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Influence of Varieties and Spacings on Growth, Yield Attributes and Productivity of Pigeonpea

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ABSTRACT

Background: The field experiment was conducted to evaluate pigeon pea varieties *viz*., AL 882 and Pusa Arhar 16 under different spacing in Amritsar region" during *kharif* season 2019-2020 at Students' Research Farm, Department of Agriculture, Khalsa College, Amritsar.

Methods: The experiment was laid out in Randomized Block Design (factorial), replicated thrice. There were six treatments of spacing S_1 (30 × 12.5), S_2 (40 × 12.5), S_3 (50 × 12.5), S_4 (30 × 25), S_5 (40 × 25), S_6 (50 × 25 cm) and two varieties V_1 (Pusa Arhar 16) and V_2 (AL 882). All the cultural practices were performed to get maximum productivity of pigeonpea from each plot.

Result: The results revealed that cv. AL 882 performed better under spacing 30 × 12.5 cm for growth parameters such as plant height and LAI whereas dry matter accumulation, crop growth rate and number of primary and secondary branches were significantly higher in spacing 50 × 25 cm. Among yield attributes, cv. AL 882 showed significantly higher number of pods per plant, pod length (cm), number of seeds per plant and 100 seed weight (g) under spacing 50 × 25 cm than cv. Pusa Arhar 16. However, seed yield was maximum in wider spacing (50 × 25 cm) and narrow spacing (30 × 12.5 cm) with cv. AL 882 and Pusa Arhar 16, respectively. However, both varieties produced highest stover and biological yield under narrow spacing 30 × 12.5 cm.

Key words: AL 882, Pigeonpea, Pusa Arhar 16, Spacing, Varieties.

INTRODUCTION

Pulses form an integral part of vegetarian diet in Indian subcontinent. India is the major pulse growing country, accounting for about one third of the total world area under pulses and one-fourth of the world production of pulses (Anonymous, 2020). Pigeonpea [*Cajanus cajan* (L.) Millsp] is nutritious crop grown in wide range of environmental conditions both in tropical and sub-tropical regions of the world, both as a sole and intercrop under wide range of agro-ecological situations. Pigeonpea is commonly known as redgram or arhar or tur. Total area under cultivation of pigeonpea is 7.02 million ha with total production of 6.8 M tonnes in world (Anonymous, 2017). India is the also largest producer of pigeonpea with 5.3 million ha area under cultivation and production of 4.8 million tonnes (Anonymous, 2017). The area under pulses is not enough to meet the requirement of per capita availability of pulses. It has led to the severe shortage of pulses in India, which has aggravated the problem of malnutrition in large section of vegetarian population. Thus, there is a good scope of increasing productivity of pulses through different agronomic manipulations (Mallikarjun *et al.,* 2014).

Pigeonpea being cultivated on limited area of 8,000 ha with total production of 7,000 tonnes with average productivity of 875kg/ha in Punjab which offer good scope to increase the productivity through different agronomic practices (Anonymous, 2020a). Selection of cultivars and choice of optimum spacing are the major constrains in production of pigeonpea in Punjab region. The indeterminate growth of earlier varieties of pigeonpea is an undesirable character which leads to more vegetative growth. Recently dwarf varieties were released by ICAR (Pusa Arhar 16) and PAU (AL 882) having less foliage cover, high yield with very low height as compared to traditional varieties and can also be closely planted. Therefore, optimum spacing required for these varieties need to be evaluated.

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MATERIALS AND METHODS

A field experiment was conducted at Students' Research Farm, Department of Agriculture, Khalsa College, Amritsar, Punjab to study the pigeon pea varieties (Pusa Arhar 16 and AL 882) under different spacings for growth, productivity and profitability during *kharif,* 2019. The climatic condition under Amritsar district of Punjab is subtropical. The total rainfall received during the crop-growing period was 583.33 mm. The weekly maximum and minimum temperature during

the experimental period ranged from 24.3°C to 43.6°C and 11.2°C to 28.9°C, respectively (Fig 1). The soil of the experimental plot was sandy loam with low organic carbon (0.45%), low in available nitrogen (164 kg ha^{-1}) and available potassium (235 kg/ha) but high in available phosphorus (28.5 kg/ha). The soil reaction of the experimental field was nearly neutral (pH 7.1) with an electrical conductivity of 0.26 dS/m.

The experiment was laid out in a factorial randomized block design, with two varieties *i.e.* (V_1: Pusa Arhar 16 and V_2: AL 882) and 6 crop spacings (S_1, 30 × 12.5; S_2, 40 × 12.5; S_3, 50 × 12.5; S_4, 30 × 25; S_5, 40 × 25; S_6, 50 × 25 cm). All these treatment combinations were replicated thrice. The Pigeonpea seeds were treated with Rhizobium culture and sown in well-prepared soil by single-row hand operated drill in a net plot area of 6.0 × 3.0m. The amount of seeds varies as per the spacing. A uniform basal dose of 87.5 kg/ha P_2O_5 and 50 kg/ha K_2O was applied through DAP and MOP before sowing of the crop respectively. Nitrogen, Phosphorus and potassium were applied as basal dose at the time of sowing. One pre-sowing irrigation was applied to the crop 7 days before sowing and post-sowing irrigation was applied to the crop 8 DAS. One spray of pendimethalin @ 450 g/ha at 1 DAS followed by one hoeing was done to control the emerged weeds at 50 DAS as per recommended package of practices. Crop was harvested manually with sickle and tied in bundles with tags from each plot and left for sun drying. Threshing operations were also performed plot wise manually. The growth parameters, *viz*. plant height (cm), dry matter/plant (g/plant), number of primary branches, number of secondary branches at the time of harvesting. Various growth, yield attributes and yield, *viz*. LAI, CGR, plant height (cm,) dry matter (g /plant), primary and secondary branches pods/plant, Seeds/pod, 100 seed weight (g), seed yield (kg/ha) and Stover yield (kg/ha) at the time of harvesting of pigeonpea. The analysis of statistical data was done by using EDA, software developed by the Department of Mathematics and Statistics, PAU, Ludhiana.

RESULTS AND DISCUSSION

Growth analysis

Plant height (cm)

Plant height showed a non-significant difference under different spacing where maximum plant height was recorded in spacing 30 × 12.5 cm followed by 40 × 12.5, 50 × 12.5, 30 × 25, 40 × 25 and 50 × 25 cm (Table 1). Out of two varieties, cv. AL 882 had significantly higher plant height as compared to cv. Pusa Arhar 16. This might be due to the difference in the genetic characteristics of cv. Pusa Arhar 16 as compared to cv. AL 882. Similar results were reported by Mallikarjun *et al.* (2015).

Leaf area index

Leaf area index (LAI) showed a significant difference under different spacing whereas spacing 30 × 12.5 cm showed a higher leaf area index followed by 40 × 12.5, 50 × 12.5, 30 × 25, 40 × 25 and 50 × 25 cm (Table 1). It has been observed that the LAI varied significantly but 40 × 25 and 50 × 25 cm spacing were statistically at par with each other. The highest leaf area index at narrow spacing might be due to an increase in plant density. Similar results were reported by Saritha *et al.* (2012). Both varieties varied significantly but with each other, it has been observed that cv. AL 882 showed a higher leaf area index than cv. Pusa Arhar 16. This might be due to differences in genetic characters of both varieties. Similar results were revealed by Walelign *et al.* (2012).

Dry matter accumulation (g /plant)

Dry matter accumulation was significantly higher at spacing 50 × 25 cm followed by 40 × 25, 30 × 25, 50 × 12.5, 40 × 12.5 and 30 × 12.5 cm (Table 1). However, 50 × 12.5 were at par with 30 × 25 and 40 × 12.5 cm spacing. This might be due to more foliage and better exposure of solar radiation interception. Out of two varieties, cv. AL 882 had significantly higher dry matter accumulation as compared to cv. Pusa Arhar 16. This might be due to the variation in growth habits.

Number of branches per plant

The primary and secondary branches are the important determinant of stover and seed yield in pigeonpea. More number of branches leads to a higher number of pods resulting in a higher seed yield. The data (Table 1) revealed that spacing 50 × 25 cm had a significantly higher number of primary branches and secondary branches than 40 × 25, 30 × 25, 50 × 12.5, 40 × 12.5 and 30 × 12.5 cm. Spacing 50 × 25 cm being at par with S_5 produced significantly more primary branches than all the other spacings. Spacing 50 × 25 cm produced significantly more no. of secondary branches than 30 × 12.5 cm and 40 × 12.5 cm. It was observed that 50 × 25 cm showed 51.2 and 24.0% more primary branches and secondary branches than 30 × 12.5 cm respectively. This might be due to more space available horizontally leading to better plant geometry. Also, cv. AL 882 had 23.2 and 18.5% more number of primary branches and secondary branches than cv. Pusa Arhar 16 at harvesting stage respectively. This might be due to genetic capability and better utilization of resources of cv. AL 882 as compared to cv. Pusa Arhar 16. Similar results were reported by Kaur *et al.* (2018).

Crop growth rate (CGR) (g m^{-2} day^{-1})

Crop growth rate (CGR) increased upto 90 days of crop age, thereafter it declined. Crop growth rate was non-significant at different spacings, Maximum CGR (Table 1) was found in spacing 50 × 25 cm followed by 40 × 25, 30 × 25, 50 × 12.5, 40 × 12.5 and 30 × 12.5 cm. Similar results were reported reported by Suresh *et al.* (2012). Out of two varieties, cv. AL 882 showed significantly more CGR than cv. Pusa Arhar 16. This might be due to different varietal characteristics.

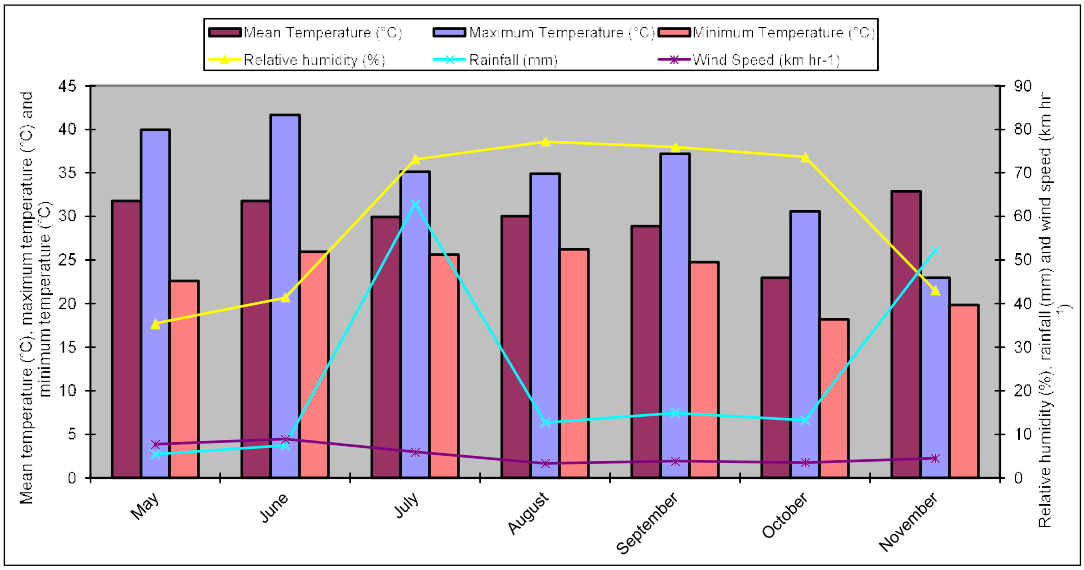


Fig 1: Weekly mean meteorological data recorded during the crop season (May-November 2019).

Table 1: Growth parameters at harvest as affected by spacing and varieties of pigeonpea.

Treatments	Plant height at harvest (cm)	Leaf area index at harvest (LAI)	Dry matter at harvest (g/plant)	CGR at harvest (g/plant/day)	Number of primary branches at harvest	Number of secondary branches at harvest
Spacings (cm)						
S_1 (30 × 12.5)	248.15	4.26	181.77	1.43	14.00	12.50
S_2 (40 × 12.5)	245.88	3.23	187.53	1.46	15.50	13.33
S_3 (50 × 12.5)	244.86	2.66	193.62	1.51	17.00	13.83
S_4 (30 × 25)	241.85	2.27	198.32	1.55	18.33	14.50
S_5 (40 × 25)	241.41	1.73	205.91	1.62	19.67	14.83
S_6 (50 × 25)	238.7	1.42	213.38	1.68	21.17	15.50
SEm±	8.02	0.12	7.17	0.06	0.61	0.61
CD (p=0.05)	NS	0.37	20.85	NS	1.81	1.78
Variety						
V_1 (Pusa Arhar 16)	194.77	2.25	166.37	1.30	15.78	12.89
V_2 (AL 882)	292.18	2.94	227.14	1.77	19.44	15.28
SEm±	4.63	0.07	4.10	0.03	0.35	0.35
CD (p=0.05)	13.58	0.21	12.04	0.10	1.04	1.03

Yield parameters

Number of pods per plant

Spacing S_6 (194.33) gave significantly higher number of pods per plant followed by S_5 (159.50), S_4 (127.00), S_3 (113.83), S_2 (106.17), S_1 (93.67) respectively. Spacing S_6 being at par with S_5 and S_4 produced significantly more number of pods per plant than S_1, S_2 and S_3 which were again at par with each other (Table 2). This might be due to the availability of wider space available for better growth and development of plants. Both varieties showed non-significant results however cv. AL 882 had slightly higher number of pods as compared to cv. Pusa Arhar 16. Interaction between varieties and spacing was found to be significant. Both varieties cv. Pusa Arhar 16 (152.33) and cv. AL 882 (236.33) produced the highest pods at 50 × 25 cm. Cultivar AL 882 under 50 × 25 cm produced 55.26% more pods than cv. Pusa Arhar 16 under 50 × 25 cm spacing.

Pod length (cm)

The data on pod length presented in Table 2 revealed that the different spacings have significant effect on the pod length. The spacing 50 × 25 cm (5.35 cm) had maximum pod length followed by 40 × 25(5.18), 30 × 25 (5.00), 50 × 12.5 (4.78), 40 × 12.5 (4.62) and 30 × 12.5 cm (4.52 cm). Spacing S_6 being at par with S_5 and S_4 produced significantly more pod length than S_1, S_2 and S_3 which were again at par with each other. The highest pod length might be due to better reproductive phase and photosynthetic assimilation from source to sink. The genotypes cv. Pusa Arhar 16 and cv. AL 882 had non-significant results in pod length.

Table 2: Yield attributes and yield as influenced by different spacing and varieties of pigeonpea.

Treatment	Number of pods per plant	Pod length (cm)	Number of seeds per pod	100-seed weight (g)	Seed yield (q/ha)	Stover yield (q/ha)
Spacing (cm)						
S_1 (30 × 12.5)	93.67	4.52	3.17	6.95	13.08	60.62
S_2 (40 × 12.5)	106.17	4.62	3.33	7.01	12.15	57.38
S_3 (50 × 12.5)	113.83	4.78	3.83	7.13	12.23	53.21
S_4 (30 × 25)	127.00	5.00	4.17	7.21	11.06	49.91
S_5 (40 × 25)	159.50	5.18	4.33	7.30	11.59	48.31
S_6 (50 × 25)	194.33	5.35	4.67	7.40	12.28	45.73
SEm±	5.06	0.16	0.07	0.18	0.40	1.86
CD (p=0.05)	14.85	0.47	NS	NS	1.19	5.47
Variety						
V_1 (Pusa Arhar 16)	129.33	4.89	3.89	7.10	11.72	39.98
V_2 (AL 882)	135.50	4.92	3.94	7.23	12.41	65.08
SEM±	2.92	0.09	0.10	0.11	0.23	1.07
CD (p=0.05)	NS	NS	NS	NS	0.69	3.16
Interaction	21.01	NS	NS	NS	1.68	NS

Number of seeds per pod

Numbers of seeds per pod were not significantly affected under different spacings. Similar findings have been reported by Kashyap *et al.* (2003). Out of two the varieties, cv. AL 882 had more number of seeds per pod than Pusa Arhar 16, but both varieties were non-significant. Similar results reported by Chandrakar *et al.* (2015).

100 seed weight (g)

100 seed weight (g) were non-significantly affected under different spacings (Table 2). Varieties also showed non-significantly results. These finding were inconformity with Das *et al.* (1996) and Chandrakar *et al.* (2015).

Seed yield

The data revealed that maximum mean seed yield was recorded in the spacing of 30 × 12.5 cm (13.08 q ha^{-1}) followed by 50 × 25 (12.28 q ha^{-1}), 50 × 12.5 (12.23 q ha^{-1}), 40 × 12.5 (12.15 q ha^{-1}), 40 × 25 (11.59 q ha^{-1}) and 30 × 25 cm (11.06 q ha^{-1}), respectively (Table 2). It has been observed that spacing S_1 varied significantly with S_4 and S_5. The results are in accordance with the findings of Chandrakar *et al.,* (2015).Significantly higher mean yield was recorded with cv. AL 882 (12.41 q ha^{-1}) with 5.9% more seed yield than cv. Pusa Arhar 16(11.72 q ha^{-1}). This might be due to differences in genetic characters of both varieties. Interaction between varieties and spacing was found to be significant (Table 3). cv. Pusa Arhar 16 produced the highest yield at 30 × 12.5 cm (16.42 q ha^{-1}), whereas cv. AL 882 at 50 × 25 cm (15.93 q ha^{-1}). cv. Pusa Arhar 16 at 30 × 12.5 cm showed 3.1% more seed yield than cv. AL 882 at 50 × 25 cm. Pusa Arhar 16 produced 98.8% less seed yield as spacing increased from S_1 to S_6 whereas, AL 882 produced 63.6% more yield under S_6 than S_1. This might be due to the dwarf nature of cv. Pusa Arhar 16 that requires less space per plant as compared to cv. AL 882.

Stover yield

The superiority of growth characters like plant height, branches, LAI and dry matter accumulation may be the possible reasons for the production of higher stover yield. A higher yield of the stover was recorded from the planting geometry of 30 × 12.5 cm (60.62 q ha^{-1}), (Table 2) followed by 40 × 12.5 (57.38 q ha^{-1}), 50 × 12.5 (53.21 q ha^{-1}), 30 × 25 (49.91 q ha^{-1}) and 40 × 25 cm (48.31 q ha^{-1}), while the lowest yield of the stove (45.73 q ha^{-1}) was recorded in the planting geometry of 50 × 25 cm wider spacing respectively (Table 2). It has been observed that stover yield varied significantly but S_1 and S_2 were statistically at par with each other. It might be due to more number of plants per unit area. Similar results have also been reported by Umesh *et al.* (2013) and Tuppad *et al.* (2012). Out of two varieties, cv. AL 882 (65.08) showed significantly higher stover yield than cv. Pusa Arhar 16 (39.98). This might be due to dwarfed nature of cv. Pusa Arhar 16.

Relationship study

In case of cv. Pusa Arhar 16, yield was highly positively correlated with number of plants per hectare (r=0.986). However, highly negative correlation was found between yield and number of primary branches per plant (r = -0.965), number of pods per plant(r = -0.955), 100 seed weight (r = -0.994) and number of seed per pod(r = -0.647) (Table 4). This might be due to the fact that although plants of cv. Pusa Arhar 16 has less number of primary branches per plant, number of pods per plants,100 seed weight and seeds per pod but seed yield was compensated by higher number of plants per hectare at narrow spacing. On other hand AL 882, highly positive correlation was found between yield and number of primary branches per plant (r = 0.971), number of pods per plant (r = 0.988), 100 seed weight (r = 0.993) and number of seed per pod (r = 0.978). However, yield was highly

Table 3: Interaction effect of different spacing and varieties on seed yield of pigeonpea.

Spacing (cm) → Varieties ↓	S_1 (30 × 12.5)	S_2 (40 × 12.5)	S_3 (50 × 12.5)	S_4 (30 × 25)	S_5 (40 × 25)	S_6 (50 × 25)
V_1 (Pusa Arhar 16)	16.42	13.58	12.59	9.90	9.19	8.26
V_2 (AL 882)	9.74	10.71	11.85	12.21	13.98	15.93
SEm±	0.57					
CD (p=0.05)	1.68					

Table 4: Correlation coefficients (r).

Yield attributes / Seed yield	Number of plants per hectare	Number of primary branches per plant	Number of pods per plant	100 seed weight	Number of seed per pod
cv. Pusa Arhar 16	r = 0.986	r = -0.965	r = -0.955	r = -0.994	r = -0.647
cv. AL 882	r = -0.937	r = 0.971	r = 0.988	r = 0.993	r = 0.978

Table 5: Effect of spacing and varieties on soil properties after harvest.

Treatment	Available N	Available P	Available K	Electrical conductivity	pH
	(kg ha^{-1})			(ds/m)	
Spacing (cm)					
S_1 (30 × 12.5)	183.33	26.40	197.33	0.35	7.15
S_2 (40 × 12.5)	180.16	26.76	200.83	0.36	7.21
S_3 (50 × 12.5)	178.50	26.95	206.00	0.37	7.20
S_4 (30 × 25)	177.00	27.38	211.16	0.37	7.28
S_5 (40 × 25)	175.83	27.75	218.16	0.38	7.40
S_6 (50 × 25)	173.50	28.20	226.00	0.38	7.45
Variety					
V_1 (Pusa Arhar 16)	177.38	27.33	212.38	0.37	7.31
V_2 (AL 882)	178.72	27.14	207.44	0.36	7.25
Initial soil status	164	28.5	235	0.40	7.5

negatively correlated with number of plants per hectare (r = -0.937). In this case, yield contributing attributes sufficiently compensated the yield loss due to low plant population under wider spacing.

Effect on soil properties after harvest

The findings of the experiment as provided in Table 5 showed that none of the treatments for canopy modification had any major effect on the available N, P, K, pH and EC. Moreover, the data showed that the treatments for nutrient control had a major impact on the soil's usable N, P, K and pH.

Treatment with spacing 30 × 12.5 cm spacing provided the maximum accumulation of nitrogen. This might be due to more number of root nodules present per unit area leading to more nitrogen fixation at narrow spacing than wider spacing. The maximum drain of available P and K might be due to narrow spacings which drain more nutrient than wider spacings.

In the case of varieties, cv. AL 882 drained more P, K and add more nitrogen and organic carbon whereas available soil organic carbon and EC showed non-significant results.

CONCLUSION

On the basis of one year study, it can be concluded that Pusa Arhar 16 at 30 × 12.5 cm spacing and AL 882 at 50 × 25 cm performed better in terms of for yield under Amritsar's agro- climatic conditions.

Conflict of interest

All authors declare that they have no conflict of interest.

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