 kg P$_2$O$_5$ ha$^{-1}$. Further increase in P from 60 to 80 kg P$_2$O$_5$ ha$^{-1}$, failed to record statistical significance and the trend was illustrated in Fig. 2.

Increase in grain yield up to certain level of phosphorus was directly related to the vegetative and reproductive growth phases of the crop and attributes to complex phenomenon of phosphorus utilization in plant metabolism. Similar results were obtained by Araei and Mojaddam (2014) and Nsanzabaganwa et al., (2014). Highest grain yield of maize was recorded with N$_3$P$_2$ (250 kg N + 60 kg P$_2$O$_5$ ha$^{-1}$) which was statistically superior over lower levels of N and P, while on par with the higher levels (Table. 4). The balanced nitrogen and phosphorus levels might have helped in efficient absorption and utilization of other required plant nutrients which ultimately increased the grain yield. Similar results were obtained by Jaliya et al., (2008) and Abera et al., (2009).

Stover yield of maize increased significantly with increase in nitrogen levels from 200 to 300 kg N ha$^{-1}$. Increased stover yield with increase in nitrogen level could be attributed to adequate nutrient supply, which in turn improved growth parameters like plant height, leaf area index and dry matter production which resulted in higher stover yield. These results are agreement with the findings of Srikanth et al., (2009), Reddy et al., (2012), Hoshang (2012) and Om et al., (2014).

**Stover yield**

During both the instances of study, stover yield differed significantly due to the nitrogen levels. The higher stover yield was recorded with 300 kg N ha$^{-1}$ (N$_3$), which was however on par with that obtained with 250 kg N ha$^{-1}$ (N$_2$) and significantly higher than 200 kg N ha$^{-1}$ (N$_1$). The lowest stover yield was obtained with 200 kg N ha$^{-1}$ (N$_1$) (Table. 3).

Graded phosphorus levels influenced the stover yield of maize with distinct disparity between the levels tried. The higher stover yield of maize was obtained, when the crop was supplied with 60 kg P$_2$O$_5$ ha$^{-1}$ (P$_2$) (Fig. 2) followed by 40 kg P$_2$O$_5$ ha$^{-1}$ (P$_1$) with significant disparity between them. The lowest stover yield was resulted with the phosphorus level of 80 kg P$_2$O$_5$ ha$^{-1}$ (P$_3$) during both the years of study. Interaction effect could not be traced among nitrogen and phosphorus levels tried during both the years of study.

Stover yield of maize increased significantly with increase in nitrogen levels from 200 to 300 kg N ha$^{-1}$. Increased stover yield with increase in nitrogen level could be attributed to adequate nutrient supply, which in turn improved growth parameters like plant height, leaf area index and dry matter production which resulted in higher stover yield. These results are agreement with the findings of Srikanth et al., (2009), Reddy et al., (2012), Hoshang (2012) and Om et al., (2014).

Stover yield of maize increased significantly up to 60 kg P$_2$O$_5$ ha$^{-1}$. Further increase in phosphorus from 60 to 80 kg P$_2$O$_5$ ha$^{-1}$, decreased the stover yield. Higher straw yield at medium phosphorus level could be attributed to adequate and balanced nutrient supply over higher and lower levels tested. Similar results were obtained by Arunkumar et al., (2007), Araei and Mojaddam (2014) and Nsanzabaganwa et al., (2014).

Nitrogen uptake in maize varied significantly due to N levels but not by P levels and their interaction at all the growth stages except N uptake by grain during both the years. The uptake of nitrogen was found to increase with each successive increase in nitrogen level
from 200 to 300 kg ha\(^{-1}\) and phosphorus level from 40 to 60 kg ha\(^{-1}\) with increase in age of the crop and the highest uptake of nitrogen was recorded with 300 kg N ha\(^{-1}\) and phosphorus at 60 kg ha\(^{-1}\). With respect to interaction, the higher nitrogen uptake was recorded with the combination of 250 kg N and 80 kg P\(_2\)O\(_5\) ha\(^{-1}\) in the first year, 300 kg N and 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) in the second year.

During both the years, the highest and lowest grain and stover yields were recorded with N level of 300 kg ha\(^{-1}\) and 200 kg ha\(^{-1}\) and with P level of 60 kg ha\(^{-1}\) and 40 kg ha\(^{-1}\) respectively. Interaction was significant on grain yield during the second year and the highest values were recorded with 250 kg N and 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) while the lowest was with 200 kg N and 40 kg P\(_2\)O\(_5\) ha\(^{-1}\).

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