Phosphorus Requirement and Its Use Efficiency in Zero Tilled Maize After Kharif Rice

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ABSTRACT. Field experiment was conducted during Rabi 2010-11 and Rabi 2011-12 at the College Farm, College of Agriculture, Rajendranagar, Hyderabad, to study the effect of different phosphorus levels (0, 25, 50, 75, and 100% the recommended dose of phosphorus) on yield and phosphorus uptake parameters of zero tilled maize grown after kharif rice by using P^{32} radio isotope. The maize grain and stover yields increased by 45 and 34%, respectively, over the control due to application of 100% recommended dose of phosphorus (RDP). Application of 100% RDP gave the highest yields of maize grain (5478 kg/ha) and stover (7773 kg/ha) than those on plots applied with the other levels of P fertilizer. The highest dry matter yield (6627 kg/ha) and P uptake (12.08 kg/ha) at flowering stage were recorded at 100% RDP. The percentages of P derived from the fertilizer and the P uptake by maize plants at flowering stage increased up to 75% RDP while at 100% RDP it decreased slightly. The highest percentages of P derived from the P fertilizer (10.44%) and the P uptake (1.21 kg/ha) were noticed when P was applied at 75% RDP. The percentages of P use efficiency decreased from 10.6% at 25% RDP to 6.8%, 6.1%, and 4.3%, respectively, due to the increase in P applications at 50%, 75%, and 100% RDP.

Key words: Zero tilled maize, P levels, P-use efficiency, maize.

Introduction

In Andhra Pradesh, India, rice-rice is the predominant cropping sequence under assured irrigated regions, where 94% of the rice cropped area is transplanted under irrigation. Farmers are turning to diversify their crops with maize, sorghum, and sunflower under zero tillage condition immediately after harvest of wet land rice crop, especially in areas of Andhra Pradesh, where double cropping of rice is becoming difficult due to shortage of irrigation water. Investigations showed that rice-maize and rice-sunflower cropping sequences were found better than other crops (Avil Kumar *et al.* 2005). There is a tremendous increase in area, production, and productivity in non-traditional areas of Andhra Pradesh mainly due to adoptions of high yielding hybrids under zero-tilled conditions in rice–fallows. Presently, maize under rice-maize sequence covers an area of 0.25 million ha in coastal area of Andhra Pradesh with yield potential of 7.2-8.8 t/ha (Anonymous 2009).

Nutrient management especially phosphorus management in rice based cropping system is another area for successful crop production. The unique conditions created by submergence influenced the transformation and availability of both native and applied phosphorus (P) fertilizer. In the zero tilled condition, due to less mineralization, more quantity of nutrients is required than in the normal tillage condition. Therefore, rationalization of P is essential under this condition for obtaining maximum crop yields. The current recommended dose of P fertilizer application (RDP) for maize crops was 60kg P_2O_5/ha. The present investigation was initiated to study the P requirement and its use efficiency in a zero tilled maize crop after kharif rice.

Materials and Methods

A field experiment was conducted during *rabi* 2010 and 2011 at the Agricultural College farm of Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad. The initial characteristics of the experimental fields as determined following standard procedures (Tandon 1993) are presented in Table 1. The soils were normal without any salt problem and excess free $CaCo_3$. The soils were low in available N, medium in available P_2O_5, and high in available K_2O. During kharif 2010 and 2011, rice crop was grown with recommended doses of fertilizers (120-60-40 kg/ha NPK). After harvest the kharif rice, the field was allowed to dry and maize was sown in rows at 60 cm apart by opening small furrows with a cultivator.

Fertilizers were applied in the furrow, maize seeds (variety DHM-117) were dibbled, and the field was irrigated. Five levels namely 100, 75, 50, 25 and 0 % RDP were imposed as treatments. Each treatment plot was divided into two parts, i.e., main plot and micro plot, separated by a small bund. The micro plots were laid out in such a way that they

were blocked on both sides by main plots. Recommended doses of N (120kg/ha) and K_2O (40 kg/ha) were applied uniformly to all the treatment plots. Parts of N and P_2O_5 as per treatment were supplied through DAP. Balances of N and K_2O were applied through urea and MOP. The entire dose of P_2O_5 and K_2O were applied at the time of sowing, while the N was applied in three equal splits as recommended, i.e., at sowing, knee high, and tasseling stages. Maize plants in the micro plots were treated with P in DAP that was tagged with ^{32}P radioisotope @ 12.95 MBq (0.35mCi)/g P_2O_5, while the plants in the main plots were treated with P from the untagged DAP. The treatments were replicated five times in a randomized block design. The crop was grown duly following the standard package of practices. The plants in the main plots were used exclusively for recording maize yield, while the plants in the micro plots were used for estimating the chemical constituents.

Plant samples were collected at the tasseling stage to determine yields of plant dry matter and P uptake parameters. Grain and stover yields of maize and P uptakes were determined at harvest. Radioassay of ^{32}P in plant samples was carried out following the procedure given by IAEA (1990). The radiation counting was done with a Geiger-Muller counter (Model- RCS 4207A).

Table1. Some soil characteristics in the experimental plots at The the College Farm, College of Agriculture, Rajendranagar, Hyderabad, in Rabi 2009-2010 and Rabi 2010-2011.

Characteristics	Rabi	
	2009-10	2010-11
pH	7.9	7.4
EC (dSm^{-1})	0.82	1.32
Available N (kg/ha)	245	176
Available P_2O_5 (kg/ha)	48	46
Available K_2O (kg/ha)	476	406

Results and Discussion

Dry Matter Yields of Maize at the Tasseling Stage

Dry matter accumulation of maize increased with the increased rates of P fertilizer application. The dry matter yield of maize at the tasseling stage increased gradually and significantly with the increased levels of P fertilizer application from 0 to 25, 50, 75, and 100% RDP (Table 2). The highest dry matter yield (6627 kg/ha) was recorded at 100% RDP. The dry matter yield recorded at 25% RDP was significantly less than those obtained at the other higher levels of P application. These results were in agreement with that reported by Hussein *et al.* (2009).

P-content and P-uptake by Maize Plants at the Tasseling Stage

No regular trend was observed in the P-content (Table 2) of maize dry matter at the tasseling stage. The highest P-content (0.19%) was noticed with the application of 25% RDP over the other levels of P applications. With regards to the P-uptake by the maize plants, it increased significantly with increasing the levels of P doses from 0 to 100 % RDP. The highest P-uptake (12.08 kg/ha) by maize dry matter at the tasseling stage was recorded due to the application of 100% RDP. The higher dry matter yield at !00% RDP might be the reason for the higher P-uptake. Increases in P-uptakes with increased levels of P application were also reported by Surendra Babu *et al.* (2005).

Table 2. Effect of different levels of P fertilizer applications on yields of maize dry matter and P uptake parameters in zero tilled maize at tasseling stage.

Treatment	Dry matter (kg/ha)	P-content (%)	P-uptake (kg/ha)	% Pdff	P fertilizer uptake (kg/ha)	P use efficiency (%)	Soil P uptake (kg/ha)
Control	4108	0.15	6.27	——	——	——	——
25% RDP	4426	0.19	8.24	8.48	0.69	10.58	7.54
50% RDP	5567	0.18	10.03	8.85	0.89	6.76	9.14
75% RDP	6328	0.18	11.55	10.44	1.21	6.13	10.35
100% RDP	6627	0.18	12.08	9.23	1.12	4.25	10.97
Mean	5411	0.17	9.63	9.25	0.98	6.93	9.50
CD (p=0.05)	276.4	0.024	1.07	0.90	0.49	0.59	1.17

Notes: RDP = Recommended Dose of P Fertilizer. %Pdff = Percentage of P derived from the fertilizer. CD (p=0.05) = Coefficient of Deviation at 5% level of significance.

Percentage of P derived from the Fertilizer (%Pdff)

The percentages of P derived from the fertilizer in the maize plants at the tasseling stage were significantly influenced by the level of P applications (Table 2). The mean percentages of P derived from the fertilizer (%Pdff) were higher with the increasing levels of P fertilizer application up to 75% RDP and thereafter it decreased. The %Pdff recorded at 25 and 50% RDP were on par with each other. The increase in %Pdff with the increasing levels of P application was due to its higher availability in soil. These results were in accordance with the results of Sonali Mazumdar *et al.* (2004).

Phosphorous Fertilizer Uptake

The P fertilizer uptakes (P-uptake) by the maize plants at the tasseling stage followed the trend similar to the %Pdff that was more influenced by the yields (Table 2). The P-uptake observed at 25% and 50% RDP, and at 50, 75, and 100% RDP were on par with each other.

Phosphorous Fertilizer Use Efficiency

The P fertilizer use efficiency by the maize plants was significantly affected by the P fertilizer application (Table 2). The percentages P use efficiency decreased gradually with the increasing levels of P application. The P use efficiency decreased from 10.6% at 25% RDP to 6.8%, 6.1%, and 4.3% due to the increases in the P applications to 50%, 75%, and 100% RDP, respectively. The P use efficiency recorded at 50% and 75% RDP were statistically on par. The magnitude of decreases in the applied P use efficiency by the crop were more at high levels of P application with in recommended dose. These results were in line with the results reported by Surendra Babu *et al*. (2005).

Grain and Stover Yields

The maize grain and stover yields were significantly influenced by the P levels under zero tillage condition after the kharif rice (Table 3). The grain and the stover yields were increased by 45 % and 34%, respectively, over the control or 100% RDP. The grain yields recorded at 25, 50, and 75% RDP were not significantly different, and the straw yields recorded at 50 and 75% RDP were statistically on par. The significant improvements in the grain and stover yields at higher levels of P fertilizer applications might be due to more dry matter accumulations and thereby ultimately the more grain yields. The response to applied P fertilizer was more because of the low contribution of native soil P due to less mineralization under the zero tillage condition (Selles *et al.* 1997).

P-uptake by Maize Grain and Stover

P-uptakes by the maize grain and stover (Table 3) increased significantly with the increasing levels of P applications. The highest P-uptake by the maize grain and stover was noticed with application of 100% RDP when compared to other levels of P in this study. The increase in P-uptakes with the increase levels of P applications were mainly due to higher grain and stover yields at high levels of P.

The present investigation indicated that in a medium status of P in the soil, the application of 100% RDP, which was 60 kg P_2O_5/ha, on maize resulted in a higher grain yield in the zero tilled maize after kharif rice. The applied P fertilizer use efficiency was more at lower levels of P applications than those at higher levels of P application.

Table 3. Effect of different levels of P fertilizer applications on grain and stover yields of maize and P uptake in a zero tilled maize crop at harvest stage.

Treatment	Grain yield (kg/ha)	P-content (%)	P-uptake (kg/ha)	Stover yield (kg/ha)	P-content (%)	P-uptake (kg/ha)
Control	3788	0.18	6.82	5615	0.07	3.93
25% RDP	4384	0.20	8.77	6326	0.08	5.06
50% RDP	4661	0.22	10.25	6869	0.08	5.49
75% RDP	4815	0.22	10.59	7329	0.09	6.60
100% RDP	5478	0.21	11.50	7773	0.09	7.00
Mean	4625	0.21	9.59	6782	0.08	5.62
CD (p=0.05)	404	0.018	0.82	503	0.008	0.49

Notes: RDP = recommended dose of P application. CD (p=0.05) = Coefficient of Deviation at 5% level of significance.

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