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Effect of inter and intra row pacing on yield and economics of pigeonpea (*Cajanus cajan* (L.) Millsp.)

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Abstract
Significantly higher number of pods per plant (442.73) was recorded with 144 cm x 60 cm spacing when compared to closer spacing of 90 cm x 30 cm (336.40). Pod weight per plant is also one of the important yield attributing traits, where wider spacing of 144 cm x 60 cm recorded significantly higher pod weight per plant (257.18 g plant^{-1}), when compared to narrow spacing like 90 cm x 30 cm (189.97 g plant^{-1}). Number of seeds per pod is another important yield attributing traits and was higher at a spacing of 144 cm x 60 cm (5.80) as compared to the spacing of 90 cm x 30 cm (4.77). Closer spacing of 90 cm x30 cm recorded significantly higher seed yield (2266 kg ha^{-1}) when compared to other spacings tested *viz*., 90 cm x 45 cm (1718 kg ha^{-1}), 120 cm x 30 cm (1898 kg ha^{-1}). Among the different spacings, the spacing of 90 cm x 30 cm recorded higher cost of cultivation (₹ 17,000 ha^{-1}) as it consumed higher seed when compared to other row spacings. Further it also recorded higher gross returns (₹ 80310 ha^{-1}), higher net returns (₹ 63, 310 ha^{-1}) than other spacings and B: C ratio was also higher in spacing of 90 cm x 30 cm (3.72) when compared to all other spacings.

Keywords: Pigeon pea, spacing, net returns and yield

Introduction
Pigeonpea [*Cajanus cajan* (L.) Mills.] Is an important grain legume in the semi-arid tropics of Asia and Africa due to its high protein (20-22%) content? India is the largest producer and consumer because pigeonpea plays an important role in food security, balanced diet and alleviation of poverty (Rao *et al*., 2002) [1]. Agronomic activities are regarded as important factor in increasing crop production such as soil moisture, light intensity, and inter- and intra-row spacing influence pigeon peas growth and development (Sinha *et al*., 1988) [2].The yield of pigeon pea is limited by a number of factors such as agronomic, pathogenic, entomological, genetic and their interaction with environment. Normally the crop is grown under dry land during *kharif* under low management conditions and is fairly drought tolerant, but it does not tolerate water logged conditions for very long. Pigeon pea also needs some amount of moisture and optimum temperature particularly during its pod development stages. However, the productivity of the crop is quite low. One of the possible ways of increasing its productivity is through intensive cultivation with suitable crop geometry (inter and intra row spacing). Pigeon pea being photosensitive, highly branching and indeterminate growth habit responds very well to spacing. Hence yield is very much influenced by both inter and intra row spacing. To achieve potential yields, it is important to maintain optimum plant population for effective utilization of moisture, nutrients and solar radiation. It is also evident that providing protective irrigation during drought period will increase the yield due to more uptake of water and nutrients by the plants.

Material and methods
The field experiment was conducted at Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru during *kharif* 2011 to study the **"**Optimization of spacing for pigeonpea (*Cajanus cajan* (L.) Millsp.) under protective irrigation**"**. The soil of the experimental site was sandy clay loam in texture (coarse sand 21.36 %, fine sand 22.11 %, silt 20.60 % and clay 35.93 %). The soil pH was around neutral (6.64) with an electrical conductivity of 0.15 dSm^{-1}. The soil was low in organic carbon (0.45 %) and medium in available nitrogen, phosphorus and potassium (278.5, 35.53 and

161.24 kg ha^{-1}). Experiment included nine treatments consisted of T_1- 90 cm x 30 cm, T_2- 90 cm x 45 cm, T_3- 90 cm x 60 cm, T_4- 120 cm x 30 cm, T_5- 120 cm x 45 cm, T_6- 120 cm x 60 cm, T_7- 144 cm x 30 cm, T_8- 144 cm x 45 cm and T_9- 144 cm x 60 cm were laid out in Randomized Complete Block Design (RCBD) with three replications. Yield parameters and yield (biological and economical) was recorded from individual plots at harvest and converted to kg/ha. Standard statistical methods were used for comparing the treatment means. The price of inputs that were prevailing at the time of their experimentation was considered for working out the cost of cultivation. Benefit-cost ratio was worked out.

Results and discussion

Yield parameters

Significantly higher number of pods per plant (442.73) was recorded with 144 cm x 60 cm spacing when compared to closer spacing of 90 cm x 30 cm (336.40). This may be due to wider availability of spacing, more availability of light and moisture, which made the plant to grow vigorously and this might have experienced less competition compared to narrow spacings. Pod weight per plant is also one of the important yield attributing traits, where wider spacing of 144 cm x 60 cm recorded significantly higher pod weight per plant (257.18 g plant^{-1}), when compared to narrow spacing like 90 cm x 30 cm (189.97 g plant^{-1}). Number of seeds per pod is another important yield attributing traits and was higher at a spacing of 144 cm x 60 cm (5.80) as compared to the spacing of 90 cm x 30 cm (4.77) (Table 1). Similarly hundred seed weight was higher with wider spacing of 144 cm x 60 cm (12.67 g) as compared to closer spacing of 90 cm x 30 cm (11.17 g). These results are in accordance with the results obtained by Satpute, 1994[3] and Puste and Jana, 1996 [4]. Significantly higher pod bearing length was observed with the spacing of 144 cm x 60 cm (56.87 cm) over closer spacing of 90 cm x 30 cm (43.48 cm) and 90 cm x 45 cm (44.87cm) (Table 2). Satpute, 1994 [3] and Laxman Singh *et al*, (1971) [5] also observed a higher pod bearing length with lower plant density. The better performance of plants at wider spacing of 144 cm x 60 cm may be attributed to least inter plant competition and greater availability of growth resources *viz.*, light, moisture, nutrients and space for each plant.

Table 1: Effect of spacing on pod bearing length, number of pods per plant, number of seeds per pod, pod weight per plant and 100 seed weight of pigeon pea

Treatments	Pod bearing length (cm)	Number of pods per plant	Number of seeds per pod	Pod weight per plant (g)	100 seed weight (g)
T_1- 90 cm x 30 cm	43.48	336.40	4.77	189.97	11.17
T_2- 90 cm x 45 cm	44.87	376.60	4.97	215.51	11.69
T_3- 90 cm x 60 cm	52.59	379.00	5.23	227.30	11.76
T_4- 120 cm x 30 cm	50.72	408.93	4.87	191.13	11.86
T_5- 120 cm x 45 cm	53.89	386.80	5.37	235.55	12.08
T_6- 120 cm x 60 cm	55.54	422.87	5.60	248.28	12.35
T_7- 144 cm x 30 cm	52.70	423.00	5.03	203.43	12.42
T_8- 144 cm x 45 cm	56.25	438.00	5.47	241.05	12.61
T_9- 144 cm x 60 cm	56.87	442.73	5.80	257.18	12.67
S. Em±	2.013	16.801	0.233	15.270	0.544
C. D. at 5%	6.034	50.369	0.698	45.781	NS

Table 2: Effect of spacing on seed yield, stalk yield, and harvest index of pigeonpea

Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index
T_1- 90 cm x 30 cm	2266	6392	0.230
T_2- 90 cm x 45 cm	1719	4763	0.225
T_3- 90 cm x 60 cm	1311	3292	0.230
T_4- 120 cm x 30 cm	1898	5283	0.230
T_5- 120 cm x 45 cm	1310	3445	0.230
T_6- 120 cm x 60 cm	945	2316	0.226
T_7- 144 cm x 30 cm	1679	5214	0.217
T_8- 144 cm x 45 cm	952	2352	0.232
T_9- 144 cm x 60 cm	938	2449	0.225
S. Em±	116.06	294.34	0.003
C. D. at 5%	347.96	882.43	NS

Yield of pigeonpea

In the present study, closer spacing of 90 cm x30 cm recorded significantly higher seed yield (2266 kg ha^{-1}) when compared to other spacings tested *viz*., 90 cm x 45 cm (1718 kg ha^{-1}), 120 cm x 30 cm (1898 kg ha^{-1}), 144 cm x 30 cm (1679 kg ha^{-1}), 90 cm x 60 cm (1311 kg ha^{-1}), 120 cm x 45 cm (1310 kg ha^{-1}), 120 cm x 60 cm (945 kg ha^{-1}), 144 cm x 45 cm (952 kg ha^{-1}) and 144 cm x 60 cm (938 kg ha^{-1}). Significant differences in seed yield of pigeonpea was observed with closer spacing of 90 cm x 30 cm over other spacings, because of more plant population per unit area i.e., 37,037 plants ha^{-1} and five protective irrigations were given at three and forty days after sowing, at flowering, pod initiation stage and at maturity stage. However, the yield attributes per plant were significantly lower with narrow spacing (because of the competition between plants) when compared to the yield attributes per plant recorded with wider spacing. These results are in accordance with the findings of Pavan *et al*, (2009) [6] and Mula *et al*, (2011) [7].

Economics

Among the different spacings, the spacing of 90 cm x 30 cm recorded higher cost of cultivation (₹ 17,000 ha^{-1}) as it consumed higher seed when compared to other row spacings. Further it also recorded higher gross returns (₹ 80310 ha^{-1}), higher net returns (₹ 63, 310 ha^{-1}) than other spacings due to

its higher seed yield than other spacings. B: C ratio was also higher in spacing of 90 cm x 30 cm (3.72) when compared to all other spacings (Table 3). These results are in agreement with the findings of Arjun Sharma *et al*, (2003) [8] and Ravikumar Bhavi and Desai, 2007 [9].

Table 3: Economics of pigeonpea as influenced by different spacing intervals

Treatments	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B: C ratio
T_1- 90 cm x 30 cm	17,000	80,310	63,310	3.72
T_2- 90 cm x 45 cm	16,870	60,865	43,995	2.61
T_3- 90 cm x 60 cm	16,610	46,485	29,875	1.80
T_4- 120 cm x 30 cm	16,573	67,230	50,657	3.06
T_5- 120 cm x 45 cm	16,610	46,450	29,840	1.80
T_6- 120 cm x 60 cm	16,299	33,575	17,276	1.06
T_7- 144 cm x 30 cm	16,685	59,215	42,530	2.55
T_8- 144 cm x 45 cm	16,345	33,820	17,475	1.07
T_9- 144 cm x 60 cm	16,248	33,330	17,082	1.05

Conclusion

Among the different spacings 90 x 30 cm resulted in significantly higher yield parameters, yield and economic returns. This treatment closely followed by 90 x 45 cm and 120 x 30 cm spacings. Wider spacing observed lower yield and economic returns.

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