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# Effect of nitrogen and phosphorus levels on growth, yield and quality of forage maize

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## ABSTRACT

An experiment was conducted during rabi season of 2010-11 at Instructional farm of Department of Agronomy, JAU, Junagadh (Gujarat ) to find the effect of nitrogen and phosphorus on yield, quality and economics of forage maize. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction (8.0 pH). The experiment was laid out in Randomized Block Design with factorial concept with three replications consisting of four levels of each factor, i.e. nitrogen in $N_0$ (control), $N_1$ (60 kg ha$^{-1}$), $N_2$ (80 kg ha$^{-1}$) and $N_3$ (100 kg ha$^{-1}$) and phosphorus in $P_0$ (control), $P_1$ (30 kg ha$^{-1}$), $P_2$ (40 kg ha$^{-1}$) and $P_3$ (50 kg ha$^{-1}$). The results indicated that, application of 100 kg N ha$^{-1}$ ($N_3$) and phosphorus 50 kg $P_2O_5$ ha$^{-1}$ ($P_3$) recorded significantly the highest plant height, number of leaves per plant, number of internodes per plant, stem thickness, length of internodes, leaf area index, chlorophyll content, green forage yield, crude protein content of fodder, nitrogen and phosphorus content of fodder, nitrogen and phosphorus uptake by fodder maize crop. The application of 100 kg N ha$^{-1}$ ($N_3$) and phosphorus 50 kg $P_2O_5$ ha$^{-1}$ ($P_3$) were significantly increased available nitrogen, phosphorus and organic carbon % status in soil after harvest of maize crop and proved beneficial in recording maximum gross returns, net returns and Cost Benefit Ratios of fodder maize crop.

***Key words :** Growth attributes, Yield, Quality, Available nutrient and cost benefit ratios forage maize*

## Introduction

Maize (*Zea mays* L.) is one of the most important fodder crops in the world's agriculture economy as feed for animals. It is called as "King of fodder" due to its great importance in animal diet. Among the cultivated non-legume fodder as well as grain crops, maize is the most important cereal crop in India, which can be grown in all the three seasons- *kharif*, *rabi* and summer. Among different major nutrients, nitrogen is the most commonly deficient nutrient in the soil and gives considerable response in forage maize crop. It has the quickest and most pronounced effect on plant growth and development, and ultimately on forage yields. The adequate supply of this element is associated with vigorous vegetative growth and deep green colour of the forage. In plants, phosphorus is common component of organic compounds. Phosphorus deficiency, however, significantly reduced plant growth. Phosphorus also influences on green forage and dry matter yield of the crop. It also affects on plant height, stem thickness and leaf: stem ratio of fodder maize and quality characters like crude protein content (Patel *et al.*, 1997). The present study was therefore conducted to study the effect of nitrogen and phosphorus on growth, yield and quality of forage maize (*Zea mays* L.) during *rabi* season of 2010-2011.

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## Material and Methods

A field experiment was conducted during rabi season of 2010-11 at Instructional farm of Department of Agronomy, JAU, Junagadh (Gujarat) on clayey in soil texture and slightly alkaline in reaction (8.0 pH). The experimental site is characterized by semi arid climate in Saurashtra region The experiment was laid out in Randomized Block Design with factorial concept with three replications consisting of four levels of each factor i.e. nitrogen in $N_0$ (control), $N_1$ (60 kg $ha^{-1}$), $N_2$ (80 kg $ha^{-1}$) and $N_3$ (100 kg $ha^{-1}$) and phosphorus in $P_0$ (control), $P_1$ (30 kg $ha^{-1}$), $P_2$ (40 kg $ha^{-1}$) and $P_3$ (50 kg $ha^{-1}$). The forage maize (African Tall) were sown on $14^{th}$ December, 2010 keeping 30 cm spacing at 3 to 4 cm depth manually by using seed rate of 60 kg $ha^{-1}$, thereafter the seeds were slightly covered with soil. Statistical analysis of the individual data of various characters studied in the experiment was carried out as per Factorial Randomized Block Design (FRBD). Significance of difference was tested by "F" test (Panse and Sukhatme, 1985).

## Results and Discussion

### Effect of nitrogen

#### Effect on growth parameters

Growth parameters *viz.*, plant height at 40 and 60 DAS, number of leaves per plant, number of internodes per plant, stem thickness, length of internode, LAI at 40 and 60 DAS and leaf chlorophyll content (Table-1) were significantly influenced by nitrogen levels. Significantly the highest values of these growth parameters were observed with application of 100 kg N $ha^{-1}$ ($N_3$), among these parameters plant height at 60 DAS, number of internodes and LAI at 40 DAS were remained statistically at par with application of 80 kg N $ha^{-1}$ ($N_2$). While, significantly the lowest values were recorded under treatment $N_0$ (control).The improvement in growth parameters with application of 100 kg N $ha^{-1}$ might have resulted in better and timely availability of N for their utilization by plant as judged from nitrogen content of fodder (Table 2). Nitrogen is considered to be a vitally important plant nutrient. In addition to its role in the formation of proteins, nitrogen is an integral part of chlorophyll which is the primary absorber of light energy needed for photosynthesis. Besides these, it is also a constituent of certain organic compounds of physiological importance. Under the present investigation, profound influence of N, a component of fertility management, on crop growth seem to be due to maintaining congenial nutritional environment of plant system on account of their greater availability from soil media. The significant improvement in nutrient status of plant parts (leaves) might have resulted in greater synthesis of amino acids, proteins and growth promoting substances, which seems to have enhanced the meristematic activity and increased cell division and their elongation. Further increased chlorophyll content accompanied with more functional leaves and leaf area under the application of 100 kg N $ha^{-1}$might have increased interception, absorption and utilization of radiant energy which in turn increased photosynthesis and thereby plant height, stem diameter and finally results in better growth. The enhanced growth with nitrogen was also reported by Hassan *et al.* (2010), Nadeem *et al.* (2009), Bindhani *et al.* (2007) and Patel *et al.* (1997) in maize.

#### Effect on green forage yield

A close perusal of data on green forage yield (Table1) indicates that application of 100 kg N $ha^{-1}$ ($N_3$) produced significantly highest green forage yield and it remained at par with treatment $N_2$ (80 kg N $ha^{-1}$). Since, yield of the crop is a function of several yield components which are dependent on complementary interaction between vegetative and reproductive growth of the crop. As significant increase in green forage yield under these fertility levels appears to be on account of their influence on dry matter production and indirectly via increase in plant height, number of leaves, leaf area index, stem thickness and possibly as result of higher uptake of nutrients. The present findings are in close agreement with the results obtained by Reddy and Bhanumurthy (2010), Hassan *et al.* (2010), Bindhani *et al.* (2007) and Patel *et al.* (1990) in maize.

#### Effect on quality parameters

Quality parameters (Table 1) *viz.*, crude protein content of fodder was significantly influenced by nitrogen level, while the nitrogen levels had equal effect on fibre content of fodder. Significantly the highest protein content was observed with application of 100 kg N $ha^{-1}$ ($N_3$) and it was found non-significant with treatment $N_2$ (80 kg N $ha^{-1}$). While, significantly the lowest protein content was observed under treatment $N_0$ (control). The higher protein content of

**Table 1.** Effect of N and P levels on plant growth attributes quality parameters and yield of forage maize.

| Treatments | Plant height (cm) at 40 DAS | Plant height (cm) at 60 DAS | Number of leaves per plant | Number of internodes per plant | Stem thickness (cm) | Length of internode (cm) | Leaf area index at 40 DAS | Leaf area index at 60 DAS | Leaf chlorophyll content (mg $g^{-1}$) | Crude protein content (%) | Crude fibre content (%) | Green forage yield (q $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen levels (kg N $ha^{-1}$) | | | | | | | | | | | | |
| $N_0$ – 0 | 81.03 | 122.32 | 12.78 | 11.97 | 1.01 | 14.56 | 8.78 | 13.76 | 0.72 | 5.67 | 24.30 | 375 |
| $N_1$ – 60 | 97.74 | 143.26 | 14.75 | 13.38 | 1.12 | 15.27 | 9.51 | 15.20 | 0.83 | 6.01 | 24.34 | 412 |
| $N_2$ – 80 | 106.58 | 169.77 | 15.37 | 14.07 | 1.24 | 15.77 | 11.29 | 16.13 | 0.96 | 7.29 | 24.40 | 438 |
| $N_3$ – 100 | 117.85 | 179.72 | 16.88 | 15.07 | 1.48 | 17.04 | 11.59 | 17.80 | 1.08 | 7.69 | 24.66 | 445 |
| S.Em.± | 2.02 | 3.55 | 0.31 | 0.45 | 0.02 | 0.33 | 0.21 | 0.39 | 0.02 | 0.20 | 0.45 | 8.79 |
| C.D. at 5% | 5.84 | 10.25 | 0.91 | 1.31 | 0.07 | 0.95 | 0.60 | 1.12 | 0.05 | 0.58 | NS | 25.39 |
| Phosphorus levels (kg $P_2O_5$ $ha^{-1}$) | | | | | | | | | | | | |
| $P_0$ – 0 | 95.22 | 141.97 | 13.68 | 11.94 | 1.12 | 14.90 | 9.82 | 14.52 | 0.88 | 6.12 | 23.80 | 387 |
| $P_1$ – 30 | 98.40 | 153.39 | 14.72 | 13.63 | 1.20 | 15.71 | 10.13 | 15.78 | 0.89 | 6.53 | 24.50 | 416 |
| $P_2$ – 40 | 101.31 | 155.25 | 15.17 | 14.06 | 1.23 | 15.73 | 10.40 | 16.05 | 0.90 | 6.80 | 24.69 | 426 |
| $P_3$ – 50 | 108.28 | 164.46 | 16.21 | 14.85 | 1.29 | 16.30 | 10.82 | 16.55 | 0.92 | 7.22 | 24.70 | 443 |
| S.Em.± | 2.02 | 3.55 | 0.31 | 0.45 | 0.02 | 0.33 | 0.21 | 0.39 | 0.02 | 0.20 | 0.45 | 8.79 |
| C.D. at 5% | 5.84 | 10.25 | 0.91 | 1.31 | 0.07 | 0.95 | 0.60 | 1.12 | NS | 0.58 | NS | 25.39 |
| Interaction | | | | | | | | | | | | |
| N X P | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| C.V.% | 6.95 | 8.00 | 7.29 | 11.56 | 6.95 | 7.28 | 7.04 | 8.53 | 7.03 | 10.51 | 6.40 | 7.29 |

fodder under 100 and 80 kg N $ha^{-1}$ as compared to control is due to its dependence on nitrogen content. In the present investigation, higher N content of fodder and subsequently higher N uptake by fodder (Table 1) were recorded with the above mentioned levels that lend support to enhance protein content under the effect. This could also be explained on the basis of better availability of desired and required nutrients in crop root zone and enhanced photosynthetic and metabolic activity resulting in better partitioning of photosynthates to sinks, which reflected in quality enhancement in terms of protein content. This finding closely associated with those of Nadeem *et al.,* (2009) and Bindhani *et al.,* (2007) in maize.

### Effect on nutrient content and uptake

The content of N in fodder and uptake of N by fodder (Table 2) were significantly influenced by nitrogen levels, while it was found non-significant with respect to P and K content and uptake. Significantly the higher values of these parameters were recorded with application of 100 kg N $ha^{-1}$ ($N_3$), which was at par with 80 kg N $ha^{-1}$ ($N_2$). Higher photosynthetic activity in plant as evident from increase in biomass accumulation at successive duration and plant height reveals higher availability of metabolites from leaves to root. This might have promoted growth of root as well as their functional activity resulting in higher extraction of nutrients from soil environment to aerial parts. The uptake of N by fodder was increased significantly due to 100 kg N $ha^{-1}$ ($N_3$) nitrogen level which is at par with 80 kg N $ha^{-1}$ ($N_2$) nitrogen level. The nutrient uptake is a function of yield and nutrient concentration in plant. Thus, significant improvement in uptake of N might be attributed to their concentration in leaves and associated with higher green forage yield. This might also be attributed due to the medium level of available nitrogen already present in the soil under these treatments. The results of present investigation are in close agreements with the findings of Reddy and Bhanumurthy (2010); Hassan *et al.,* (2010); Bindhani *et al.* (2007) in maize.

**Effect on available nutrients in soil after harvest**

The status of available N in the soil under 100 kg N $ha^{-1}$ ($N_3$) nitrogen level which was at par with 80 kg N $ha^{-1}$ ($N_2$) level of nitrogen. But the levels of nitrogen were found unable to create a significant effect on P and K content in soil. The level of nitrogen 100 kg N $ha^{-1}$ ($N_3$) which was at par with 80 kg N $ha^{-1}$ ($N_2$) in case of organic carbon status of soil, but was found unable to create any significant effect on soil pH. The significant building up of available N status under these nitrogen levels could be attributed to adequate supply of N to meet the crop demand. The results of present investigation strongly support the findings of Cox *et al.* (1993).

**Effect of phosphorus**

**Effect on growth parameters**

Growth parameters (Table 1) *viz.*, plant height at 40 and 60 DAS, number of leaves per plant, number of internodes per plant, stem thickness, length of internode and LAI at 40 and 60 DAS were significantly influenced by phosphorus levels. In these parameters, significantly the highest values were observed with application of P @ 50 kg $P_2O_5$ $ha^{-1}$ ($P_3$), among these parameters the plant height at 60 DAS, number of internodes per plant, stem thickness, length of internode and LAI at 40 and 60 DAS were found at par with treatment $P_2$ (40 kg $P_2O_5$ $ha^{-1}$). While, significantly the lowest values were recorded under treatment $P_0$ (control). The improvement in growth parameters with application of 40 kg $P_2O_5$ $ha^{-1}$ might have resulted in better and timely availability of P for their utilization by plant as judged from phosphorus content of fodder (Table 4.9). Phosphorus fertilization improves the various metabolic and physiological processes and thus known as "energy currency" which is subsequently used for vegetative and reproductive growth through photo-phosphorylation. In addition to vital metabolic role, P is an important structural component of nucleic acid, phytein, phospholipids and enzymes. An adequate supply of phosphorus early in the life cycle of plant is important in laying down the primordia of its reproductive part. It also increases the initiation of both first and second order rootlets and their development. The extensive root system helps in exploiting the maximum nutrients and water from the soil. Under the present investigation, profound influence of P, a component of fertility management, on crop growth seems to be due to maintaining congenial nutritional environment of plant system on account of their greater availability from soil media. The significant improvement in nutrient status of plant parts (forage) might have resulted in greater synthesis of amino acids, proteins and growth promoting substances, which seems to have enhanced the meristematic activity and increased cell division and their elongation. The enhanced growth with phosphorus was also reported by Banerjee *et al.* (2006) in maize.

**Effect on green forage yield**

A close perusal of data on green forage yield (Table1) indicates that application of P @ 50 kg $P_2O_5$ $ha^{-1}$ ($P_3$) produced significantly higher green forage yield over rest levels of phosphorus except 40 kg $P_2O_5$ $ha^{-1}$ ($P_2$). Since, yield of the crop is a function of several yield components which are dependent on complementary interaction between vegetative and reproductive growth of the crop. As significant increase in green fodder yield under higher dose of phosphorus appears to be on account of their influence on dry matter production and indirectly via increase in plant height, number of leaves, leaf area index, stem thickness, number of internodes and possibly a result of higher uptake of nutrients. The present findings are in close agreement with the results obtained by Arya and Singh (2000) and Patel *et al.*, (1990) in maize.

**Effect on quality parameters**

The quality parameter (Table 1) viz., crude protein content of fodder was significantly influenced by phosphorus levels, while fibre content remained unaffected. Significantly the highest crude protein content of fodder was recorded with application of P @ 50 kg $P_2O_5$ $ha^{-1}$ ($P_3$), which was at par with 40 kg $P_2O_5$ $ha^{-1}$ ($P_2$). While opposite was factual for treatment $P_0$ (control). In the present investigation, higher P content of fodder and subsequently higher uptake were recorded with the above mentioned treatments that lend support to enhance protein content under the effect. The favourable effect of phosphorus supply system on protein content of fodder could also be explained on the basis of better availability of desired and required nutrients in crop root zone resulting from its solubilization caused by the organic acid produced from the decaying organic matter and also the increased uptake by roots. This finding closely associated with Arya and Singh (2000) in maize.

### Effect on nutrient content and uptake

The content of P in fodder and uptake of P by fodder (Table 2) were significantly influenced by phosphorus levels but it was found non-significant with respect to N and K content and uptake. Significantly the highest phosphorus content and uptake were recorded with application of P @ 50 kg $P_2O_5$ $ha^{-1}$ ($P_3$). While, significantly the lowest phosphorus concentration and uptake was observed under treatment $P_0$ (control). Thus, significant improvement in uptake of P might be attributed due to the low level of available phosphorus already present in the soil under these treatments.

Higher photosynthetic activity in plant as evident from increase in biomass accumulation at successive duration and plant height reveals higher availability of metabolites from shoot to root. This might have promoted growth of root as well as their functional activity resulting in higher extraction of nutrients from soil environment to aerial parts.

The nutrient uptake is a function of yield and nutrient concentration in plant. Thus, significant improvement in uptake of P might be attributed to their concentration in fodder and associated with higher green forage yield. This might also be attributed to better availability of nutrients in the soil under phosphorus fertilization treatments. The results of present investigation are in close conformity with the findings of Arya and Singh (2000) and Rai *et al.* (1984) in maize.

### Effect on available nutrients in soil after harvest

The status of available P in the soil under application of P @ 50 kg $P_2O_5$ $ha^{-1}$ ($P_3$) significantly improved over rest of the P levels (Table-2). The application of phosphorus was found non-significant with respect to N and K in soil. The significant building up of available P status under this dose could be attributed to adequate supply of P to meet the crop demand. The results of present investigation strongly support the findings of Singaram and Kothandaraman (1994) and Krishnasamy *et al.* (1984).

### Economics of treatments

Data for net returns (Table 2) clearly indicated that the highest net returns of ₹ 28858 $ha^{-1}$ and CBR of 2.86 were accrued with application of 100 kg N $ha^{-1}$ ($N_3$). This can be attributed to higher green forage yield recorded with application of 100 kg N $ha^{-1}$ ($N_3$). With regard to phosphorus levels, application

**Table 2.** Effect of N and P levels on nutrient content, uptake, soil fertility status and economics of after harvest of forage maize

| Treatments | N content (%) | P content (%) | N uptake (kg $ha^{-1}$) | P uptake (kg $ha^{-1}$) | Available Nutrients (kg $ha^{-1}$) N | P | K | Organic carbon (%) | pH | Net return (₹$ha^{-1}$) | CBR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen levels (kg N $ha^{-1}$) | | | | | | | | | | | |
| $N_0$ – 0 | 0.91 | 0.138 | 25.65 | 5.84 | 228.11 | 26.50 | 240.89 | 0.49 | 8.49 | 23160 | 2.62 |
| $N_1$ – 60 | 0.98 | 0.141 | 30.54 | 5.92 | 243.26 | 26.48 | 244. | 0.52 | 8.54 | 26079 | 2.74 |
| $N_2$ – 80 | 1.17 | 0.144 | 38.46 | 6.03 | 266.72 | 26.83 | 244.40 | 0.56 | 8.77 | 28418 | 2.85 |
| $N_3$ – 100 | 1.23 | 0.145 | 40.33 | 6.16 | 274.66 | 28.00 | 245.66 | 0.58 | 8.98 | 28858 | 2.86 |
| S.Em.± | 0.04 | 0.005 | 1.93 | 0.10 | 4.32 | 0.79 | 1.36 | 0.017 | 0.14 | - | - |
| C.D. at 5% | 0.11 | NS | 5.56 | NS | 12.48 | NS | NS | 0.048 | NS | - | - |
| Phosphorus levels (kg $P_2O_5$ $ha^{-1}$) | | | | | | | | | | | |
| $P_0$ – 0 | 1.00 | 0.120 | 29.76 | 5.62 | 244.42 | 24.48 | 241.27 | 0.52 | 8.53 | 24360 | 2.70 |
| $P_1$ – 30 | 1.05 | 0.133 | 32.91 | 5.89 | 251.67 | 26.63 | 243.63 | 0.53 | 8.63 | 26323 | 2.72 |
| $P_2$ – 40 | 1.09 | 0.150 | 35.44 | 5.95 | 255.25 | 27.17 | 244.69 | 0.55 | 8.69 | 27010 | 2.73 |
| $P_3$ – 50 | 1.15 | 0.164 | 36.87 | 6.48 | 261.41 | 29.53 | 245.70 | 0.55 | 8.95 | 28398 | 2.79 |
| S.Em.± | 0.04 | 0.005 | 1.93 | 0.10 | 4.32 | 0.79 | 1.36 | 0.017 | 0.14 | - | - |
| C.D. at 5% | NS | 0.013 | NS | 0.30 | NS | 2.29 | NS | NS | NS | | |
| Interaction | | | | | | | | | | | |
| N X P | NS | NS | NS | NS | NS | NS | NS | NS | NS | - | - |
| C.V.% | 12.45 | 11.33 | 13.48 | 6.04 | 5.91 | 10.03 | 1.94 | 10.77 | 5.41 | - | - |
| Initial value | | | | | 258.18 | 27.67 | 236.20 | 0.54 | 8.0 | - | - |

of P @ 50 kg $P_2O_5$ $ha^{-1}$ ($P_3$) gave highest net returns of ₹ 28398 $ha^{-1}$ and CBR 2.79 owing to highest green forage. The reason is self-explanatory that green forage yield was highest with application of phosphorus in 50 kg $P_2O_5$ $ha^{-1}$. Reddy and Bhanumurthy (2010) also reported alike results.

## Conclusion

From foregoing it can be inferred that application of nitrogen @ 100 kg N $ha^{-1}$ ($N_3$) and phosphorus @ 50 kg $P_2O_5$ $ha^{-1}$ ($P_3$) was found best to obtain a good crop of forage maize with better growth, yield and quality as well as with maximum net returns of (₹ 28858 $ha^{-1}$ and ₹ 28398 $ha^{-1}$, respectively) and CBR (2.86 and 2.79 respectively).

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