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Effect of Phosphorus Management Practices on Nutrient Uptake, Soil Fertility Status and Economics of Pearl millet in Pearl millet-Pulse Sequence

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ABSTRACT

A field experiment was conducted during *kharif* and *rabi* seasons of 2017-18 and 2018-19 at Agricultural College Farm, Bapatla to evaluate the direct effect of phosphorus management practices on pearl millet and residual effect on pulses (blackgram, greengram and chickpea). In *kharif* season, seven treatments consisted of T_1: No P, T_2: 50% RDP T_3: 75 % RDP, T_4: 100 % RDP, T_5: 50 % RDP + seed inoculation with PSB, T_6 :75 % RDP + seed inoculation with PSB, T_7 : 100 % RDP + seed inoculation with PSB with RBD design. While in *rabi*, each *kharif* treatment plots were subdivided into three plots to accommodate three different pulses. Thus, for *rabi* season study, residual phosphorus management practices were considered as main plot treatments and the three crops as sub plot treatments. The results revealed that significantly the highest nitrogen, phosphorus and potassium uptake were recorded with application of 100 % RDP + seed inoculation with PSB but remained statistically on par with the treatment which received 100 % RDP during both years of experimentation and in pooled data. Similarly maximum net returns were also obtained in those treatments.

Key words: *pearl millet-pulses, phosphorus management practices, PSB, uptake and returns*

Among the coarse cereals grown, pearl millet occupies pivotal position in the arid and semi-arid regions of India, occupying an area of 6.98 mha with a total production of 8.06 Mt and productivity of 1,154 kg ha^{-1}. It is traditionally an indispensable component of dry farming region and it is considered more efficient in utilization of soil moisture and has a higher level of heat tolerance than even sorghum and maize crops.

In India, pulses have been considered as the poor man's diet which is considered as the principal source of dietary proteins in a vegetarian country like India. Among the different pulse crops, redgram, chickpea or gram, black gram, green gram and lentil are major pulses. Pulses not only provides dietary proteins but also these crops help to increase soil fertility.

The productivity of upland/dryland crops is very low because of low and erratic rainfall and poor adoption of improved technologies. To bridge this gap, the crop diversification is required for increasing the productivity and profitability per unit area and per unit time. Pearlmillet and pulses sequence one of the promising crops which can perform well even under upland areas.

In all major nutrients phosphorus is the essential nutrient for biological growth and development of crop especially for pulses. Phosphorus nutrition is desired and balanced dose enhances cell division and meristematic growth in living tissues, root development, nodulation and hastens maturity (Tisdale *et al*., 1995).

Inadequate phosphorus supply is considered as one of the major limiting factor in crop production. The situation is becoming more complicated because the natural reserves and the raw materials for the manufacture of phosphatic fertilizers are depleting at a faster rate. All these factors lead to wide spread deficiency of P for agricultural production. Hence, we need to improve its use efficiency and availabilityof phosphorus. Under such conditions, use of biofertilizers like phosphorus solubilizing biofertilizer (PSB) will increase the bio-availability of native and added phosphorus.

MATERIAL AND METHODS

The field experiment was conducted at Agricultural college farm, Bapatla which is situated at a latitude of 15^0 54' N and 80^0 25'E longitude, at an altitude of 5.49 m above the mean sea level. The experiment was conducted for two years during *kharif* and *rabi* seasons of 2017-18 and 2018-19. Experimental soil was clay loam, neutral in reaction, medium in organic C content, low in available N, medium in available P and high in K. In *kharif* the experiment was conducted in RBD with seven phosphorus management practices *viz*., T_1: No P, T_2: 50% RDP, T_3: 75 % RDP, T_4: 100 % RDP, T_5: 50 % RDP + seed inoculation with Phosphate Solubilzing Biofertilizer, T_6 :75 % RDP + seed inoculation with

Table 1. Nitrogen uptake (kg ha^{-1}) of *kharif* pearl millet as influenced by phosphorus management practices

Treatments	2017			2018			Pooled		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
T_1- No P (control)	28.2	20.6	48.7	24.9	18.8	43.7	26.5	19.7	46.2
T_2- 50 % RDP	34.0	25.1	59.1	30.7	23.2	53.9	32.3	24.1	56.5
T_3- 75 % RDP	45.3	29.6	74.9	43.5	28.3	71.8	44.4	28.9	73.3
T_4-100 % RDP	54.7	38.3	93.0	51.3	36.2	87.6	53.0	37.3	90.3
T_5- 50 % RDP+PSB	37.0	26.7	63.7	31.9	24.4	56.4	34.5	25.6	60.1
T_6- 75 % RDP+PSB	48.4	31.4	79.9	45.5	29.4	74.9	46.9	30.4	77.4
T_7- 100 % RDP+PSB	57.7	37.2	95.0	54.4	35.3	89.7	56.1	36.3	92.3
SEm±	2.7	1.8	3.7	2.8	1.7	3.5	2.4	1.5	3.1
CD (P =0.05)	8.4	5.6	11.3	8.6	5.2	10.9	7.4	4.6	9.4

Table 2. Phosphorus uptake (kg ha^{-1}) at harvest of *kharif* pearl millet as influenced by phosphorus management practices.

Treatments	2017			2018			Pooled		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
T_1- No P (control)	4.8	3.8	8.6	4.2	3.4	7.6	4.5	3.6	8.1
T_2- 50 % RDP	7.7	5.3	13.0	6.2	4.7	10.9	6.9	5.0	11.9
T_3- 75 % RDP	11.2	6.3	17.5	9.5	5.8	15.3	10.4	6.0	16.4
T_4-100 % RDP	13.7	8.8	22.5	12.0	7.9	19.9	12.8	8.4	21.2
T_5- 50 % RDP+PSB	9.6	5.8	15.4	7.8	4.9	12.7	8.6	5.3	14.0
T_6- 75 % RDP+PSB	11.9	7.5	19.5	10.7	6.6	17.3	11.3	7.1	18.4
T_7- 100 % RDP+PSB	14.4	9.6	23.9	13.5	9.0	22.5	13.9	9.3	23.2
SEm±	1.0	0.4	1.3	1.3	0.4	1.3	1.1	0.4	1.3
CD (P =0.05)	3.2	1.3	3.9	3.9	1.2	4.0	3.2	1.1	3.9

Table 3. Potassium uptake (kg ha^{-1}) of *kharif* pearl millet as influenced by phosphorus management practices.

Treatments	2017			2018			Pooled		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
T_1- No P (control)	7.3	41.2	48.6	6.8	36.1	42.8	7.1	38.7	45.7
T_2- 50 % RDP	9.9	43.5	53.4	8.4	37.5	45.9	9.1	40.5	49.6
T_3- 75 % RDP	13.4	50.5	63.9	12.3	50.4	62.7	12.9	50.4	63.3
T_4-100 % RDP	17.2	64.7	81.9	16.2	63.8	80.0	16.7	64.2	80.9
T_5- 50 % RDP+PSB	10.9	46.4	57.4	9.8	42.9	52.7	10.4	44.7	55.0
T_6- 75 % RDP+PSB	14.5	54.8	69.4	13.9	52.9	66.8	14.2	53.9	68.1
T_7- 100 % RDP+PSB	17.0	66.3	83.3	16.8	64.7	81.6	16.9	65.5	82.5
SEm±	0.8	3.3	3.6	0.9	3.5	3.4	0.7	2.6	2.6
CD (P =0.05)	2.4	10.0	10.9	2.7	10.9	10.4	2.1	8.0	8.1

Table 4. Post harvest available soil nutrient (kg ha^{-1}) status of *kharif* pearl millet as influenced by phosphorus management practices

Treatments	2017			2018			Pooled		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1- No P (control)	159.8	15.4	244.1	156.5	18.8	239.1	158.1	17.1	241.6
T_2- 50 % RDP	165.5	23.0	250.2	168.7	24.3	247.9	167.1	23.6	249.0
T_3- 75 % RDP	179.3	25.3	266.4	180.6	27.1	269.1	180.0	26.2	267.8
T_4-100 % RDP	190.7	30.3	287.2	193.2	32.5	290.5	192.0	31.4	288.8
T_5- 50 % RDP+PSB	172.9	24.7	258.9	171.7	25.4	262.2	172.3	25.1	260.5
T_6- 75 % RDP+PSB	185.2	29.7	273.3	189.5	30.7	272.0	187.4	30.2	272.7
T_7- 100 % RDP+PSB	195.1	32.0	299.2	198.5	33.4	303.2	196.8	32.7	301.2
SEm±	4.2	1.4	11.2	4.5	1.5	12.5	3.0	1.2	11.6
CD (P =0.05)	13.0	4.1	34.5	13.8	4.5	38.5	9.3	3.6	35.7
CV (%)	14.2	8.9	7.2	15.0	9.2	8.0	10.1	8.0	7.5

Phosphate Solubilzing Biofertilizer, T_7 : 100 % RDP + seed inoculation with Phosphate Solubilzing Biofertilizer. The seeds of pearlmillet were inoculated with PSB. A solution of jaggery (100 g in 500 ml water) obtained after 15 minutes of boiling to get slurry and cooled to room temperature. The slurry was poured on the seeds and mixed to have a uniform coating of culture over the seeds. The inoculated seed were spread on a dried floor in shade for drying for about 30 minutes. The dried seeds were sown immediately and covered with soil. PSB treated seeds of pearlmillet hybrid (Rana) were sown in lines by manually @ two seeds per hill with a spacing of 45 cm x 15 cm during 2017 and 2018, respectively. While in *rabi*, the experiment was conducted in split plot design. Each of the *kharif* treatmental plot was subdivided into three plots to accommodate three different pulses. Thus, for *rabi* season study, residual phosphorus management practices were considered as main plot treatments and the three crops as sub plot treatments. Uniform application of nitrogen and potassium were given to pearlmillet and *rabi* pulses (blackgram, greengram and chickpea). Phosphorus was given to pearlmillet as per the treatments and blackgram, greengram and chickpea were grown on residual fertility without any added doses phosphorus. The five random plants were selected from each plot, excluding the border row, for recording biometric observations of *kharif* pearlmillet and *rabi* pulses.

RESULTS AND DISCUSSION

Nutrient uptake

A perusal of the data (Table. 1 to 3) showed significant differences in nutrient uptake (nitrogen, phosphorus and potassium) in plant at maturity (grain and stover) due to different phosphorus management practices in combination with biofertilizers.

Among the different treatments tested, the T_7 (100 % RDP + seed inoculation with PSB) recorded significantly the highest uptake which was found to be at par with T_4 (100 % RDP) in grain and straw of pearl millet during both years of study followed by T_6 (75 % RDP + seed inoculation) treatment. The treatment control (no phosphorus) was recorded the lowest nitrogen uptake.

The concentration and uptake of any nutrient in the plant is directly related to its availability in the root zone and growth of the plant. The increased uptake was due to sufficient and continued availability of nutrients from applied fertilizers in soil favoring the efficient use of major and micro nutrients.

Increasing levels of inorganic fertilizers along with biofertilizers resulted into higher photosynthetic activities with higher dry matter production right from initial stages of the crop growth indicating adequate availability of nutrient in the rhizosphere. This might have helped in better root growth and their activity resulting in higher absorption of nutrient from soil and their translocation to aerial parts thus increasing the uptake.

These findings corroborate with the results obtained by many researchers *viz*., Ansari *et al.* (2011) Singh and Agrawal (2004) and Meena and Gautam (2005).

Availabile soil nutrient (nitrogen, phosphorus and potassium) status after harvest of pearlmillet

Data pertaining to soil available nitrogen (Table.4) after harvest of pearl millet crop showed the significant variations among the different phosphorus

Table 5. Cost of cultivation (Rs. ha^{-1}), gross returns (Rs. ha^{-1}) , net returns (Rs. ha^{-1}) and returns per rupee invested of *kharif* pearl millet in soil as influenced by phosphorus management practices.

Treatments	2017				2018				Pooled			
	Cost of cultivation	Gross returns	Net returns	Return per rupee invested	Cost of cultivation	Gross returns	Net returns	Return per rupee invested	Cost of cultivation	Gross returns	Net returns	Return per rupee invested
T_1- No P (control)	23182	32416	9234	0.40	24150	32111	7961	0.33	23666	32700	9034	0.38
T_2- 50 % RDP	23319	38859	15540	0.67	24287	38898	14611	0.6	23803	39403	15600	0.66
T_3- 75 % RDP	23393	49382	25989	1.11	24361	52017	27656	1.14	23877	51341	27464	1.15
T_4-100 % RDP	23452	58340	34888	1.49	24420	59751	35331	1.45	23936	59819	35883	1.50
T_5- 50 % RDP+PSB	23344	42980	19636	0.84	24312	41248	16936	0.7	23828	42718	18890	0.79
T_6- 75 %RDP+PSB	23418	51295	27877	1.19	24386	53763	29377	1.2	23902	53196	29294	1.23
T_7- 100 % RDP+PSB	23477	59235	35758	1.52	24445	61201	36756	1.5	23961	60997	37036	1.55
SEm±	-	2211.2	2211.2	0.095	-	2536.1	2536.1	0.104	-	2280.1	2280.1	0.095
CD (P =0.05)	-	6813	6813	0.29	-	7814	7814	0.32	-	7026	7026	0.29
CV (%)	-	8.1	15.9	15.9	-	9.1	18.2	18.2	-	8.1	16	16

management practices. The highest soil nitrogen was recorded with application of 100 % RDP + seed inoculation with PSB (T_7) *i.e* 195.1 kg ha^{-1} and 198.5 kg ha^{-1} during both years and remained statistically at par with treatment T_4 (100 %) - 190.7 kg ha^{-1} and 193.2 kg ha^{-1} and T_6 (75 % RDP + seed inoculation with PSB) -185.2 kg ha^{-1} and 189.5 kg ha^{-1} during two years of experimentation. The lowest soil nitrogen was recorded with T_1 (control) treatment.

With regard to soil available phosphorus (Table.4) 100 % RDP + seed inoculation with PSB (T_7) was on par with T_4 (100 % RDP) treatment but found significantly superior to rest of treatments. Phosphorus status was slightly high in seed inoculation (T_5, T_6 and T_7) treatments when compared to without seed inoculation treatments (T_2, T_3 and T_4) of 50, 75 and 100 % RDP, respectively. The lowest available soil phosphorus was obtained with no phosphorus (T_1) treatment. Similar trend of response was observed in soil available potassium ((Table.4) as that of soil available nitrogen. Similar results were observed by Rathore *et al*. (2004), Raj and Sangwan (2002).

Economics

Among the different treatments, gross returns and net returns increased (Table.5) with the increase in levels of phosphorus applied along with PSB. Significantly the highest gross returns, net returns and returns per rupee invested were obtained with application of 100 % RDP + seed inoculation with PSB (T_7), however, it was found to be at par with 100 % PDP (T_4) followed by T_6 which received the 75 % RDP + seed inoculation. The T_6 treatment was found to be at par with T_4 treatment and significantly lowest to the T_7 treatment in 2017 and pooled data, where as in 2018 remains at par with T_7 and T_6. The lowest gross returns net returns and returns per invested were obtained with control treatment (T_1) during both years of study and pooled data also. These results are in accordance with observations noticed by Singh and Agrawal (2004), Jakhar (2006) and Meena *et al*.(2008).

The PSB and higher level of phosphorus might have helped in accumulation and availability of both macro and micro nutrients and solubilization of fixed form of phosphorus. This might lead to the grater absorption of nutrients by the crop as and when crop demand needs which might be leading to maximum yields and further reflected in higher net returns.

CONCLUSION

From the study it can be concluded that enhanced fertility of soil after harvest of pearl millet as well as returns can be obtained with 100 per cent inorganic phosphorus applied along with combination of PSB.

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