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Pathade KS
Research scholar, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Patil PR
Assistant professor, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Karpe AH
Assistant Professor, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Danawale NJ
Chief Scientist (Seeds), Seed Cell, MPKV, Rahuri, Maharashtra, India

Gotsurya PS
Research Scholar, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Wagh AA
Research scholar, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Gaikwad SC
Research Scholar, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Corresponding Author:
Pathade KS
Research scholar, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Effect of different phosphorus nutrient sources on the growth, yield and quality of pigeonpea (*Cajanus cajan* (L.) Millsp.)

Pathade KS, Patil PR, Karpe AH, Danawale NJ, Gotsurya PS, Wagh AA and Gaikwad SC

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Abstract
A field experiment on pigeonpea entitled "Effect of different phosphorus nutrient sources on growth, yield and quality of pigeonpea (*Cajanus cajan* (L.) Millsp.)" was conducted during *kharif* season 2023 at Instructional Farm of Dr. Sharadchandra Pawar College of Agriculture, Baramati. The field experiment was laid out in randomized block design with three replications. There were seven treatments *viz*., T_1: Absolute control, T_2: Control (No P_2O_5), T_3: 100% P_2O_5 through Phosphate Rich Organic Manure (PROM), T_4: 100% P_2O_5 through Di-ammonium phosphate (DAP), T_5: 75% P_2O_5 through PROM +25% P_2O_5 through DAP, T_6: 50% P_2O_5 through PROM +50% P_2O_5 through DAP and T_7: 25% P_2O_5 through PROM +75% P_2O_5 through DAP. As demonstrated by the experimental results, treatment T_5 i.e. application of 75% P_2O_5 through PROM + 25% P_2O_5 through DAP resulted significantly higher in plant growth parameter including plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of functional leaves plant^{-1}, dry matter plant^{-1}, number of nodules plant^{-1}, yield contributing characters, including number of pods plant^{-1}, weight of pods plant^{-1}, weight seeds plant^{-1}, seed yield, stalk yield, harvest index (%) and non-significant in number of seeds pod^{-1}, 100 seed weight, Protein content and Protein yield. Treatment T_3 i.e. application of 100% P_2O_5 through Phosphate Rich Organic Manure (PROM) and treatment T_6 i.e. application of 50% P_2O_5 through PROM + 50% P_2O_5 through DAP are at par with treatment T_5.

Keywords: Pigeonpea, phosphorus nutrient sources, Phosphate Rich Organic Manure (PROM), Di-Ammonium Phosphate (DAP)

Introduction
Pigeonpea (*Cajanus cajan* L. Millsp.) is an essential seed legume in the tropics and subtropics, particularly for smallholder farmers in developing countries. Ranking sixth in global cultivation, India is the top producer, contributing 4.34 million tons in 2022 (Anonymous, 2022) [1]. Pigeonpea enhances soil fertility through nitrogen fixation and is resilient to climate variability, serving as a staple food and a key component of subsistence farming. Its de-hulled seeds are used to make dal, while whole seeds are incorporated into porridge in Africa and South America. When harvested green, it can be consumed fresh, frozen, or canned. Byproducts also serve as animal feed and fuel. pigeonpea the nickname "Biological plough" for its ability to enrich soil and thrive in various, even degraded, soil types (Saxena *et al*., 2010) [10].
Phosphorus (P) is crucial for plant growth, particularly for root development and energy processes. However, many Indian soils are deficient in phosphorus, which limits crop yields. Traditional fertilizers often have low phosphorus recovery rates, typically between 10% and 30%, emphasizing the need for alternative nutrient sources (Khan *et al*., 2007) [3]. Phosphate Rich Organic Manure (PROM) presents a cost-effective and eco-friendly solution by improving phosphorus availability and supplying essential micronutrients (Khatik *et al*., 2022) [5].

Materials and Methods
A field experiment was carried out to study the "Effect of Different Phosphorus Nutrient Sources on Growth, Yield and Quality of Pigeonpea (*Cajanus cajan* (L.) Millsp)''.

During *kharif* season 2023-24 under irrigated conditions at Instructional Farm of Dr. Sharadchandra Pawar College of Agriculture, Baramati. Is situated in between 18° 13” and 18° 57” North latitudes and between 74° 54” and 74° 27” East longitudes. The altitude varies from 559 to 565 meters above the mean sea level. This tract lying on the eastern side of western Ghat and falls under rain shadow areas. The soil of experimental plot was slightly alkaline in reaction (pH 7.73), moderate in organic carbon (0.54%), clay in texture, low in available nitrogen (215.32 kg ha^{-1}), medium in available phosphorous (18.8 kg ha^{-1}), and very high in available potassium (342.32 kg ha^{-1}). experimental plots laid out in a randomized block design with 7 treatments and 3 replications. The general recommended dose of fertilizer (25:50:00 kg ha^{-1} N: P_2O_5: K_2O + FYM 5 t ha^{-1}) were given to pigeonpea as per treatment details at the time of dibbling of pigeonpea. The experiment, there were seven treatments of different phosphorous nutrient sources i.e. T_1: Absolute control, T_2: Control (No P_2O_5), T_3:100% P_2O_5 through Phosphate Rich Organic Manure (PROM), T_4: 100% P_2O_5 through Di-ammonium phosphate (DAP), T_5: 75% P_2O_5 through PROM + 25% P_2O_5 through DAP, T_6: 50% P_2O_5 through PROM + 50% P_2O_5 through DAP, T_7: 25% P_2O_5 through PROM + 75% P_2O_5 through DAP. Good quality pigeonpea seeds of variety BDN 2013-41 (Godavari) obtained from Krishi Vigyan Kendra, Baramati. The recommended spacing of 120 cm x 30 cm was adopted for dibbling of pigeonpea.

3. Results and Discussion

1)Growth characters

At all phases of plant growth, the application of 75% P_2O_5 through PROM + 25% P_2O_5 through DAP resulted significantly higher plant height, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, number of functional leaves $plant^{-1}$, dry matter $plant^{-1}$, number of nodules $plant^{-1}$ and days to 50% flowering at harvest as compared to rest of the different phosphorus nutrient sources (Table 1, 2 and 3). This treatment was found significant but at par with application of 100% P_2O_5 through Phosphate Rich Organic Manure (PROM) and application of 50% P_2O_5 through PROM + 50% P_2O_5 through DAP with plant height, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, number of functional leaves $plant^{-1}$, dry matter $plant^{-1}$, number of nodules $plant^{-1}$ and days to 50% flowering.

Table 1: Effect of different phosphorus nutrient sources on plant height and number of primary branches $plant^{-1}$ of pigeonpea.

Tr. No.	Treatment	Plant height (cm)					No. of primary branches $plant^{-1}$				
		30 DAS	60 DAS	90 DAS	120 DAS	At Harvest	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
T_1	Absolute control	28.35	66.15	116.76	124.73	128.87	0.81	4.73	8.27	9.77	9.92
T_2	Control (No P_2O_5)	29.66	72.76	124.26	132.69	136.49	0.86	6.70	9.12	10.67	10.95
T_3	100% P_2O_5 through PROM	32.23	90.87	156.05	165.02	171.89	1.09	8.30	12.09	14.00	14.53
T_4	100% P_2O_5 through DAP	32.36	83.57	139.06	149.05	153.44	1.06	7.33	10.69	13.47	13.69
T_5	75% P_2O_5 through PROM + 25% P_2O_5 through DAP	32.41	92.44	160.60	171.99	177.28	1.10	8.67	13.72	15.33	15.80
T_6	50% P_2O_5 through PROM + 50% P_2O_5 through DAP	32.66	87.64	149.78	157.73	164.40	1.07	8.00	11.71	13.90	14.51
T_7	25% P_2O_5 through PROM + 75% P_2O_5 through DAP	30.49	83.72	141.11	150.18	155.36	1.04	7.60	11.52	13.47	13.70
	S.Em±	1.55	2.76	4.35	4.78	4.29	0.07	0.38	0.69	0.53	0.65
	C.D. at 5%	NS	8.52	13.43	14.75	13.22	NS	1.19	2.14	1.63	2.00
	General Mean	31.16	82.45	141.08	150.19	155.39	1.0	7.33	11.01	12.94	13.30

The application of PROM increased the availability of phosphorus, either separately or in combination with DAP, probably boosted the concentration and uptake of phosphorus. The organic matter in PROM, during decomposition, releases humic acids which convert insoluble phosphates into forms that plants can utilize and increases phosphorus availability in the soil, likely enhances phosphorus concentration and uptake by plants. This improved phosphorus availability supports earlier root development, resulting in better plant height. Phosphorus is a key component of phosphonucleotides, which promote higher rates of cell division and expansion, leading to an increase in the number of leaves $plant^{-1}$ (Patil 2011). The parallel result was also observed by Raiger *et al.* (2012) [7], Jakanoor and Backiyavathy (2019) [2], Khangarot (2020) [4] and Rathore (2021) [9].

Table 2: Effect of different phosphorus nutrient sources on no. of secondary branches $plant^{-1}$ and dry matter $plant^{-1}$ (g) of pigeonpea.

Tr. No.	Treatment	No. of secondary branches $plant^{-1}$					Dry matter $plant^{-1}$ (g)				
		30 DAS	60 DAS	90 DAS	120 DAS	At Harvest	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
T_1	Absolute control	-	3.90	12.80	15.68	18.09	3.00	17.05	76.40	114.78	152.69
T_2	Control (No P_2O_5)	-	4.10	15.67	17.76	18.96	3.06	17.21	80.33	120.75	168.45
T_3	100% P_2O_5 through PROM	-	6.07	20.13	24.44	27.14	3.17	25.38	104.13	157.10	224.89
T_4	100% P_2O_5 through DAP	-	5.23	18.73	21.37	23.15	3.09	20.52	93.63	133.70	198.72
T_5	75% P_2O_5 through PROM + 25% P_2O_5 through DAP	-	6.10	21.83	25.38	28.04	3.31	27.76	110.53	162.39	240.19
T_6	50% P_2O_5 through PROM + 50% P_2O_5 through DAP	-	5.47	19.20	23.51	25.61	3.13	24.81	100.90	150.93	214.11
T_7	25% P_2O_5 through PROM + 75% P_2O_5 through DAP	-	5.33	19.13	22.76	24.98	3.10	21.82	98.93	138.87	206.62
	S.Em±	-	0.25	0.91	1.01	1.31	0.21	1.00	3.68	3.76	9.37
	C.D. at 5%	-	0.79	2.82	3.12	4.04	NS	3.08	11.35	11.61	28.90
	General Mean	-	5.17	18.21	21.55	23.71	3.12	22.07	94.98	139.78	200.80

Table 3: Effect of different phosphorus nutrient sources on no. of functional leaves plant^{-1}, no. of nodules plant^{-1} and day to 50% flowering of pigeonpea.

Tr. No.	Treatment	No. of functional leaves plant^{-1}					No. of nodules plant^{-1}	Day to 50% flowering
		30 DAS	60 DAS	90 DAS	120 DAS	At Harvest		
T_1	Absolute control	10.87	74.95	247.07	846.82	416.30	17.45	113.93
T_2	Control (No P_2O_5)	11.23	83.20	285.40	912.31	437.19	19.45	114.76
T_3	100% P_2O_5 through PROM	11.47	101.6	348.73	1143.37	655.60	31.59	116.88
T_4	100% P_2O_5 through DAP	11.13	95.92	334.87	1022.72	528.95	26.24	115.89
T_5	75% P_2O_5 through PROM + 25% P_2O_5 through DAP	11.99	107.8	386.00	1159.92	667.58	31.16	117.69
T_6	50% P_2O_5 through PROM + 50% P_2O_5 through DAP	11.23	99.64	338.60	1110.66	610.99	27.83	115.66
T_7	25% P_2O_5 through PROM + 75% P_2O_5 through DAP	11.43	98.81	337.27	1036.93	586.56	26.32	115.13
	S.Em±	0.24	2.92	15.73	32.97	24.79	1.22	1.59
	C.D. at 5%	NS	9.01	48.49	101.60	76.38	3.77	NS
	General Mean	11.33	94.57	325.41	1033.24	557.59	25.71	115.70

2) Yield Contributing Characters and Yield

The application of 75% P_2O_5 through PROM + 25% P_2O_5 through DAP resulted significantly higher number of pods plant^{-1}, weight of pods plant^{-1}, weight seeds plant^{-1}, seed yield, stalk yield, harvest index and non-significant in number of seeds pod^{-1}, 100 seed weight at harvest as compared to rest of the different phosphorus nutrient sources treatment (Table 4). This treatment was found significant but at par with application of 100% P_2O_5 through Phosphate Rich Organic Manure (PROM) and application of 50% P_2O_5 through PROM + 50% P_2O_5 through DAP with number of pods plant^{-1}, weight of pods plant^{-1}, weight seeds plant^{-1}, number of seeds pod^{-1}, 100 seed weight, seed yield, stalk yield, harvest index.

Table 4: Effect of different phosphorus nutrient sources on yield contributing characters and yield of pigeonpea.

Tr. No.	Treatment	No. of pods plant^{-1}	weight of pods plant^{-1} (g)	weight of seeds plant^{-1} (g)	No. of seeds pod^{-1}	100 seed weight (g)	Seed yield (q ha^{-1})	Stalk yield (q ha^{-1})	Harvest index (%)
T_1	Absolute control	252.00	101.50	63.59	3.33	10.15	12.99	46.81	21.72
T_2	Control (No P2O5)	264.67	105.17	66.49	3.60	10.21	15.21	51.00	22.97
T_3	100% P2O5 through PROM	321.27	132.83	85.20	3.80	10.92	20.91	64.81	24.40
T_4	100% P2O5 through DAP	288.60	119.37	77.96	3.67	10.29	18.18	57.26	24.10
T_5	75% P2O5 through PROM + 25% P2O5 through DAP	331.33	141.70	92.07	3.90	10.99	21.55	65.44	24.77
T_6	50% P2O5 through PROM + 50% P2O5 through DAP	309.53	128.53	81.39	3.63	10.70	19.66	61.48	24.23
T_7	25% P2O5 through PROM + 75% P2O5 through DAP	292.33	122.83	78.70	3.60	10.30	18.47	58.01	24.15
	S.Em±	7.27	4.50	3.49	0.14	0.49	0.78	1.76	-
	C.D. at 5%	22.43	13.89	10.76	NS	NS	2.42	5.42	-
	General Mean	294.24	121.70	77.91	3.64	10.51	18.13	57.83	23.76

An increased nutrient availability due to application of PROM might have increased these yield attributes because nutrient supply favourably influenced the chlorophyll synthesis and hence increased carbohydrate metabolism. Therefore, increased pod numbers with P addition indicate that more flowers are formed and retained due to a better supply of nutrients and metabolites. The favourable effect helps to increase translocation of photosynthates towards seed, resulting in formation of bold seeds. Similar findings were documented by Singh *et al.* (2015) [11], Yadav *et al* (2017) [12] and Nichal (2018) [6] and Rathore (2021) [9].

3) Quality Parameters

Protein content and yield

The application of 75% P_2O_5 through PROM + 25% P_2O_5 through DAP resulted non-significantly in protein content (21.48%) and significantly in Protein yield (463.77 kg ha^{-1}) as compared to rest of the different phosphorus nutrient sources treatment (Table 5). This treatment was found significant but at par with application of 100% P_2O_5 through Phosphate Rich Organic Manure (PROM) and application of 50% P_2O_5 through PROM + 50% P_2O_5 through DAP with Protein yield.

The increase in protein content due to higher availability of phosphorus in these treatments may have boosted the nitrogen absorption and had positive influence on amino acid metabolism. Similar results were also reported by Ramesh babu *et al*., (2009) [8] and Singh *et al*., (2015) [11].

Table 5: Effect of different phosphorus nutrient sources on yield contributing characters and yield of pigeonpea

Tr. No.	Treatment	Protein content (%)	Protein yield (kg ha^{-1})
T_1	Absolute control	20.42	264.84
T_2	Control (No P_2O_5)	20.58	312.73
T_3	100% P_2O_5 through Phosphate Rich Organic Manure (PROM)	21.35	446.54
T_4	100% P_2O_5 through Di-ammonium phosphate (DAP)	21.02	382.37
T_5	75% P_2O_5 through PROM + 25% P_2O_5 through DAP	21.48	463.77
T_6	50% P_2O_5 through PROM + 50% P_2O_5 through DAP	21.25	417.80
T_7	25% P_2O_5 through PROM + 75% P_2O_5 through DAP	21.17	390.97

	S.Em±	0.26	17.81
	C.D. at 5%	NS	54.90
	General Mean	21.03	383.71

Conclusion
The study demonstrates that the application of phosphorus from various sources significantly influences the growth, yield, and quality of pigeonpea. Notably, the treatment involving 75% P_2O_5 through PROM + 25% P_2O_5 through DAP consistently outperformed other treatments in promoting plant height, branching, leaf production, dry matter and nodulation. This treatment also yielded higher pod counts, seed weight and overall seed yield, indicating enhanced nutrient availability and utilization. Overall, utilizing a combination of PROM and DAP presents a viable strategy for improving pigeonpea cultivation, ensuring better yield attributes and quality parameters, while promoting sustainable agricultural practices through organic nutrient sources.

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