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Influence of applied as well as residual phosphorus and defoliant on yield and nutrient uptake of maize under pigeonpea-maize cropping system

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Abstract
A field experiment was conducted at college farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during 2016-17 and 2017-18 on applied as well as residual phosphorus and defoliant on maize under pigeonpea-maize cropping system. Various RDF (Recommended Dose of Fertilizer) doses and defoliant were applied to the pigeonpea crop and different RDP (Recommended dose of Phosphorous) supplied to the maize crop. The results of the investigation revealed that the maize plant exhibited maximum values of yield and uptakes of NPK by applying combination of residual 20: 75: 0 NPK (Kg ha^{-1}) + Defoliant (T_7) + 100% RDP (S_3) during both years of study. Highest grain yield of 8730 kg ha^{-1} (2016) and 8932 kg ha^{-1} (2017) and maximum total NPK uptakes of 226.77, 57.53 and 199.14 kg ha^{-1} (2016) and 245.89,57.52 and 208.14 kg ha^{-1} (2017) was obtained by applying combination of residual 20: 75: 0 NPK (Kg ha^{-1}) + Defoliant (T_7) + 100% RDP (S_3) and is on par with 20: 50: 0 NPK (Kg ha^{-1}) + Defoliant (T_6) + 100% RDP (S_3) of maize crop in pigeonpea-maize cropping system.

Keywords: Maize, residual effect, phosphorus, NPK, yield, uptake

Introduction
Maize (*Zea mays* L.) is an important food and feed crop and is the world's widely grown highland cereal and primary staple food crop in many developing countries. It is the third most important cereal after rice and wheat as human food, contributing almost nine percent to India's food basket and five percent to world's dietary energy supply and considered as integral component of food security at global level. Maize has high production potential compared to any other cereal crop. Hence, it is called as the "Miracle crop" and also "Queen of cereals" and because of its high yield potential and wider adaptability, it is finding a place in cropping systems. It is used as both food for human and feed for livestock especially in poultry industry and because of its expanded use in the agro-industries, *viz*. maize corn, corn starch, corn oil, baby corn, pop corn, dairy feed, piggery etc., and maize also serves as a source of raw material for developing hundreds of industrial products *viz*., starch, protein, alcoholic beverages, food sweeteners, pharma, cosmetics, bio-fuel etc. The huge potential for export has added the demand for maize all over the world. India is the fifth largest producer of maize in the world contributing to 3% of the global production. The area, production and productivity of maize is 10.74 M ha, 38.09 M t and 3.55 t ha^{-1}, respectively (Ministry of Agriculture and Farmers Welfare 2022-23).
Phosphorus play a pivotal role in photosynthesis, root development, energy conservation and transformations, carbon metabolism, redox reactions, enzyme activation or inactivation, signaling and nucleic acid synthesis (Vance *et al*., 2003) [15]. It also has a significant role in sustaining and build up soil fertility, particularly under intensive system of agriculture but it is one of the most inaccessible plant nutrients present in soil. Phosphorus is the backbone of balanced fertilization in Indian agriculture. Intensive cereal-cereal cropping systems are predominantly followed with indiscriminate use of nutrients and irrigation water and also with excessive tillage using heavy machinery (Yadav *et al*. 1998) [16].

With the evolution of short duration varieties of pigeonpea, it has provided an opportunity for multiple cropping in irrigated as well as rainfed areas. The response of the succeeding crops in a cropping system are influenced greatly by the preceding crops and the inputs applied therein. Therefore, greater emphasis is being laid on legume based cropping system as whole rather than on the individual crops in a sequence.

Materials and Methods

A field experiment to study the Production potential of pigeonpea-maize cropping system as influenced by applied as well as residual phosphorus and defoliant was conducted during *kharif* and *rabi* 2016-17 and 2017-18 at College Farm, College of Agriculture, Rajendranagar, Hyderabad, Southern Telangana. The soil of experimental site was sandy clay loam with pH of 7.6, Electrical conductivity 0.60 dSm^{-1}, low in organic carbon (0.53), low in available nitrogen (238.74 kg ha^{-1}) and medium in phosphorus (64.06 kg ha^{-1}) and high in potassium (388.6 kg ha^{-1}). The experiment was laid out in a split-plot design in *Rabi* for maize by taking seven treatment combinations given to the *kharif* pigeonpea as main-plot treatments i.e (T_1 Control (0 NPK), T_2 RDF (20: 50: 0 N: P_2O_5: K_2O, T_3 20: 25: 0 N: P_2O_5: K_2O, T_4 20: 75: 0 N: P_2O_5: K_2O, T_5 20: 25: 0 N: P_2O_5: K_2O + Defoliant, T_6 20: 50: 0 N: P_2O_5: K_2O + Defoliant and T7 20: 75: 0 N: P_2O_5: K_2O + Defoliant). Each of these main plots was divided into three sub-plots during *rabi* season maize crop, and allotted with three levels of phosphorus fertilizer i.e., 50, 75 and 100 percent RDP. This cycle of experiment was conducted on pigeonpea maize sequence. The cropping system was repeated on the same site for two consecutive years in the same field during 2016-17 and 2017-18. The data on yield and NPK uptakes were recorded after harvesting in maize crop during both years of study.

Results and Discussion

Grain yield and Stover yield

Grain yield (kg ha^{-1}) and stover yield (kg ha^{-1}) of maize was significantly influenced by residual treatments and phosphorous levels. The grain yield (7329 and 7498 kg ha^{-1}) and stover yield (10260 and 10782 kg ha^{-1}) were during 2016-17 and 2017-18, respectively with the application of 20: 75: 0 NPK (Kg ha^{-1}) + Defoliant (T_7) and with significant disparity between rest of the treatments tried to preceding pigeonpea (Table 1). This might be due to the incorporation of the residues might have interacted positively with the soil and the release of nutrients which might have enabled the maize to get assured. Decomposition and mineralization of residues might have coincided with the early growth stages of succeeding maize which might have contributed for the better performance of the maize over no residue incorporation. The residue incorporation might have led to the increased solubilization of all the nutrients for absorption, ensured continuous nitrogen supply distributed during entire crop growth period which might have resulted in the enhanced yield attributes like number of grain per row, grain weight and test weight and finally in grain yield. Similar results were also reported Arif *et al*. (2011) [1], and Shafi *et al.* (2007) [9].

Among the various phosphorus levels grain yield of maize was significantly differed. Highest maize grain and stover yield was observed with 100% RDP (S_3) (Grain: 6715 kg ha^{-1} and 6995 kg ha^{-1}, during 2016-17 and 2017-18 respectively) and (Stover: 9786 kg ha^{-1} and 10355 kg ha^{-1}, during 2016-17 and 2017-18 respectively) which was significantly superior to 75% RDP (S_2) and 50% RDP (S_1) respectively during both the years of study (Table 1). Incremental levels of phosphorus fertilization subscribe adequate availability of metabolites / photosynthates which might have helped plants to express / develop potentials of yield. The results of present investigation are in close conformity with the findings of Manimaran and Poonkodi (2009) [6]. With regard to interaction between residual treatments and fertilizer levels, combination of T_7S_3 (8730kg ha^{-1} and 8932 kg ha^{-1}, respectively) recorded the higher grain yield compared with other treatments of present investigation. Higher yields in maize is mainly attributed to the residue incorporation which might have provided positive impact on soil physical properties and fertility. Incorporation of residues as mulch might have reduced evaporation losses leading to moisture conservation in addition to soil fertility effect that might had also contributed to higher kernel yield. The findings are in conformity with the experimental results of Alfred (2009) [2], Egbe and Ali (2010) [3], Svubure *et al*. (2010) [12], Talebbeigi and Ghadiri (2012) [13], Fabunmi and Agbonlahor (2012) [4] and Usman *et al*. (2013) [14].

Table 1: Grain and stover yield (kg ha^{-1}) of maize as influenced by residual effect and phosphorus levels

Treatments	Grain yield						Stover yield					
	2016-17			2017-18			2016-17			2017-18		
	Subplot treatments			Subplot treatments			Subplot treatments			Subplot treatments		
	Recommended dose of phosphorus			Recommended dose of phosphorus			Recommended dose of phosphorus			Recommended dose of phosphorus		
Main treatments	50%	75%	100%	50%	75%	100%	50%	75%	100%	50%	75%	100%
T_1: Control (0 NPK)	4659	4736	5187	4937	5050	5306	7344	7925	7969	7717	8328	8370
T_2: RDF (20: 50: 0 N: P_2O_5: K_2O)	5261	5877	6869	5382	6012	7361	8594	9304	9817	9027	9687	10760
T_3: 20: 25: 0	5218	5458	5593	5338	5585	5722	7969	8873	8906	8374	9329	9359
T_4: 20: 75: 0	5351	6272	6955	5474	6416	7449	8595	9375	10009	9030	9852	10843
T_5: 20: 25: 0+ Defoliant	5240	5500	5611	5361	5661	5949	7991	8906	9089	8538	9342	9674
T_6: 20: 50: 0+ Defoliant	5386	7422	8059	5510	7593	8244	8750	10000	11304	9178	11042	11494
T_7: 20: 75: 0+ Defoliant	5455	7803	8730	5580	7983	8932	8750	10625	11406	9195	11165	11986
	S.Em±	CD (P=0.05)	CV%	S.Em±	CD (P=0.05)	CV%	S.Em±	CD (P=0.05)	CV%	S.Em±	CD (P=0.05)	CV%
Main treatments(M)	177	545	8.8	155	478	7.46	181.55	559.42	5.97	158.79	489.27	5.95
Sub plot treatments(S)	106	306	8.02	90.3	262	6.64	91.73	265.74	5.61	107.78	312.22	5.13
M at same level of S	289	856		249	740		268.76	801.19		281.82	832.9	
S at same level of M	279	809		239	692		242.7	703.09		285.15	826.06	

Nutrient uptake

Phosphorus uptake

The phosphorus uptake by grain and stover was the highest in 20: 75: 0 NPK kg ha^{-1} + Defoliant (T_7) (Grain: 23.41 kg ha^{-1} and 25.48 kg ha^{-1}during 2016-17 and 2017-18, respectively) and (Stover: 22.01 kg ha^{-1} and 22.11 kg ha^{-1} during 2016-17 and 2017-18, respectively) which is due to the residue incorporation and retained its superiority over the other treatments during both the years with regard to phosphorus uptake (Table 2). Significant variation among different factors under investigation with regard to uptake of P may be due to increase in drymatter accumulation coupled with percent increase in nutrient content in drymatter that might have contributed for the increase of uptake of phosphorus. Fertilizer levels exerted a significant influence on phosphorus uptake by grain and stover of maize and it was the highest with 100% RDP (S_3) (Grain: 20.72 kg ha^{-1}and 23.28 kg ha^{-1} during 2016-17 and 2017-18, respectively) and (Stover: 20.89 kg ha^{-1} and 21.17 kg ha^{-1} during 2016-17 and 2017-18, respectively) was significantly superior to 75% RDP (S_2) and 50% RDP (S_1), these results are in close conformity to the findings of Mehta *et al.* (2005) [7]. With regard to interaction between residual treatments and fertilizer levels, phosphorus uptake by grain and stover of maize have recorded significantly higher with combination of T_7S_3 (30.81 kg ha^{-1} (Grain) and 26.72 kg ha^{-1} (Stover) during 2016-17) and (33.44 kg ha^{-1} (Grain) and 24.08 kg ha^{-1} (Stover) during 2017-18) respectively. These results are in line with those of Shivran and Ahlawat (2000) [11].

Table 2: Phosphorus uptake (kg ha^{-1}) by grain and stover at harvest of maize as influenced by residual effect and phosphorus levels

Treatments	P uptake by grain						P uptake by stover					
	Subplot treatments						Subplot treatments					
	Recommended dose of phosphorus						Recommended dose of phosphorus					
	2016-17			2017-18			2016-17			2017-18		
Main treatments	50%	75%	100%	50%	75%	100%	50%	75%	100%	50%	75%	100%
T_1: Control (0 NPK)	10.86	10.92	11.87	11.92	12.52	13.29	15.54	15.99	16.51	16.17	15.94	16.58
T_2: RDF (20: 50: 0 N: P_2O_5: K_2O)	13.11	17.47	21.09	14.58	18.81	23.68	17.36	19.97	20.16	18.58	20.99	22.03
T_3: 20: 25: 0	12.12	15.09	15.52	13.51	16.34	17.17	16.78	18.51	19.25	18.13	19.14	19.61
T_4: 20: 75: 0	13.76	18.67	22.04	15.14	20.07	25.05	18.01	20.04	20.57	18.63	21.41	22.19
T_5: 20: 25: 0+ Defoliant	12.57	15.16	16.04	13.74	16.69	18.1	16.97	19.01	19.8	18.34	19.6	19.8
T_6: 20: 50: 0+ Defoliant	14.21	23.5	27.68	15.35	25.51	32.21	17.9	21.46	23.21	18.74	23.26	23.89
T_7: 20: 75: 0+ Defoliant	14.71	24.71	30.81	16.24	26.78	33.44	17.75	21.57	26.72	18.85	23.41	24.08
	S.Em±	CD (P=0.05)	CV%	S.Em±	CD (P=0.05)	CV%	S.Em±	CD (P=0.05)	CV%	S.Em±	CD (P=0.05)	CV%
Main treatments(M)	0.48	1.47	6.3	0.52	1.62	8.21	0.4	1.22	6.18	0.38	1.18	5.74
Sub plot treatments(S)	0.23	0.68	4.24	0.35	1	6.37	0.36	1.03	7.32	0.28	0.8	6.88
M at same level of S	0.7	2.08		0.91	2.7		0.86	2.54		0.71	2.1	
S at same level of M	0.62	1.8		0.91	2.64		0.94	2.73		0.73	2.13	

Nitrogen and Potassium uptake

Nitrogen uptake (kg ha^{-1}) of maize was significantly influenced by residual treatments and fertilizer levels during both the years of study. During both the years of study, the nitrogen uptake of 75.55 kg ha^{-1} (Grain) and 106.78 kg ha^{-1} (Stover) during 2016-17 and 77.73 kg ha^{-1} (Grain) and 109.78 kg ha^{-1} (Stover) during 2017-18 (Table 3). Potassium uptake of 44.25 kg ha^{-1} and 120.46 kg ha^{-1} by grain and stover respectively, during 2016-17 and 48.89 kg ha^{-1}and 125.59 kg ha^{-1} by grain and stover respectively, during 2017-18 was highest in the treatment 20:75: 0 NPK kg ha^{-1} + Defoliant (T_7). Among phosphorus levels significant influence on nitrogen uptake by grain and stover of maize was observed. Highest N uptake was with 100% RDP (S_3) (64.36 kg ha^{-1} and 98.57 kg ha^{-1} by grain and stover of maize respectively, during 2016-17) and 69.63 kg ha^{-1} and 100.77 kg ha^{-1} by grain and stover of maize respectively, during 2017-18, whereas potassium uptake of maize grain and stover were highest with 100% RDP (S_3) (Grain: 41.93 kg ha^{-1} and 113.87 kg ha^{-1} by grain and stover of maize respectively, during 2016-17) and stover uptake upto 46.05 kg ha^{-1}and 119.68 kg ha^{-1} by grain and stover of maize respectively, during 2017-18) which was significantly superior to 75% RDP (S_2) and 50% RDP (S_1) (Table 3). With regard to interaction between residual treatments and phosphorus levels no significant difference was observed in Nitrogen and Potassium uptake during both years of study.

Incorporation of crop residues has resulted in increase in uptake of nitrogen and potassium of crop during both the years under investigation. Leaf residue incorporation has increased the total uptake of nutrients by grain and stover during both the years compared to the no leaf residue treatments. Higher uptake of N by maize due to incorporation of legume crop residues might be due to better availability of nitrogen in soil after their decomposition and consequent increase in drymatter production. Several researchers like Shafi *et al*. (2007) [9], Ozpinar (2009) [8], Sharma and Behera, 2009) [10] and Kouelo *et al*. (2013) [5] observed significant increase in N uptake of maize with incorporation of crop residues.

Table 3: Nitrogen and potassium uptake (kg ha^{-1}) by grain and stover at harvest of maize as influenced by residual effect and phosphorus levels

Treatments	Nitrogen uptake (Kg ha^{-1})				Potassium Uptake (Kg ha^{-1})			
Main treatments	2016-17		2017-18		2016-17		2017-18	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_1: Control (0 NPK)	28.82	50.03	29.01	54.55	22.03	54.47	24.96	57.51
T_2: RDF (20: 50: 0 of N: P_2O_5: K_2O)	52.10	85.92	52.90	86.86	35.81	100.72	40.25	105.30
T_3: 20: 25: 0	40.55	71.26	45.18	72.32	29.82	83.86	33.89	88.19
T_4: 20: 75: 0	54.65	88.31	59.73	89.86	37.44	106.90	42.76	111.48
T_5: 20: 25: 0+ Defoliant	42.02	74.41	46.31	75.52	30.81	87.80	35.46	92.52
T_6: 20: 50: 0+ Defoliant	73.04	101.15	73.61	103.70	42.53	118.62	46.90	124.02
T_7: 20: 75: 0+ Defoliant	75.55	106.78	77.73	109.78	44.25	120.46	48.89	125.59
S.Em±	1.82	1.90	2.41	2.55	1.00	3.76	0.82	3.59
CD (P=0.05)	5.60	5.86	7.44	7.85	3.08	11.59	2.51	11.07
CV%	6.10	7.91	7.18	6.58	6.36	6.27	6.27	8.71
Sub Plots								
S_1: 50% P	37.10	60.70	34.88	65.26	24.34	68.52	29.31	70.87
S_2: 75% P	55.71	88.38	60.27	87.94	37.74	105.97	41.69	111.43
S_3: 100% P	64.36	98.57	69.63	100.77	41.93	113.87	46.05	119.68
S.Em±	2.68	2.46	2.81	2.32	1.29	2.74	1.00	2.77
CD (P=0.05)	7.76	7.13	8.14	6.73	3.73	7.94	2.89	8.03
CV%	4.32	3.53	5.45	4.84	7.02	4.06	7.54	6.61
M x S								
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
S x M								
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

Highest grain yield (8730 kg ha^{-1} and 8932 kg ha^{-1}, respectively) and stover yield (11406 kg ha^{-1} 1 and 11986 kg ha^{-1}, respectively) were obtained with 20: 75: 0+ Defoliant (T_7) + 100% RDP (S_3) when compared with other treatments, but it is on par with 20: 50: 0+ Defoliant (T_6) + 100% RDP (S_3) during both the years.

Nitrogen, phosphorus and potassium uptake was significantly influenced by treatments where by application of 20: 75: 0+ Defoliant (T_7) + 100% RDP (S_3) realized significantly higher uptake when compared with other treatments, however which was on par with application of 20: 50: 0+ Defoliant (T_6) + 100% RDP (S_3) during both the years of study.

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