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Effect of spacing and phosphorus management on pigeon pea grown on heavy black soil

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Abstract

Studies on effect of row spacing and phosphorus management on pigeon pea (AGT 2) grown on heavy black soil of middle Gujarat was carried out during the years 2021-22 to 2023-24. The experiment was laid out in split plot design with three replications. The results revealed that among the four spacing treatments, significantly the highest plant population was recorded under treatment S₁: 60-120-60 cm (Paired row) over S₂: 60-150-60 cm (Paired row), S₃: 60-180-60 cm (Paired row) & S₄: 180 x 60 cm (Farmer's practice) treatments during all the three years as well as in pooled result. Growth and yield attributes of pigeon pea like, plant height, number of branches per plant, number of pods per plant, seed yield per plant and seed index of pigeon pea (AGT 2) were remain unaffected due to the different spacing treatments during all the three years and in pooled analysis. Growth and yield attributes of pigeon pea (AGT 2) were remain unaffected due to the phosphorus management treatments, however, Phosphorus level P₂: 25 kg P₂O₅/ha + PSB recorded higher seed yield. Interactions effects were found non-significant with respect to growth attributes, yield attributes and yield. Among the spacing treatments, maximum net realization and BCR were recorded under treatments S₁: 60-120-60 cm (Paired row) followed by S₂: 60-150-60 cm (Paired row), while, in phosphorus management maximum net realization and BCR were recorded under treatment P₂: 25 kg P₂O₅/ha + PSB.

Keywords: Pigeon pea, plant population, paired row spacing, phosphorus management

Introduction

Pigeon pea is the second most important pulse crop of India after chickpea. It has occupied an area of 4.34 million hectares with a production of 3.62 million tonnes and average productivity of 836 kg/ha (Anon., 2024). In Gujarat, the area under pigeon pea was 0.17 million ha with production 0.20 million tonnes and the productivity was 1162 kg/ha (Anon., 2024). It is one of the protein rich legume crops of semi-arid and subtropics and requires due attention in view of large scale shortage of pulses to meet the domestic requirement. Thus, there is an urgent need to increase the production of pulses to meet the increasing demand by manipulating the production technologies appropriately. The yield of pigeon pea is limited by a number of factors such as agronomic, pathogenic, entomological, genetic and their interaction with environment. Among the agronomic practices, choice of a suitable row spacing and phosphorus management is one of the important factors.

Arrangement of proper row spacing is a simple agronomic technique which may plays an important role in obtaining higher yield. Under black soil conditions, vegetative growth of crop is higher on account of high soil moisture. Under these circumstances, farmers of middle Gujarat growing pigeon pea in heavy black soil are generally preferred wider spacing which may led to low yield, therefore, it is very necessary to quantify optimum plant population by adjusting the row spacing.

Phosphorus is an important plant nutrient for pulse crop in which it improves the germination, cell division, flowering, fruiting and other biochemical activities in plant. It induces root proliferation and nodulation, It also helps in root development, energy transformation and metabolic processes, which resulted in greater translocation of photosynthates towards the sink development. Phosphate solubilizing bacteria (PSB) may improve phosphorus availability and crop growth by promoting biological nitrogen fixation through releasing growth promoters such

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as indoleacetic acid, gibberellic, and cytokinin's. Inoculation of PSB has been found to improve the yield and phosphorus nutrition of different crops. Use of PSB also reduces the chemical load of soil by reducing the dose of phosphate fertilizer.

Keeping in view of the above fact, the experiment was conducted to find out the suitable plant spacing and phosphorus management practices under black soil condition of the middle Gujarat region.

Materials and Methods

The Research experiment was conducted during *kharif* season of the consecutive three years 2021-22 to 2023-24 at Narmada Irrigation Research Project, Anand Agricultural University, Khandha (Gujarat). The soil of Khandha farm is montmorillonitic and vertisols which is characterized by very deep black clayey, imperfectly drained with low infiltration rate. The initial soil status showed that soil was high in organic carbon (0.88%), available phosphorus (71.78 kg/ha) and available potassium (663 kg/ha). It having a pH of 7.87. The experiments were laid out in split plot design with three replications. There were eight treatment combinations of two factors i.e., spacing and phosphorus management. Spacing treatments comprised of four spacing i.e., S₁: 60-120-60 cm (Paired row-18,519 plants/ha), S₂: 60-150-60 cm (Paired row-15,873 plants/ha), S₃: 60-180-60 cm (Paired row-13,888 plants/ha) and S₄: 180 x 60 cm (Farmer's practice- 9,259 plants/ha), while, Phosphorus management comprised of two treatments i.e., P₁: 50 kg P₂O₅/ha and P₂: 25 kg P₂O₅/ha + PSB (Phosphate solubilizing bacteria). FYM @ 5 t/ha was applied during land preparation. Improved variety Anand grain tur 2 (AGT 2) was used in the experiment. Common seed treatment with *Rhizobium* culture @ 5 ml/kg seed was done before sowing, while seed treatment with PSB @ 5 ml/kg seed was done as per the treatment before sowing. Common dose of Nitrogen @ 25 kg/ha was applied as a basal to all plots. Phosphorus was applied as per the treatments in basal. Urea and Single super phosphate were used as source for supplying N and P₂O₅ nutrients respectively. Pigeon pea seeds were dibbled as per the spacing treatments in paired row and without paired row. Gap filling operation was undertaken at 15 days after sowing to maintain uniform plant population. Besides spacing and nutrient management practices, the crop was raised with recommended package of practices. The treatment effects were evaluated in terms of growth, yield attributing parameters, yield and economics. Observations on plant population, plant height, number of branches per plant, number of pods per plant, seed yield per plant and seed index of pigeon pea were recorded as per the procedure. Soil analysis at initial and after harvest of crop was done to assess the nutrient content in the soil. Data was analyzed statistically using Fisher's analysis of variance technique and treatment means were compared using least significant difference test at 5 percent level of probability.

Results and Discussion

The pooled results of three years experimental findings on effect of row spacing and phosphorus management on growth, yield attributes, yield and economics of pigeon pea have been discussed under different heads.

Effect of plant spacing

Plant populations/net plot was significantly increased under

paired row spacing treatment S₁: 60-120-60 cm (46.5) over other spacing treatments i.e., S₂: 60-150-60 cm (31.2), S₃: 60-180-60 cm (31.2) and S₄: 180 x 60 cm (23.2). This was attributed to more plant population per unit area under paired row as compared to normal spacing. Waghmare *et al.* (2018) ^[11] and Das *et al.* (2024) supported the similar findings. The pooled results of three years experiment findings showed that growth and yield attributes like, plant height, number of branches per plant, number of pods per plant, seed yield per plant and seed index of pigeon pea (AGT 2) were remain unaffected due to the different spacing treatments. This exhibited that even at the lowest spacing, light and moisture were adequate and did not affect plant growth and yield parameters. Mishra and Husain, and Kumakech *et al.* (2024) ^[6] also supported the above findings.

Seed yield of pigeon pea was significantly influenced due to the spacing treatments. Significantly the highest seed yield (1148 kg/ha) was recorded under treatment S₁: 60-120-60 cm (Paired row) over normal sowing treatment S₄: 180 x 60 cm i.e, farmer's practice (713 kg/ha) and it was statistically at par with treatment S₂: 60-150-60 cm (Paired row) in pooled results. This could be attributed to more number of plants per unit area under closer spacing of paired row which resulted in higher yield. These findings corroborates the results of Waghmare *et al.* (2018) ^[11], Das *et al.*, Navi *et al.* (2024) ^[9] and Jadhav *et al.* (2025) ^[4].

Different soil parameters like Organic carbon, Av. P₂O₅, Av. K₂O, Soil pH and Soil EC were not significantly influenced by the spacing treatments.

Effect of Phosphorus management

Plant population, growth attributes yield attributes and yield and soil parameters were not found significant due to the phosphorus management treatments. However, higher seed yield of pigeon pea (997 kg/ha) was recorded under treatment P₂: 25 kg P₂O₅/ha + PSB over treatment P₁: 50 kg P₂O₅/ha. This might be due to inoculation of seed with biofertilizer increase root development, more nutrient availability resulting in vigorous plant growth with improved flowering and pod formation, resulted in increased seed yield. Further, concomitant effect of rhizobium and PSB inoculation led to the enhanced nitrogen and phosphorus availability which might have utilized by plants in synthesis of protein, carbohydrates, starch and its partitioning towards formation of flowers and increases in sink capacity both in size and numbers which seems to have improved yield attributes and consequently yield. The results corroborated with the findings of Jat *et al.* (2002) ^[5], Mehta *et al.* (2012) ^[7], Tank *et al.* (2022) ^[10] and Das and Debbarma.

Interaction effects of spacing and phosphorus management:

The interaction effects between spacing and phosphorus management with respect to plant population, growth attributes, yield attributes, yield and soil parameters of pigeonpea were found non-significant.

Economics

The results revealed that among the spacing treatments, maximum net realization and BCR were recorded under treatments S₁: 60-120-60 cm (Paired row) followed by S₂: 60-150-60 cm (Paired row), while, in phosphorus management maximum net realization and BCR were recorded under treatment P₂: 25 kg P₂O₅/ha + PSB. Similar findings are related with Waghmare *et al.* (2018) ^[11] and Tank *et al.* (2022) ^[10].

Table 1: Effect of row spacing and nitrogen on plant population, growth attributes, yield attributes, yield and seed index of pigeon pea

Treatments	Plant population/ Net plot	Plant height (cm)	No. of branches /plant	No. of pods/plant	Seed yield/plant (g)	Seed yield (kg/ha)	Seed index
Main plot: Spacing (S)							
S ₁ : 60-120-60 cm (Paired row)	46.5	169	6.97	239	100	1148	9.07
S ₂ : 60-150-60 cm (Paired row)	31.2	167	7.09	239	100	1067	8.91
S ₃ : 60-180-60 cm (Paired row)	31.2	166	6.99	238	101	962	9.05
S ₄ : 180 x 60 cm (Farmer's practice)	23.2	164	7.23	245	106	713	8.98
S.E.m±	0.146	3.29	0.137	5.20	3.18	40.8	0.066
C.D. at 5%	0.434	NS	NS	NS	NS	141	NS
C.V. (%)	1.88	8.39	8.24	9.20	13.2	10.14	3.09
Sub plot: Phosphorus management (P)							
P ₁ : 50 kg P ₂ O ₅ /ha	33.0	165	6.93	238	101	948	8.98
P ₂ : 25 kg P ₂ O ₅ /ha + PSB	33.1	168	7.21	242	103	997	9.02
S.E.m±	0.136	2.22	0.104	3.53	2.31	31.64	0.049
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	2.47	7.99	8.81	8.81	13.6	10.24	3.26
Interaction							
S X P	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of spacing and phosphorus management on soil parameters

Treatments	Organic carbon (%)	Av. P ₂ O ₅ (kg/ha)	Av. K ₂ O (kg/ha)	Soil pH	Soil EC (dS/m)
Main plot: Spacing (S)					
S ₁ : 60-120-60 cm (Paired row)	1.01	59.2	781	8.12	0.45
S ₂ : 60-150-60 cm (Paired row)	1.03	58.9	768	8.10	0.46
S ₃ : 60-180-60 cm (Paired row)	1.00	57.9	754	8.10	0.45
S ₄ : 180 x 60 cm (Farmer's practice)	0.98	58.5	767	8.05	0.46
S.E.m±	0.021	1.44	19.3	0.019	0.013
C.D. at 5%	NS	NS	NS	NS	NS
C.V. (%)	8.68	10.4	10.7	0.990	12.5
Sub plot: Phosphorus management (P)					
P ₁ : 50 kg P ₂ O ₅ /ha	1.00	58.6	770	8.09	0.46
P ₂ : 25 kg P ₂ O ₅ /ha + PSB	1.01	58.7	765	8.10	0.45
S.E.m±	0.014	1.15	9.97	0.015	0.008
C.D. at 5%	NS	NS	NS	NS	NS
C.V. (%)	8.13	11.7	7.79	1.08	11.2
Interactions					
S X P	NS	NS	NS	NS	NS

Table 3: Effect of spacing and phosphorus management on economics of pigeon pea

Treatments	Yield (kg/ha)	Price (₹/kg)	Gross realization (₹/ha)	Treatment cost (₹/ha)	Common cost (₹/ha)	Total cost (₹/ha)	Net realization (₹/ha)	BCR
Main plot: Spacing (S)								
S ₁	1148	90	103320	845	55458	56303	47017	1.84
S ₂	1067	90	96030	724	55458	56182	39848	1.71
S ₃	962	90	86580	635	55458	56093	30487	1.54
S ₄	713	90	64170	422	55458	55880	8290	1.15
Sub plot: Phosphorus management (P)								
P ₁	948	90	85320	2667	55458	58125	27195	1.47
P ₂	997	90	89730	1690	55458	57148	32582	1.57

Selling price (₹/kg): 90/-

Conclusion

Looking to the above results, it can be concluded that, pigeon pea (AGT₂) seeds should be treat with ANUBHAV PSB and *Rhizobium* culture each at 5 ml/kg seed each before sowing and fertilize the crop with 5 t FYM and 25 kg P₂O₅/ha.

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