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Potassium uptake at different growth stages in relation to yield of maize as influenced by various nitrogen and phosphorus levels during *Kharif* season

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Abstract
The experiment was carried out during two consecutive *kharif* seasons of 2014 and 2015 years to evaluate the potassium uptake of maize at different growth stages and its yield as influenced by various nitrogen (200, 250 and 300 kg ha^{-1}) and phosphorus (40, 60 and 80 kg ha^{-1}) levels. The uptake of potassium was found to increase with each successive increase in nitrogen level from 200 to 300 kg ha^{-1} and phosphorus was only up to 60 kg ha^{-1} with increase in age of the crop with higher uptake of potassium nutrient 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 levels of 300 kg ha^{-1} and 200 kg ha^{-1} and with P levels of 60 kg ha^{-1} and 40 kg ha^{-1} respectively.

Keywords: Potassium, uptake, maize, grain, stover, yield

Introduction
Maize (*Zea mays* L.) is the third most important cereal after rice and wheat for 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) [20]. 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}.

The demand for maize owing to increased 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) [4]. Among the factors limiting the amount of possibly obtainable higher yield, mineral nutrient imbalances play a major role. Adjustment of the fertilization system to plant quantitative needs and especially to nutrient uptake dynamics in field crops, results in balance in the functions of individual nutrients (Roberts, 2008) [19]. 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 deleterious effects. In support of the maximum crop response, nitrogen needs and adequate phosphorus levels as well as prospective nutrient interactions in potassium uptake. The aim of the present study was to assess potassium contents in maize as well as its accumulation in this crop at all the stages of crop growth, under differentiated levels 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 consecutive *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}), high 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. 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 potassium, employing the standard procedures as outlined by Jackson (1973) [8] 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.

Results and Discussion

Potassium uptake at 30 DAS

Crop fertilized with 300 kg N ha^{-1} (N_3) resulted in significantly higher uptake of potassium over lower doses during the first year of study and though similar trend was observed during the second year also but all the N levels were on par with each other (Table. 1). Application of nitrogen at 200 kg N ha^{-1} (N_1) recorded the lowest potassium uptake which was however on par with 250 kg N ha^{-1} (N_2).

Potassium uptake was higher with the application of phosphorus at 60 kg ha^{-1} (P_2) but all the levels recorded on par values of potassium uptake during both the years.

Potassium uptake at 60 DAS

Potassium uptake of maize was significantly higher with the application of nitrogen at 300 kg ha^{-1} (N_3) but it was on par with 250 kg ha^{-1} (N_2) during the first year (Table. 1). Similar trend was observed during second year also but the application of 300 kg ha^{-1} (N_3) recorded statistically superior potassium uptake values over other lower doses.

Maize supplied with 60 kg P_2O_5 ha^{-1} (P_2) registered the higher potassium uptake, which in turn was on par with 80 kg P_2O_5 ha^{-1} (P_3) level during the first year. Phosphorus applied at the rate of 40 kg ha^{-1} (P_1) resulted in the lowest potassium uptake. Similar trend was observed in the second year also but all the values of potassium uptake were on par with each other.

Potassium uptake at 90 DAS

There was no significant difference among the N levels tried with respect to potassium uptake at 90 DAS (Table. 1). However, potassium uptake was higher with the application of nitrogen at 300 kg ha^{-1} (N_3) and lower with 200 kg N ha^{-1} (N_1) during both the years.

Different phosphorus levels failed to exert significant influence on potassium uptake at 90 DAS. However, maize fertilized with 80 kg P_2O_5 ha^{-1} (P_3) registered the higher potassium uptake during the first year. But in second year, phosphorus applied at the rate of 60 kg ha^{-1} (P_2) recorded higher potassium uptake. Phosphorus applied at the rate of 40 kg ha^{-1} (P_1) resulted in the lowest potassium uptake, during both the years.

Interaction effect of nitrogen and phosphorus levels tried on uptake of potassium upto 90 DAS was not significant.

Potassium uptake by stover

Potassium uptake was higher with the application of nitrogen at 300 kg ha^{-1} (N_3), which was significantly superior over remaining nitrogen doses (Table. 1). Crop fertilized with 200 kg N ha^{-1} (N_1) recorded significantly lowest potassium uptake, during both the years.

Application of phosphorus at 60 kg ha^{-1} (P_2) recorded higher potassium uptake but it was on par with other phosphorus levels during the first year. Similarly, during the second year, application of 60 kg P_2O_5 ha^{-1} (P_2) recorded significantly higher potassium uptake over 40 kg ha^{-1} (P_1) which was superior over 80 kg ha^{-1} (P_3). Phosphorus applied at the rate of 80 kg ha^{-1} (P_3) resulted in the lowest potassium uptake during both the years.

Interaction among nitrogen and phosphorus levels existed during both the years (Table. 2) with regard to potassium uptake by stover. In the first year, at 40 kg ha^{-1} (P_1) and 60 kg ha^{-1} (P_2) phosphorus levels potassium uptake at harvest was statistically superior with 300 kg N ha^{-1} (N_3). At 200 kg (N_1) and 250 kg N ha^{-1} (N_2) doses, no phosphorus level has shown its significant superiority over other phosphorus levels. But at 300 kg N ha^{-1} (N_3) level potassium uptake was significantly highest with 60 kg P_2O_5 ha^{-1} (P_2). During the second year at 40 kg P_2O_5 ha^{-1} (P_1) level, application of 250 kg (N_2) and 300 kg N ha^{-1} (N_3) recorded significantly higher potassium uptake over 200 kg N ha^{-1} (N_1). But at 60 kg P_2O_5 ha^{-1} (P_2) potassium uptake by 300 kg N ha^{-1} (N_3) treatment was significantly higher but on par with 250 kg N ha^{-1} (N_2) which intern was superior over 200 kg N ha^{-1} (N_1). At 80 kg P_2O_5 ha^{-1} (P_3) level potassium uptake was on par in all the nitrogen levels.

Potassium uptake by grain

Potassium uptake was significantly higher with the application of nitrogen at 300 kg ha^{-1} (N_3), which was however on par with 250 kg N ha^{-1} (N_2) during both the years of study (Table. 1).

Potassium uptake of maize was higher with the application of phosphorus at 60 kg ha^{-1} (P_2), which was however on par with 80 kg P_2O_5 ha^{-1} (P_3). Significantly lower uptake of potassium was recorded with the application of phosphorus at 40 kg ha^{-1} (P_1). Similar results were recorded during both the years of study.

Interaction among nitrogen and phosphorus levels existed during the second year (Table. 3) with regard to potassium uptake by grain. At 40 kg (P_1) and 80 kg P_2O_5 ha^{-1} (P_3) level potassium uptake was significantly higher with 300 kg N ha^{-1} (N_3). But at 60 kg P_2O_5 ha^{-1} (P_2) level 250 kg N ha^{-1} (N_2) recorded significantly higher values of potassium uptake. At 200 kg (N_1) and 250 kg N ha^{-1} (N_2) level potassium uptake was significantly higher with 60 kg P_2O_5 ha^{-1} (P_2). But at 300 kg N ha^{-1} (N_3) level potassium uptake was higher with 80 kg P_2O_5 ha^{-1} (P_3) which was however on par with other remaining P levels.

Significantly, the higher uptake of potassium was recorded at all the growth stages with the application of nitrogen at 300 kg ha^{-1} (N_3) followed by 250 kg ha^{-1} (N_2) and 200 kg ha^{-1} (N_1). The increased uptake of potassium might be due to the fact that increased supply of nitrogen might have resulted in more root volume to explore more volume of soil for absorption of potassium. These results are in agreement with the findings of Singh and Totawat (2002), Kumar and Singh (2003), Hussaini *et al.* (2008), Mala (2008), Gosavi and Thorat (2009), Sunitha and Reddy (2012), Mahajan *et al.* (2013) and Sobhana *et al.* (2013) [22, 11, 7, 14, 5, 25, 13, 23].

Higher uptake of potassium was recorded with the application of phosphorus at 60 kg P_2O_5 ha^{-1} (P_2) over 40 kg P_2O_5 ha^{-1} (P_1). This higher uptake of potassium may be due to balanced availability of all nutrients at 60 kg P_2O_5 ha^{-1} (P_2) over other levels. Similar findings were reported by Paramasivan *et al.* (2013) [17].

Interaction existed among nitrogen and phosphorus levels at harvest stage *i.e* both in stover and grain. Significantly higher potassium uptake was recorded in N_3P_2 (300 kg N + 60 kg P_2O_5 ha^{-1}) treatment in the stover, while in grain it was by N_3P_3 (300 kg N + 80 kg P_2O_5 ha^{-1}). Similar results of higher potassium uptake was recorded by Kedar *et al.* (2005), Singh *et al.* (2010) and Kumar *et al.* (2015) [10, 21, 12].

Yield

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 other N levels (Table. 4). 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). 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) [15, 16, 26]. The lowest grain yield was associated with 200 kg N ha^{-1} (N_1) during both the years.

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 levels from 60 to 80 kg P_2O_5 ha^{-1}, failed to record statistical significance.

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 nitrogen, phosphorus and potassium utilization in plant metabolism. Similar results were obtained by Araei and Mojaddam (2014) and Nsanzabaganwa *et al.*, (2014) [2, 15]. 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. 5). The balanced nitrogen and phosphorus levels might have helped in efficient absorption and utilization of other required plant nutrients including potassium which ultimately increased the grain yield. Similar results were obtained by Jaliya *et al.*, (2008) and Abera *et al.*, (2009) [9, 1].

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. 4).

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) 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) [24, 18, 6, 16].

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) [3, 2, 15].

Table 1: Uptake of potassium (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	33.4	25.8	127.3	117.2	204.3	190.2	160.4	176.0	47.9	50.7
N_2: 250	35.1	28.9	166.9	143.7	215.2	234.3	180.8	233.1	50.1	54.1
N_3: 300	42.7	32.0	183.6	189.1	236.1	240.8	216.1	250.3	54.2	56.5
SEm±	2.49	1.88	8.29	9.78	15.62	15.27	9.78	8.54	1.50	1.03
CD (P = 0.05)	7.5	NS	24.8	29.3	NS	NS	29.3	25.6	4.5	3.1
Phosphorus levels (kg ha^{-1})										
P_1: 40	33.3	30.7	144.4	145.6	201.9	211.8	185.1	225.6	47.6	50.8
P_2: 60	40.1	32.7	187.7	159.7	216.6	231.6	204.5	239.1	52.3	56.8
P_3: 80	37.8	28.3	165.8	144.7	237.2	221.9	167.7	194.7	48.8	53.7
SEm±	2.49	1.88	8.29	9.78	15.62	15.27	9.78	8.54	1.50	1.03
CD (P = 0.05)	NS	NS	24.8	NS	NS	NS	NS	25.6	4.5	3.1
Interaction										
SEm±	4.32	3.26	14.36	16.94	27.05	26.45	16.95	14.80	2.60	1.78
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	50.8	44.4	NS	5.3

Table 2: Potassium uptake (kg ha^{-1}) by *kharif* maize stover as influenced by interaction of nitrogen and phosphorus levels interaction between N and P levels in 2014

	P_1	P_2	P_3	Mean
N_1	158.4	157.5	165.4	160.4
N_2	191.7	182.9	167.9	180.8
N_3	205.3	273.1	169.7	216.1
Mean	185.1	204.5	167.7	
SEm±		16.95		
CD (P = 0.05)		50.8		

Interaction between N and P levels in 2015

	P_1	P_2	P_3	Mean
N_1	152.7	189.4	185.8	176.0
N_2	255.0	253.3	191.1	233.1
N_3	269.0	274.5	207.2	250.3
Mean	225.6	239.1	194.7	
SEm±		14.80		
CD (P = 0.05)		44.4		

Table 3: Potassium uptake (kg ha^{-1}) by *kharif* maize grain as influenced by interaction of nitrogen and phosphorus levels during 2015

	P_1	P_2	P_3	Mean
N_1	45.8	53.7	52.6	50.7
N_2	50.9	61.1	50.3	54.1
N_3	55.7	55.5	58.3	56.5
Mean	50.8	56.8	53.7	
SEm±		1.78		
CD (P = 0.05)		5.3		

Table 4: Grain and stover yield (kg ha^{-1}) of maize as influenced by nitrogen and phosphorus levels during *kharif* season

	Grain yield		Stover yield	
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 5: Grain yield (kg ha^{-1}) of maize as influenced by interaction between nitrogen and phosphorus levels during *kharif*, 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		

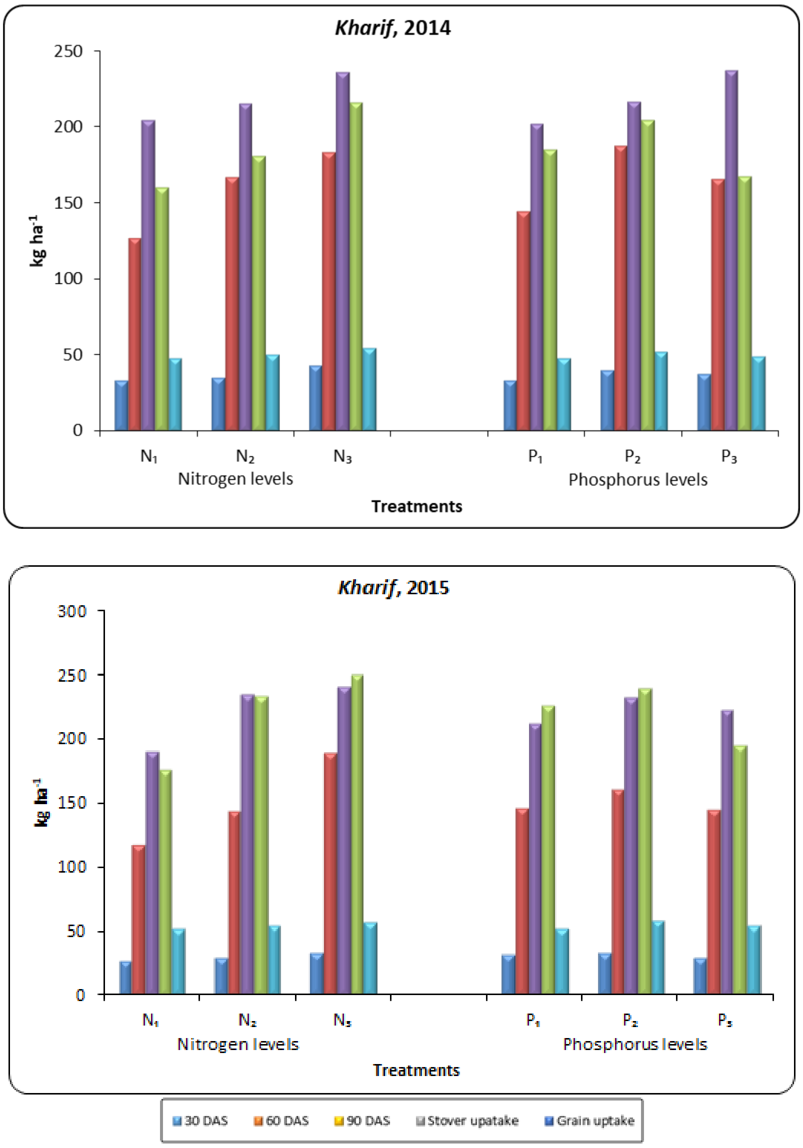
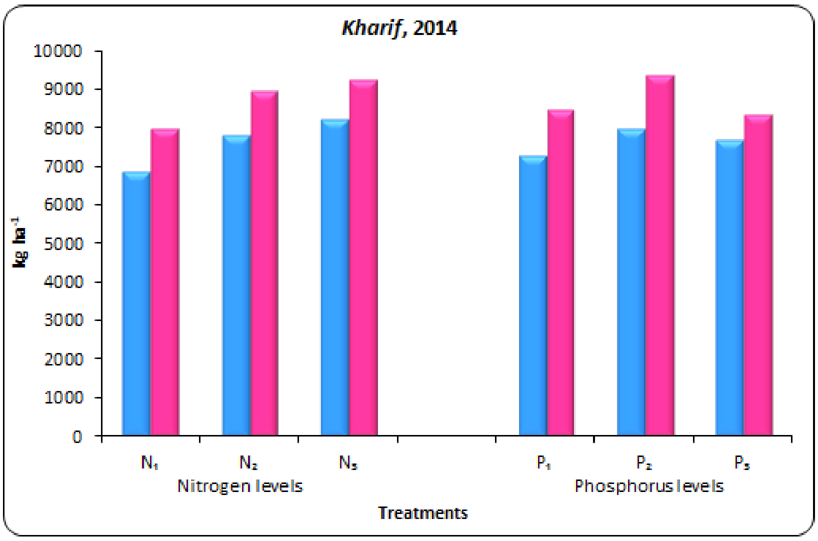


Fig 1: Uptake of potassium (kg ha^{-1}) by *kharif* maize as influenced by nitrogen and phosphorus levels



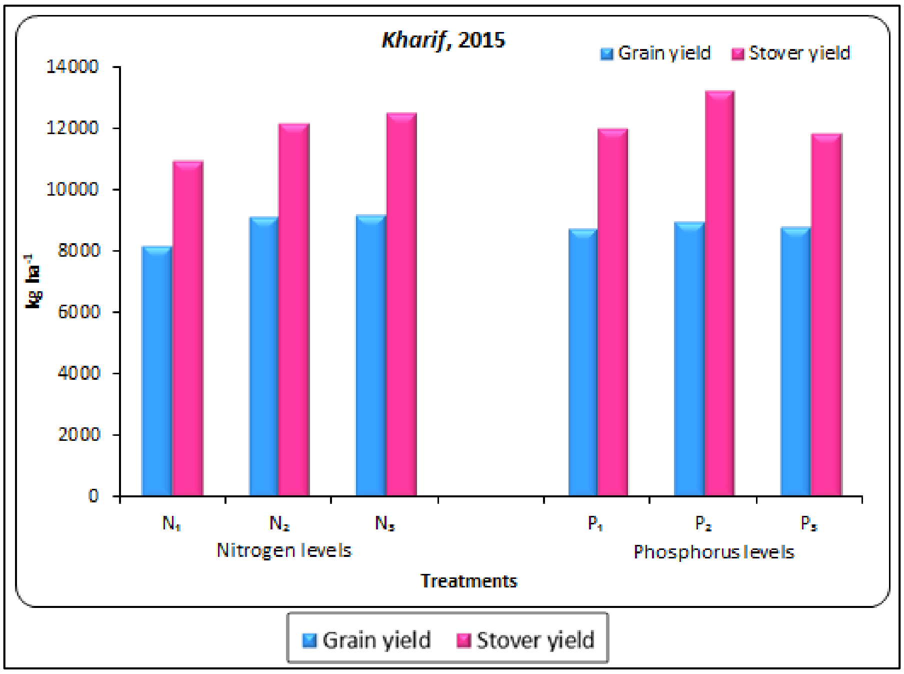


Fig 2: Grain and stover yield (kg ha^{-1}) of maize as influenced by nitrogen and phosphorus levels during *kharif* season.

References

1. Abera T, Feyisa D, Friesen DK. Effects of crop rotation and N-P fertilizer rate on grain yield and related characteristics of maize and soil fertility at Bako, Western Oromia, Ethiopia. East African Journal of Sciences. 2009; 3(1):70-79.
2. Araei M, Mojaddam M. The effect of different levels of phosphorus from triple super phosphate chemical fertilizers and biological phosphate fertilizer (fertile 2) on physiological growth parameters of corn (*sc* 704) in Ahvaz weather conditions. International Journal of Plant, Animal and Environmental Sciences. 2014; 4: 625-632.
3. Arunkumar MA, Gali SK, Hebsur NS. Effect of different levels of NPK on growth and yield parameters of sweet corn. Karnataka Journal of Agricultural Sciences. 2007; 20(1):41-43.
4. DMR. DMR Vision 2030. Directorate of Maize Research, Indian Council of Agricultural Research, New Delhi, 2011.
5. Gosavi SP, Thorat SB. Effect of mulches, levels of fertilizer and organic manure on yield and nutrient uptake of *rabi* sweet corn (*Zea may ssaccharata*). Green Farming. 2009; 2(12): 852-853.
6. Hoshang R. Effect of plant density and nitrogen rates on morphological characteristics in grain maize. Journal of Basic and Applied Scientific Research. 2012; 2(5):4680-4683.
7. Hussaini MA, Ogunlela VB, Ramalan AA, Falaki AM. Mineral composition of dry season maize (*Zea mays* L.) in response to varying levels of nitrogen, phosphorus and irrigation at Kadawa, Nigeria. World Journal of Agricultural Sciences. 2008; 4(6):775-780.
8. Jackson ML. Soil Chemical Analysis. Prentice hall of India Pvt. Ltd. New Delhi, 1973, 38-82.
9. Jaliya MM, Falaki AM, Mahamud M, Sani YA. Effect of sowing date and NPK fertilizer rate on yield and yield components of quality protein maize. ARPN Journal of Agricultural and Biological Science. 2008; 3(2):23-29.
10. Kedar P, Verma CP, Verma RN, Ram P. Effect of soil conditioners and fertilizer doses on nutrient uptake by maize crop in Maize–Wheat sequence. Crop Research. 2005; 29(1):19-22.
11. Kumar M, Singh M. Effect of nitrogen and phosphorus levels on yield and nutrient uptake in winter maize (*Zea mays* L.) under rainfed conditions of Nagaland. Crop Research. 2003; 25(1):46-49.
12. Kumar R, Bohra JS, Singh AK, Kumawat N. Productivity, profitability and nutrient-use efficiency of babycorn (*Zea mays*) as influenced by varying fertility levels. Indian Journal of Agronomy. 2015; 60(2):285-290.
13. Mahajan G, Singh RN, Kumar R. Growth, yield, nutrient uptake and net return of sweet corn (*Zea mays saccharata* Sturt.) with different fertilizer levels, plant densities and sulphur nutrition. Current Advances in Agricultural Sciences. 2013; 5(2):201-204.
14. Mala S. Response of hybrid maize to crop residue incorporation in combination with graded levels of nitrogen. Ph. D Thesis. Acharya N.G. Ranga Agricultural University, Hyderabad, Andhra Pradesh, 2008.
15. Nsanzabaganwa E, Das TK, Rana DS. Nitrogen and phosphorus effects on the growth, phenology, heat and nutrients accumulation and yield of winter maize (*Zea mays*) in Western Indo-Gangetic Plains. Indian Journal of Agricultural Sciences. 2014; 84(5):661-664.
16. Om H, Singh SP, Singh JK, Singh RN, Ansari MA, Meena RL *et al*. Productivity, nitrogen balance and economics of winter maize (*Zea mays*) as influenced by QPM cultivars and nitrogen levels. Indian Journal of Agricultural Sciences. 2014; 84(2):306-308.
17. Paramasivan M, Malarvizhi P, Tiyageswari S. Effect of balanced nutrition on yield, nutrient uptake and soil fertility of maize (*Zea mays* L.) in an inceptisol of Tamil Nadu. The Andhra Agricultural Journal. 2013; 60(1): 64-69.
18. Reddy MM, Padmaja B, Reddy DVV. Response of maize to irrigation scheduling and nitrogen doses under no-till condition in rice fallows. Journal of Research, ANGRAU. 2012; 40(1):6-12.
19. Roberts TL. Improving nutrient use efficiency. Turkish Journal of Agriculture and Forestry. 2008; 32:177-182

20. Saikumar R, Kumar B, Kaul J, Chikkappa S, Karjagi G, Jat SL, Parihar CM *et al*. Maize research in India-historical prospective and future challenges. Maize Journal. 2012; 1(1):1-6.
21. Singh MK, Singh RN, Singh SP, Yadav MK, Singh VK. Integrated nutrient management for higher yield, quality and profitability of baby corn (*Zea mays*). Indian Journal of Agronomy. 2010; 55(2):100-104.
22. Singh R, Totawat KL. Effect of integrated use of nitrogen on the performance of maize (*Zea mays* L.) on haplustalfs of sub-humid southern plains of Rajasthan. Indian Journal of Agricultural Research. 2002; 36(2):102-107.
23. Sobhana V, Kumar A, Singh I. Plant population and nutrient needs of baby corn (*Zea mays* L.) hybrids. Crop Research. 2013; 45(1, 2 & 3):117-120.
24. Srikanth M, Amanullah MM, Muthukrishnan P. Yield and economics of hybrid maize (*Zea mays* L.) as influenced by plant density and fertilizer levels. Green Farming. 2009; 2(4):203-205.
25. Sunitha N, Reddy PM. Effect of graded nutrient levels and timing of nitrogen application on yield and quality of sweet corn. Madras Agricultural Journal. 2012; 99(4-6):240-243.
26. Thimmappa V, Reddy MS, Reddy UVB, Reddy ST. Effect of nitrogen levels and plant densities on growth parameters, yield attributes and yield of *kharif* maize (*Zea mays* L.). Crop Research. 2014; 47(1, 2 & 3):29-32.