Int.J.Curr.Microbiol.App.Sci (2018) *7*(6): 1763-1773

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 06 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.706.209

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

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A B S T R A C T

Keywords

Nitrogen, Uptake, Maize, Grain, Stover, Yield

Article Info

Accepted:
18 May 2018
Available Online:
10 June 2018

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_2O_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.

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_2O_5 as per the treatments and K_2O (60 kg K_2O 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_2O_5 ha^{-1} (P_2) and 40 kg P_2O_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_2O_5 ha^{-1} (P_2) and 40 kg P_2O_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_2O_5 ha^{-1} (P_3) during the first year and 60 kg P_2O_5 ha^{-1} (P_2) during the second year, while the lower uptake in both the years was recorded with 40 kg P_2O_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 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_2O_5 ha^{-1} (P_2) and 40 kg P_2O_5 ha^{-1} (P_1) respectively and all the treatments recorded on par values of nitrogen uptake during both the years (Fig. 4.1.10).

There was no interaction effect among nitrogen and phosphorus levels tried during both the years of study at all the growth stages and also by stover uptake.

Nitrogen uptake by grain

During the first year, higher nitrogen uptake by maize grain 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 first year higher nitrogen uptake was recorded with 60 kg P_2O_5 ha^{-1} (P_2) which was statistically on par with 80 kg P_2O_5 ha^{-1} (P_3). Similarly during second year of study higher nitrogen uptake was recorded with 60 kg P_2O_5 ha^{-1} (P_2) which was significantly superior over 80 kg (P_3) and 40 kg P_2O_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_2O_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_2O_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_2O_5 ha^{-1} (P_3).

Fig.1 Uptake of nitrogen (kg ha^{-1}) by *kharif* maize as influenced by nitrogen and phosphorus levels

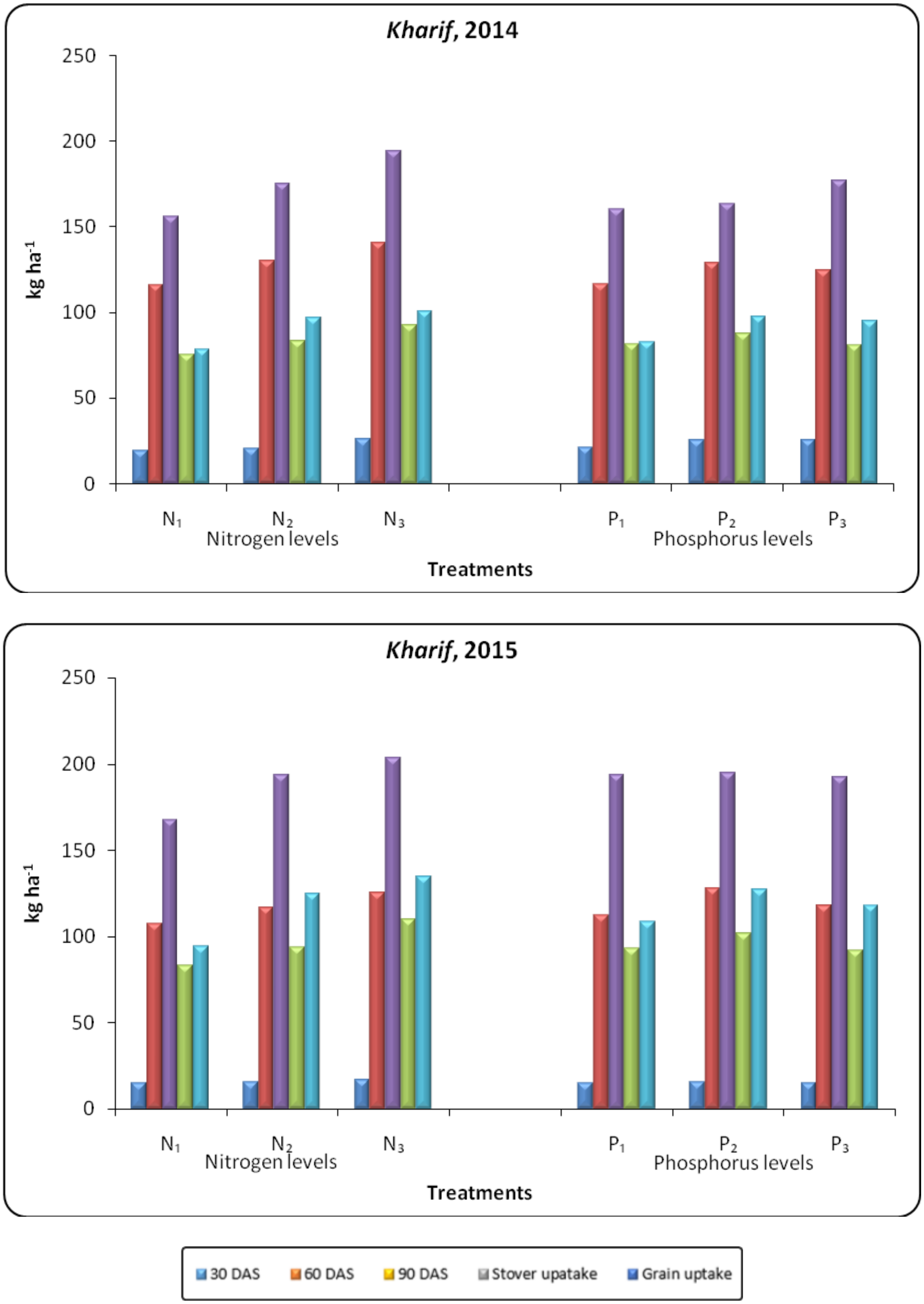

Fig.2 Grain and stover yield (kg ha^{-1}) of maize as influenced by nitrogen and phosphorus levels during *kharif*

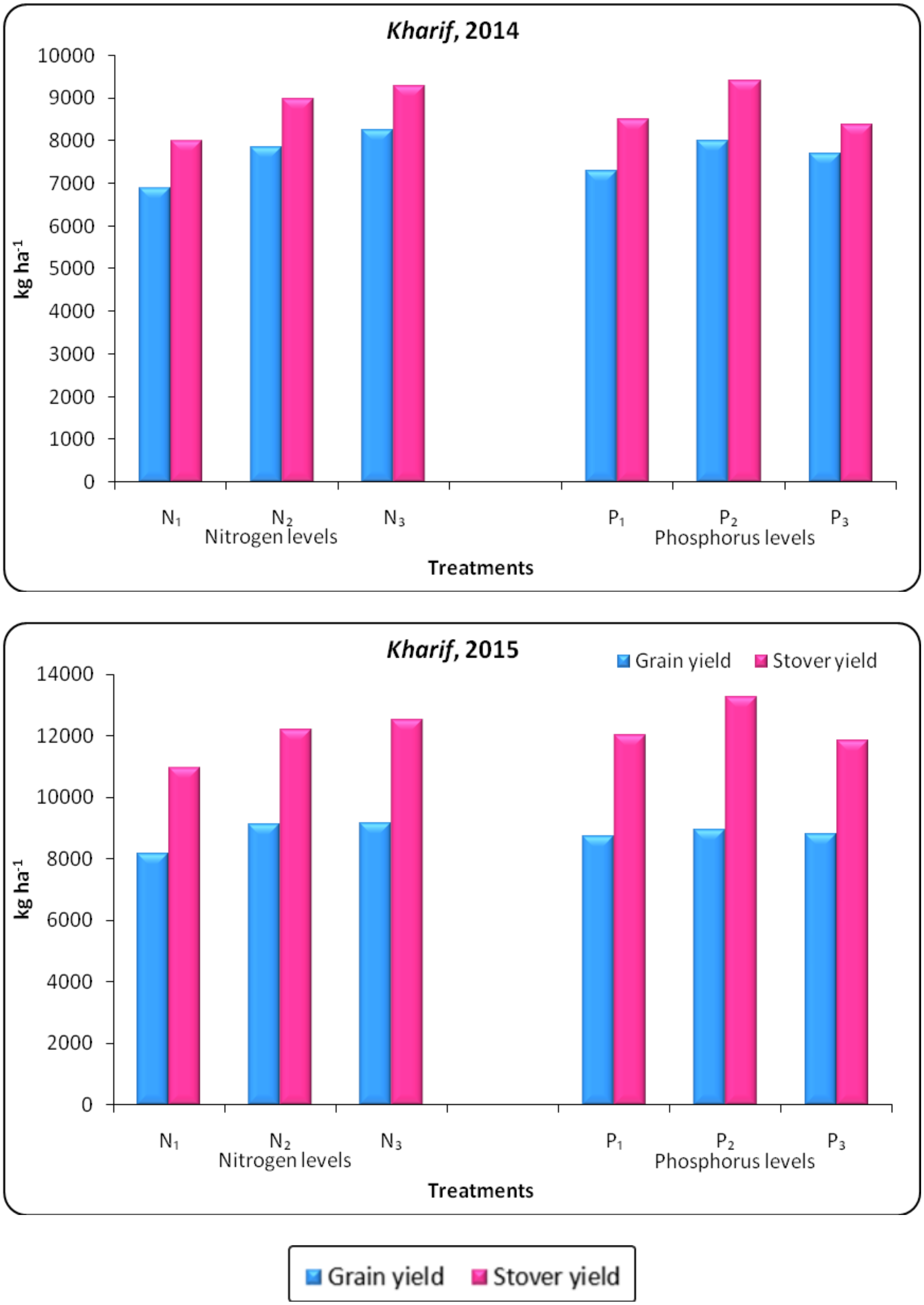

Table.1 Uptake of nitrogen (kg ha^{-1}) by *kharif* maize at different stages as influenced by nitrogen and phosphorus levels

	30 DAS		60 DAS		90 DAS		Stover Uptake		Grain Uptake	
Treatments	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Nitrogen levels (kg ha^{-1})										
N_1 : 200	19.9	14.7	116.2	107.2	156.4	167.2	75.6	82.8	78.6	94.1
N_2: 250	21.2	15.2	130.7	116.6	175.4	193.3	83.7	93.8	97.0	124.7
N_3: 300	26.4	16.5	141.3	125.1	194.3	203.4	92.8	109.7	101.1	134.9
SEm±	2.08	1.37	4.38	5.60	6.59	5.32	3.36	4.14	3.63	2.22
CD (P = 0.05)	6.2	NS	13.1	16.8	19.7	16.0	10.1	12.4	10.9	6.7
Phosphorus levels (kg ha^{-1})										
P_1: 40	21.24	14.9	116.7	112.2	160.4	193.7	82.0	92.8	82.9	108.6
P_2: 60	26.04	15.3	129.4	127.8	163.6	194.6	87.9	101.5	98.1	127.1
P_3: 80	25.80	15.0	124.7	117.6	177.5	192.2	81.3	91.9	95.6	118.0
SEm±	2.08	1.37	4.38	5.60	6.59	5.32	3.36	4.14	3.63	2.22
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	10.9	6.7
Interaction										
SEm±	3.59	2.37	7.59	9.70	11.41	9.22	5.82	7.17	6.28	3.85
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	18.8	11.5

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

	Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})	
Treatments	2014	2015	2014	2015
Nitrogen levels (kg ha^{-1})				
N_1 : 200	6885	8170	7997	10951
N_2: 250	7832	9116	8961	12186
N_3: 300	8231	9146	9277	12517
SEm±	124.4	125.5	252.9	402.3
CD (P=0.05)	373	376	758	1206
Phosphorus levels (kg ha^{-1})				
P_1: 40	7271	8714	8491	12003
P_2: 60	7983	8936	9387	13240
P_3: 80	7693	8781	8357	11844
SEm±	124.4	125.5	252.9	402.3
CD (P=0.05)	373	NS	758	1206
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_2O_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_2O_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_2O_5 ha^{-1} recorded more uptake of nitrogen over lower and higher P_2O_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_2O_5 ha^{-1} (P_2) resulted in higher grain yield, which was however statistically on par with 80 kg P_2O_5 ha^{-1} (P_3). Significantly lowest grain yield was obtained with 40 kg P_2O_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_2O_5 ha^{-1}. Further increase in P from 60 to 80kg P_2O_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_2P_2 (250 kg N + 60 kg P_2O_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 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_2O_5 ha^{-1} (P_2) (Fig. 2) followed by 40 kg P_2O_5 ha^{-1} (P_1) with significant disparity between them. The lowest stover yield was resulted with the phosphorus level of 80 kg P_2O_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_2O_5 ha^{-1}. Further increase in phosphorus from 60 to 80 kg P_2O_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_2O_5 ha^{-1} in the first year, 300 kg N and 60 kg P_2O_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_2O_5 ha^{-1} while the lowest was with 200 kg N and 40 kg P_2O_5 ha^{-1}.

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How to cite this article:

Vijaya Bhaskar Reddy U., G. Prabhakara Reddy, M. Srinivasa Reddy and Kavitha P. 2018. Nitrogen Uptake and Yield of Maize as Influenced by Nitrogen and Phosphorus Levels during *Kharif* Season. *Int.J.Curr.Microbiol.App.Sci*. 7(06): 1763-1773.
doi: https://doi.org/10.20546/ijcmas.2018.706.209