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Influence of applied as well as residual phosphorus and defoliant on yield and nutrient uptake of pigeon-pea under pigeon-pea-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 pigeonpea under pigeonpea-maize cropping system. The results of the present investigation reflected that the pigeonpea plant exhibited maximum values of yield and uptakes of NPK by applying of T_2 (20: 50: 0 N: P_2O_5: K_2O kg ha^{-1}) during both years of study. During the both years of study highest seed yield (1567 kg $ha^{-1}$and 1605 kg ha^{-1}) respectively and grain, straw and total NPK uptakes (136.36, 14.78 and 46.27 kg ha^{-1} during 2016) and (148.87, 16.19 and 50.86 kg ha^{-1} during 2017) respectively was obtained by applying T_2 (20: 50: 0 N: P_2O_5: K_2O kg ha^{-1}) followed by T_4(20: 75: 0 N: P_2O_5: K_2O kg ha^{-1}) (129.86, 13.66 and 43.06 kg ha^{-1} during 2016) and (143.46, 15.07 and 49.52 kg ha^{-1}) of pigeonpeacrop in pigeonpea-maize cropping system.

Keywords: Pigeonpea, residual effect, NPK, yield, uptake

Introduction
Among pulses, pigeonpea (*Cajanus cajan* (L.)) is cultivated in the semi-arid areas of tropics and subtropics. It is native of Africa and the early traders have introduced the crop in India. Pigeonpea seeds contain 23.3 per cent protein, 35 per cent minerals, 57.6 per cent carbohydrates and provides 335 KCW energy/100 g. However, recent findings of national institute of nutrition conducted that pulses not supply 17 to 27 per cent of protein but also supply 20 per cent calories of the dietary requirement. Thus, pulses were valued both for proteins as well as calories requirement (Anonymous, 1981 and 2004) [1-2].

Even though India has the largest area under pulses in the world, the average productivity is low and the production is not sufficient to meet the per capita requirement. In India the crop is grown to an extent of 45.5 lakh hectares with a production of 33.15 lakh tonnes and productivity of 729 kg/ha. The low yield of pigeon pea (797 kg/ha, Meena and Sharma, 2012) [11] is not only due to its cultivation in marginal lands but also because of inadequate and imbalance fertilization, mineral nutrient deficiencies limit nitrogen fixation by the legume-rhizobium symbiosis, resulting in low legume yields.

Phosphorus is an indispensible plant nutrient and no plant on planet earth can complete its life cycle with adequate supply of phosphorus. In mineral nutrition of legumes phosphorus is as important as nitrogen in cereals. An interesting fact is that adequate phosphorous nutrition to legumes also ensures adequate supply of nitrogen through symbiotic fixation (Giller, 2001) [5]. Pigeon pea being a legume requires higher amount of phosphorous for optimum production and it affects seed germination, cell division, flowering, fruiting, synthesis of fat, starch, vital role in energy transformation.

Materials and Methods
Afield 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 Randomized block design for maize during kharif 2016 and 2017 with seven treatments consisting of combinations of phosphorous levels

and defoliant treatment with three replications for kharif pigeon-pea (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 T_7 20: 75: 0 N: P_2O_5: K_2O + Defoliant). In succeeding rabi season, the experiment was laid out in Split-plot design by taking seven residual treatments from preceding pigeonpea crop as main plots and each at 50, 75 and 100 per cent RDP as three subtreatments with 3 replications for maize during rabi 2016-2017 and 2017-18.The data on yield and NPK uptakes were recorded after harvesting in pigeonpea crop during both years of study.

Results and Discussion

Seed yield (Kg ha^{-1}) of pigeonpea crop as influenced by different treatments: Data showed that application of phosphorus levels significantly increased seed yield as compared to control in pigeonpea during course of study (2016 and 2017). The highest grain yield was recorded with application of 50 kg P_2O_5 ha^{-1}(T_2) (1567 kg ha^{-1} and 1605 kg ha^{-1}respectively) and it was 23% and 33%, 20% and 30% per cent higher grain yield over 25 kg P_2O_5 ha^{-1}(T_3) (1206 kg ha^{-1} and 1272 kg ha^{-1} respectively) and control (T_1) (1048 kg ha^{-1}and 1117 kg ha^{-1}) during both the years of experimentation. 75 kg P_2O_5 ha^{-1}(T_4) (1529 and 1579 kg ha^{-1} respectively) found at par with application of 50 kg P_2O_5 ha^{-1}(T_2) in respect to grain yield. Phosphorus plays a pivotal role in the higher yield by stimulation of root development, energy transformation and metabolic processes in the plants, which inturn, resulted in greater translocation of photosynthates towards the sink development, which resulted in higher seed yield. These results are in close conformity with the findings of Singh and Sekhon (2007) [14], Singh and Yadav (2008) [16], Deshbhratar *et al.* (2010) [4], Malik *et al.* (2013) Kumar and Singh (2014) [10] and Singh *et al.* (2014).

Table 1: Seed yield (Kg ha^{-1}) of pigeonpea crop as influenced by different treatments

Treatments	2016 Seed yield	2017 Seed yield
T_1 Control (0 NPK)	1048	1117
T_2 RDF (20: 50: 0 N: P_2O_5: K_2O kg ha^{-1})	1567	1605
T_3(20: 25: 0 N: P_2O_5: K_2O kg ha^{-1})	1206	1272
T_4(20: 75: 0 N: P_2O_5: K_2O kg ha^{-1}	1529	1571
T_5 (20: 25: 0 N: P_2O_5: K_2O kg ha^{-1} + Defoliant)	1200	1271
T_6 (20: 50: 0 N: P_2O_5: K_2O kg ha^{-1} + Defoliant)	1527	1563
T_7 (20: 75: 0 N: P_2O_5: K_2O kg ha^{-1} + Defoliant)	1522	1535
S.Em ±	48.23	48.93
CD (P=0.05)	148.62	150.77
CV	8.2	10.01

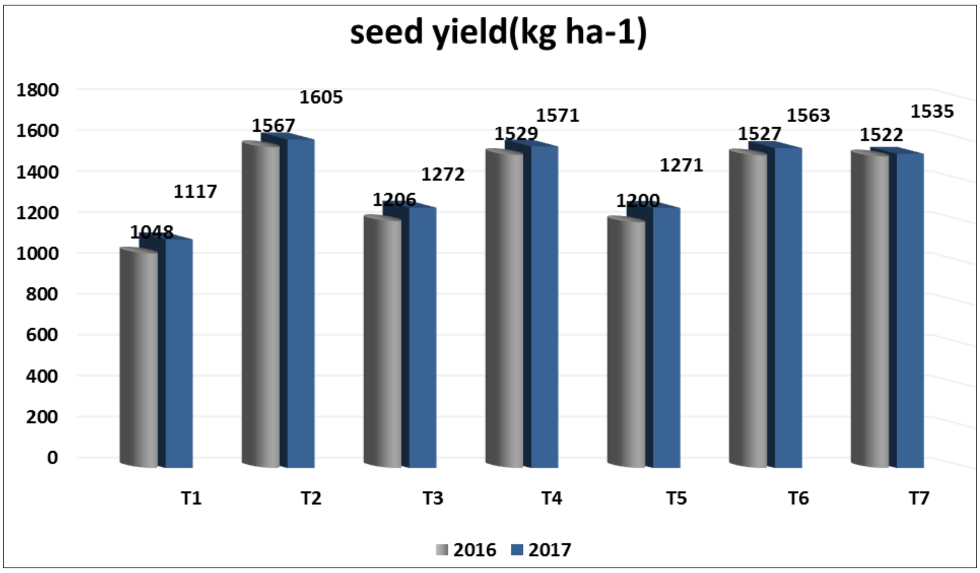

Fig 1: Seed yield (Kg ha^{-1}) of pigeonpea crop as influenced by different treatments.

Nitrogen (kg ha^{-1}) by pigeonpea influenced by different treatments

Data showed that application of phosphorus levels significantly increased nitrogen uptake by grain, stalk and total nitrogen uptake as compared to control in pigeonpea during course of study (2016 and 2017). The highest nitrogen uptake by grain, stalk and total nitrogen uptake recorded with application of 50 kg P_2O_5 ha^{-1}(T_3) (44.10, 92.26 and 136.6 kg ha^{-1} during 2016) and (48.58, 100.29 and 148.87 kg ha^{-1}during 2017) it was significantly superior over 25 kg P_2O_5 ha^{-1} (T_2) (28.93, 60.51 and 89.44 kg ha^{-1} during 2016) and (30.92, 72.50 and 103.42 kg ha^{-1} during 2017) control (T_1) (20.85, 43.05 and 63.9 kg ha^{-1}during 2016) and (22.69, 51.34 and 74.03 kg ha^{-1} during 2017) which was statistically at par with 75 kg P_2O_5 ha^{-1}(T_4) (42.8, 87.06 and 129.86 kg ha^{-1}during 2016) and (45.51, 97.95 and 143.46 kg ha^{-1}during 2017) respectively during both the years of experimentation. Legumes are said to respond characteristically to applied phosphorus by better nodulation and nitrogen fixation as well as improved uptake of nitrogen and phosphorus, and pigeonpea is no exception to this (Srinivasan, 1983) [18] and Gupta, 1990. Hegde and Saraf (1982) [7] reported that N, P and

K uptake increased by application of phosphorus up to 80 kg P_2O_5 ha^{-1}. Similar results were also reported by Chauhan and Singh (1987) [3] and Modak *et al.* (1994) [12]. Application of phosphorus improved the nutrient availability, resulting into greater uptake of the crop. Phosphorus might improved the nutritional environment in rhizosphere as well as in plant system leading to absorption, uptake and translocation of nutrients, which led to higher content and uptake. Such of the results were also authenticated by Singh and Yadav (2008) [16] who found that the application of 60 kg P_2O_5 ha^{-1} recorded highest uptake of N (112.3 kg/ha). Yadav *et al.* (2013) [19] also reported that an application of phosphorus @ 60 kg ha^{-1} recorded significantly higher uptake of N in grain and stover. Similar results were reported by Jain *et al.* (2007) [8].

Table 2: Nitrogen uptake (kg ha^{-1}) by pigeonpeaas influenced by different treatments

	2016			2017		
Treatments	**Grain**	**Stalk**	**Total**	**Grain**	**Stalk**	**Total**
T_1 Control (0 NPK)	20.85	43.05	63.90	22.69	51.34	74.03
T_2 RDF (kg ha^{-1}) (20: 50: 0 N: P_2O_5: K_2O)	44.10	92.26	136.36	48.58	100.29	148.87
T_3(20: 25: 0)	28.93	60.51	89.44	30.92	72.50	103.42
T_4(20: 75: 0)	42.80	87.06	129.86	45.51	97.95	143.46
T_5 (20: 25: 0+ Defoliant)	28.55	58.45	87.01	30.66	71.58	102.25
T_6 (20: 50: 0+ Defoliant)	42.60	85.14	127.73	45.11	97.91	143.02
T_7 (20: 75: 0+ Defoliant)	42.20	84.61	126.81	43.45	95.67	139.12
S.Em ±	2.16	3.98	4.48	2.02	4.35	4.45
CD (P=0.05)	6.65	12.27	13.80	6.21	13.39	13.71
CV	8.2	6.79	10.01	9.16	8.97	6.3

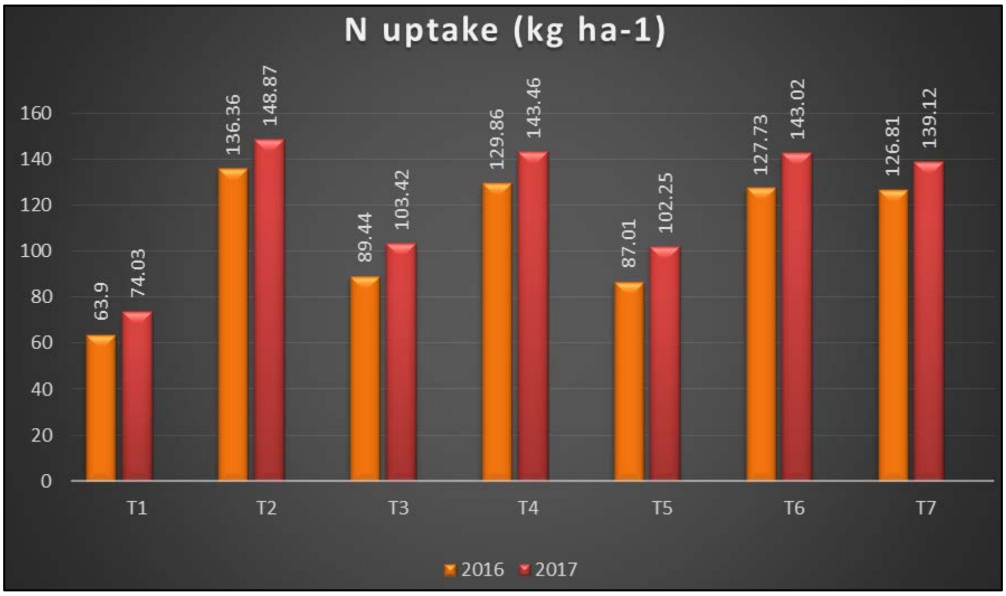

Fig 2: Nitrogen total uptake (kg ha^{-1}) by pigeonpeaas influenced by different treatments

Phosphorus uptake (kg ha^{-1}) by pigeonpeaas influenced by different treatments

Data clearly revealed that various phosphorus levels recorded significantly higher phosphorus uptake by pigeonpea grain, stalk as well as total phosphorus uptake during both the years of study (2016 and 2017). Application of 50 kg P_2O_5 ha^{-1}(T_2) (5.48, 9.30 and 14.78 kg ha^{-1} during 2016) and (5.90, 10.29 and 16.19 kg ha^{-1} during 2017) recorded significantly higher phosphorus uptake by grain, stalk as well as by total phosphorus uptake over application of 25 kg P_2O_5 ha^{-1}(T_3) (3.22, 5.32 and 8.54 kg ha^{-1} during 2016) and (3.65, 6.28 and 9.93 kg ha^{-1} during 2017) and control (T_1) (2.17, 3.28 and 5.46 kg ha^{-1} during 2016) and (2.53, 4.24 and 6.77 kg ha^{-1} during 2017) but at par with application of 75 kg P_2O_5 ha^{-1}(T_4) (5.17, 8.49, 13.66 kg ha^{-1} during 2016) and (5.58, 9.49 and 15.07 kg ha-1 during 2017) respectively during both the years of experimentation. Phosphorus uptake by crop increased by application of phosphorus, this could be attributed to the fact that added phosphorus increased N and P concentration in grain and stalk by providing balanced nutritional environment inside the plant and higher photosynthetic efficiency, which favoured growth and crop yield. Since, the uptake of nutrients is a function of dry matter (grain and stalk) and nutrient content, the increased grain and stalk yield together with higher N and P content resulted in greater uptake of these elements. The increased nutrient content and uptake with phosphorus fertilization are in line with those of Shivran and Ahlawat (2000b) [13], Jat and Ahlawat (2001) [9] and Singh (2005).

Table 3: Phosphorus uptake (kg ha^{-1}) by pigeonpeaas influenced by different treatments

	2016			2017		
Treatments	**Grain**	**Stalk**	**Total**	**Grain**	**Stalk**	**Total**
T_1 Control (0 NPK)	2.17	3.28	5.46	2.53	4.24	6.77
T_2 RDF (kg ha^{-1}) (20: 50: 0 N: P_2O_5: K_2O)	5.48	9.30	14.78	5.90	10.29	16.19
T_3(20: 25: 0)	3.22	5.32	8.54	3.65	6.28	9.93
T_4(20: 75: 0)	5.17	8.49	13.66	5.58	9.49	15.07
T_5 (20: 25: 0+ Defoliant	3.10	5.05	8.16	3.53	5.88	9.41
T_6 (20: 50: 0+ Defoliant)	5.03	7.74	12.77	5.42	8.98	14.40
T_7 (20: 75: 0+ Defoliant)	4.83	7.33	12.16	5.16	8.36	13.52
S.Em ±	0.25	0.42	0.49	0.19	0.51	0.51
CD (P=0.05)	0.77	1.29	1.50	0.57	1.59	1.57
CV	10.46	10.92	7.82	7.07	11.66	7.26

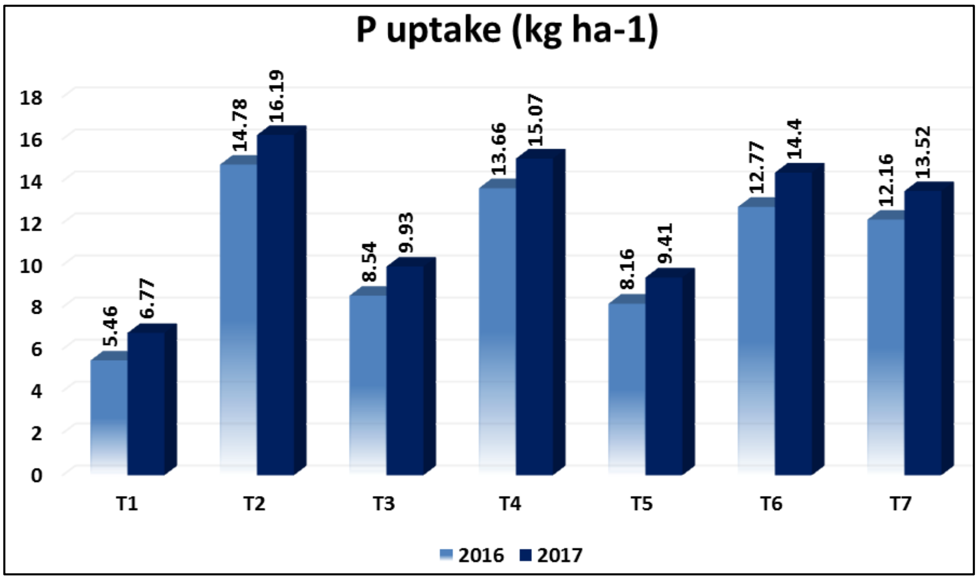

Fig 3: Phosphorus total uptake (kg ha^{-1}) by pigeonpeaas influenced by different treatments

Potassium uptake (kg ha^{-1}) by pigeonpeaas influenced by different treatments: Datarevealed that the application of phosphorus levels in pigeonpea increased significantly the potassium uptake by grain, stalk as well as total potassium uptake in pigeonpea during both the years of investigation (2016 and 2017). It is evident from the data that maximum potassium uptake by grain, stalk as well as by total potassium uptake with application of 50 kg P_2O_5 ha^{-1}(T_2) (20.48, 25.78 and 46.27 kg ha^{-1}during 2016) and (21.45, 29.41 and 50.86 kg ha^{-1}during 2017) and this treatment found significantly superior over 25 kg P_2O_5 ha^{-1}(T_3) (13.11, 15.29 and 28.40 kg ha^{-1} during 2016) and (14.33, 20.43 and 34.76 kg ha^{-1} during 2017) and control (T_1) (9.45, 10.65 and 19.50 kg ha^{-1} during 2016) and (10.38, 13.93 and 28.52 kg ha^{-1} during 2017) respectively during both the years of experimentation. Application of phosphorus might have improved the nutritional environment in rhizosphere as well as in plant system leading to absorption uptake and translocation of nutrients, especially of N, P, K in reproductive structures which led to higher content and uptake. Due to higher vegetative growth and available nutrients in soil plants uptake more amount of nutrients from soil. It might be due to nitrogenase activity and greater availability of nutrients under the application of phosphorus which ultimately increased the nutrient uptake in grain and stalk. Similar findings were reported by Yadav *et al.* (2013) [19] that an application of phosphorus @ 60 kg P_2O_5 ha^{-1} recorded significantly higher uptake of K in grain and stover. Yadav *et al.* (2017) [20] also observed that application of phosphorus upto 40 kgP_2O_5 ha^{-1}significantly increased total uptake of potassium.

Table 4: Potassium uptake (kg ha^{-1}) by pigeonpeaas influenced by different treatments

	2016			2017		
Treatments	**Grain**	**Stalk**	**Total**	**Grain**	**Stalk**	**Total**
T_1 Control (0 NPK)	9.45	10.05	19.50	10.38	13.93	24.31
T_2 RDF (kg ha^{-1}) (20: 50: 0 N: P_2O_5: K_2O)	20.48	25.78	46.27	21.45	29.41	50.86
T_3(20: 25: 0)	13.11	15.29	28.40	14.33	20.43	34.76
T_4(20: 75: 0)	19.68	23.38	43.06	20.90	28.61	49.52
T_5 (20: 25: 0+ Defoliant)	12.96	14.18	27.13	14.19	19.76	33.95
T_6 (20: 50: 0+ Defoliant)	19.54	22.58	42.13	20.64	27.86	48.50
T_7 (20: 75: 0+ Defoliant)	19.35	22.18	41.53	20.16	27.34	47.50
S.Em ±	1.02	1.00	1.36	0.96	1.24	1.73
CD (P=0.05)	3.14	3.10	4.18	2.95	3.82	5.32
CV	10.79	9.12	7.6	9.5	8.97	7.2

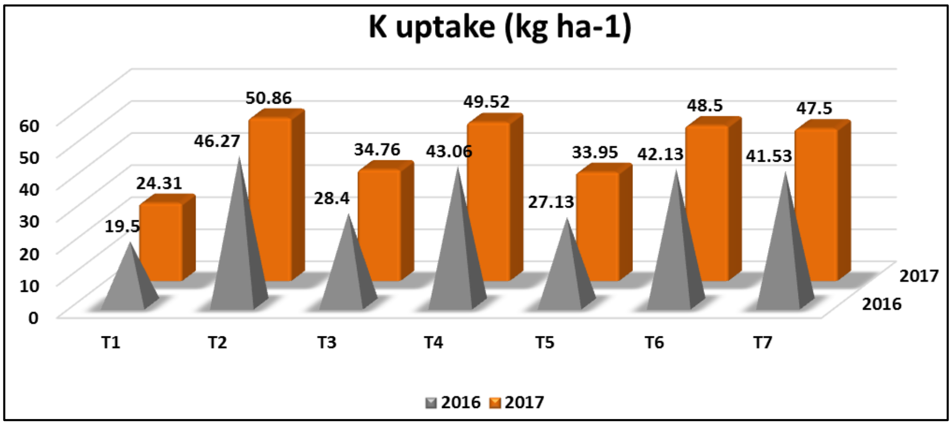

Fig 4: Potassium total uptake (kg ha^{-1}) by pigeonpeaas influenced by different treatments

Conclusion

Highest seed yield was obtained with application of T_2 (20: 50: 0 N: P_2O_5: K_2O kg ha^{-1}) (1567 kg ha^{-1}and 1605 kg ha^{-1}) respectively during both the years (2016 and 2017) of experiment and highest grain, straw and total NPK uptakes (136.36, 14.78 and 46.27 kg ha^{-1} during 2016) and (148.87, 16.19 and 50.86 kg ha^{-1} during 2017) respectively was obtained by applying T_2 (20: 50: 0 N: P_2O_5: K_2O kg ha^{-1}) followed by T_4(20: 75: 0 N: P_2O_5: K_2O kg ha^{-1}) (129.86, 13.66 and 43.06 kg ha^{-1} during 2016) and (143.46, 15.07 and 49.52 kg ha^{-1}) of pigeonpea crop in pigeonpea-maize cropping system.

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