Journal of Food Legumes 23(3&4): 186-190, 2010

Response to spacing and irrigation in a medium-duration CMS-line of pigeonpea

M.G. MULA, K.B. SAXENA, A. RATHORE and R.V. KUMAR

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru - 502 324, Andhra Pradesh, India; Email: m.mula@cgiar.org

(Received: October, 2010; Accepted: December, 2010)

ABSTRACT

The field experiment was conducted in Alfisols to develop a package of agronomic management practices for large-scale nucleus seed production of a cytoplasmic-nuclear male-sterile (CMS) line 'ICPA 2043'. The treatments included two planting ratios (4:1 and 3:1) of male sterile (MS):male fertile (MF) lines; two row-to-row distance (75 cm and 150 cm); two plant-to-plant spacings (30 cm and 50 cm); and two irrigation frequencies (14 and 18 day intervals). The phenological attributes of 'ICPA 2043' were significantly influenced by the direct and interactive effects of row ratio, irrigation and plant spacing. Individual plants at wider spacing showed significant positive effect on various agronomic traits such as stem diameter, number of branches, weight of dry biomass, number of pods and yield/plant over closer spacing. These attributes however, did not translate into increased seed yield due to plant population. The study showed that the optimum spacing and irrigation for producing maximum seed yield of 'ICPA 2043' was 75 cm x 30 cm in 3:1 row ratio with irrigation at every 18 days (from flower initiation to pod development) which produced seed yield at 2013 kg/ha while in 4:1, spacing of 75 cm x 30 cm with irrigation at every 14 days produced the highest seed yield of 1693 kg/ha.

Key words: Cytoplasmic-nuclear male-sterility, Irrigation, Pigeonpea hybrid, Plant spacing

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] or red gram is the fifth most important pulse crop in the world. In India, pigeonpea is second to chickpea in area and production at 3.58 million (m) hectares and 2.50 m tons (t), respectively (FAO 2008). As a '*dal*', pigeonpea is a vital staple food because it contains 20 - 22% protein, carbohydrates and minerals (Singh *et al.* 1990). However, India's domestic consumption annually is registered at 3.4 mt (Price *et al*. 2003) as against the production of only 2.5 mt due to its low productivity of 0.7 t/ha. To meet the domestic demand, India imports about 1.5 – 2.8 mt of pigeonpea annually from Myanmar and Africa (www.crnindia.com/commodity/tur). The pigeonpea productivity has remained static for decades, which poses a challenge to researchers. To address declining area and production, research must focus on breeding hybrid cultivars (Saxena 2008) together with developing appropriate agronomic practices to realize hybrid potential (Ali and Kumar 2000).

The development of pigeonpea hybrid technology started with the discovery of genetic male-sterility (GMS) system (Reddy *et al*. 1978); however, the system did not take off due to problems associated with multiplication of large-scale hybrid seeds. ICRISAT – researchers developed the cytoplasmic-nuclear male-sterility (CMS) system which facilitated the large-scale seed production of hybrids and their female parents (Saxena *et al*. 2005).

Growth and development of pigeonpea vary significantly from location to location and even in the same location. The major factors influencing variability in pigeonpea growth include sowing date, plant density, irrigation methods and frequency, nutrient and weed management, and other cultural practices (Ahlawat and Rana 2005). Inter- and intra-row spacing, optimum soil moisture during crop development and efficient insect control are regarded as important agronomic management practices in any seed production system. Plant density is another important factor in increasing yield, however narrow row spacings bring variation in microclimatic factors such as light intensity, evapo-transpiration and temperature of soil surface (Sinha *et al*. 1988). This research was conducted to identify the optimum plant spacing and irrigation frequency for increasing nucleus seed production of a CMS-line 'ICPA 2043' of pigeonpea.

MATERIALS AND METHODS

The experiment was conducted in an isolated area of 2,500 m^2 Alfisols in June 2009 and harvested in January 2010 at Patancheru, India. The experimental materials consisted of two parental lines: a male-sterile 'ICPA 2043' and its maintainer line 'ICPB 2043'; sown in two planting density - 4 rows of 'ICPA 2043' to 1 row of 'ICPB 2043' (4:1) and 3:1. Two row-to-row spacings (75 cm and 150 cm) and two plant-to-plant spacings (30 cm and 50 cm) were implemented to find out the optimum plant spacing in producing seeds of 'ICPA 2043'. Irrigation treatments included 14 day and 18 day intervals from flower initiation to pod development with four and three irrigation at field capacity of 50 mm/irrigation by flooding, respectively. The experiment was laid out in a split-split-plot design having two replications. There were 14 treatments *viz.,* a) Row ratio (2); in each row ratio are the following: b) Row-to-row spacing (2); c) Plant-to-plant spacing (2); and d) Irrigation frequency (2). The row length of each treatment was 10 m. The maintainer line was sown at plant-to-plant spacing of 30 cm. Total rainfall received during 2009-2010 cropping season was 897.68 mm with more rainfall in the months of August

(420.19 mm) and September (264.60 mm) during its vegetative stage and October (60.1 mm) during its flower initiation. Irrigation was stopped when the pods are at physiological maturity. A basal dose of 100 kg/ha di-ammonium phosphate was applied. Recommended agronomic practices were followed uniformly to all the treatments. Observation on plant height at 50% flowering (cm), main stem diameter (cm), dry biomass (kg), number of branches/plant, pods/plant, seeds/pod, 100-seed weight (g), and seed yield (g/plant) were collected on 10 randomly selected competitive plants within each treatment. The total seed yield (kg/ha) was calculated on plot basis. To detect the direct and interactive effects of plant spacing, row ratio and irrigation, analysis of variance for split-split plot design (SSP) was used to determine the best treatment combination in optimizing seed yield of 'ICPA 2043'.

RESULTS AND DISCUSSIONS

Effect of row ratio: Variation in row ratio (4:1 and 3:1) had no significant (P<0.05) effect on plant height, stem diameter, biomass, number of branches, seeds/pod, 100 seed mass, yield/plant and yield/ha. However, pods/plant differed significantly (P<0.05) at two row ratios of 'ICPA 2043' (Table 1). High row ratio (4:1) produced more pods/plant (308) (Table 2) which supports the previous observations of Mula *et al*. (2010a) and Saxena (2006).

Effect of planting distance*:* Planting distance was not significantly (P<0.05) different on plant height, number of branches, and 100-seed mass of 'ICPA 2043'; however, the differences were significant for stem diameter, biomass, pods/plant, seeds/pod, yield/plant and yield/ha (Table 1). Wider spacing of 150 cm x 50 cm produced the thickest stem (2.76 cm/plant), highest biomass (0.33 kg/plant), pods/plant (365), seeds/pod (3.10) and yield/plant (87.36 g), while 75 cm x 30 cm planting distance produced the highest seed yield of 1533 kg/ha (Table 2) which is similar to the findings of Mula *et al.* (2010a). However, spacing did not influence the total productivity of the female parent due to increase in number of plants in closer spacing, which is in conformity to the findings of Mula *et al*. (2010b) and Kumar *et al*. (2001) and not in agreement to the findings of Saxena (2008) where spacing of 100 cm x 50 cm produced more yield than spacing of 75 cm x 30 cm by a margin of 164%.

Effect of irrigation: Irrigation frequencies (4 vs 3) had no significant effect on agronomic traits including grain yield of 'ICPA 2043' (Table 1).

Row ratio and irrigation: Majority of the interactive effects of row ratio and irrigation were not significantly (P<0.05) different for agronomic traits including grain yield of 'ICPA 2043' except for biomass (Table 1). Row ratio of 4:1 with irrigation at every 14 days yielded the highest biomass at 0.32 kg/plant (Table 2). This is in accordance to the findings of Kumar Rao *et al.* (1992) and Lawn and Troedson (1990) where no major interactions were observed between the irrigations and spatial arrangements on the various agronomic traits.

Row ratio and planting distance: The interactive effect of row ratio and planting distance showed no significant (P<0.05) difference on plant height, biomass, number of branches, 100-seed mass, and yield/ha of 'ICPA 2043'. However, there was a significant (P<0.05) difference among the treatments for stem diameter, pods/plant, seeds/pod and yield/plant (Table 1). Four to one row ratio and 150 cm x 50 cm planting distance recorded the highest stem diameter (3.34 cm/plant); pods/plant (449); seeds/pod (3.62); and seed yield/plant (98.70 g) (Table 2), similar to those reported earlier (Mula *et al*. 2010a; and Singh *et al*. 1971).

Irrigation and planting distance: The interactive effect of irrigation and planting distance on the agronomic traits including grain yield, 100-seed mass, yield/plant and yield/ha of 'ICPA 2043' was not significantly (P<0.05) different among the treatments, while a significant difference was observed among treatments for pods/plant and seeds/pod (Table 1). Irrigation at 14 days and 150 cm x 50 cm plant spacing resulted more pods/plant (389) and seeds/pod (3.23) (Table 2). This study conforms to the findings of Remanandan (1990) and Mula *et al*. (2010a) that the number of pods/plant and seed/

Table 1. Direct and interactive effects of row ratio, irrigation and planting distance on the growth and yield traits of 'ICPA 2043' at 5% level of significance.

Direct and Interactive Effects	Growth traits				Yield traits				Seed yield (kg/ha)
	Plant height at 50% flowering (cm)	Stem diameter (cm)	Biomass (kg)	Branches/ plant (no.)	Pods/ plant (no.)	Seeds/ pod (no.)	Weight of 100 seeds (g)	Seed yield/plant (g)	
Effect of row ratio	0.53	0.08	0.08	0.19	0.008	0.13	0.88	0.47	0.60
Effect of planting distance	0.24	0.010	0.008	0.25	<.0001	<.0001	0.09	<.0001	0.0004
Effect of Irrigation	0.82	0.47	0.86	0.68	0.41	0.47	0.31	0.22	0.46
Interaction of row ratio with irrigation	0.77	0.35	0.039	0.58	0.52	0.91	0.83	0.23	0.10
Interaction of row ratio and planting distance	0.90	0.006	0.20	0.38	0.0005	0.0002	0.64	0.022	0.08
Interaction of irrigation and planting distance	0.47	0.33	0.98	0.95	0.021	0.005	0.71	0.18	0.29
Interaction among row ratio, irrigation and planting distance	0.68	0.36	0.57	0.95	0.062	0.096	0.65	0.09	0.02

Table 2. Mean attributes of 'ICPA2043' as influenced by the direct and interactive effects of row ratio, irrigation and spacing.

Agronomic trait	Factor	Treatment	Mean
Stem diameter (cm)	Effect of planting distance	150 cm x 30 cm	2.75
		150 cm x 50 cm	2.76
		75 cm x 30 cm	2.15
		75 cm x 50 cm	2.38
	Interaction of row ratio and planting distance	4:1 + (150 cm x 30 cm)	3.01
		4:1 + (150 cm x 50 cm)	3.34
		4:1 + (75 cm x 30 cm)	2.29
		4:1 + (75 cm x 50 cm)	2.38
		3:1 + (150 cm x 30 cm)	2.13
		3:1 + (150 cm x 50 cm)	2.15
		3:1 + (75 cm x 30 cm)	2.02
		3:1 + (75 cm x 50 cm)	2.39
Biomass (kg)	Effect of planting distance	150 cm x 30 cm	0.29
		150 cm x 50 cm	0.33
		75 cm x 30 cm	0.25
		75 cm x 50 cm	0.25
	Interaction of row ratio with irrigation	4:1 + (irrigation every 14 days)	0.32
		4:1 + (irrigation every 18 days)	0.26
		3:1 + (irrigation every 14 days)	0.23
		3:1 + (irrigation every 18 days)	0.29
Pods/plant (no.)	Effect of row ratio	4:1	308
		3:1	239
	Effect of planting distance	150 cm x 30 cm	343
		150 cm x 50 cm	365
		75 cm x 30 cm	178
		75 cm x 50 cm	209
	Interaction of row ratio and planting distance	4:1 + (150 cm x 30 cm)	413
		4:1 + (150 cm x 50 cm)	449
		4:1 + (75 cm x 30 cm)	174
		4:1 + (75 cm x 50 cm)	198
		3:1 + (150 cm x 30 cm)	272
		3:1 + (150 cm x 50 cm)	281
		3:1 + (75 cm x 30 cm)	183
		3:1 + (75 cm x 50 cm)	220
	Interaction of irrigation and planting distance	Irrigation every 14 days + (150 cm x 30 cm)	312
		Irrigation every 14 days + (150 cm x 50 cm)	389
		Irrigation every 14 days + (75 cm x 30 cm)	186
		Irrigation every 14 days + (75 cm x 50 cm)	250
		Irrigation every 18 days + (150 cm x 30 cm)	373
		Irrigation every 18 days + (150 cm x 50 cm)	340
		Irrigation every 18 days + (75 cm x 30 cm)	170
		Irrigation every 18 days + (75 cm x 50 cm)	168
Seeds/pod (no.)	Effect of planting distance	150 cm x 30 cm	3.09
		150 cm x 50 cm	3.10
		75 cm x 30 cm	2.22
		75 cm x 50 cm	2.41
	Interaction of row ratio and planting distance	4:1 + (150 cm x 30 cm)	3.62
		4:1 + (150 cm x 50 cm)	3.55
		4:1 + (75 cm x 30 cm)	2.20
		4:1 + (75 cm x 50 cm)	2.32
		3:1 + (150 cm x 30 cm)	2.57
		3:1 + (150 cm x 50 cm)	2.66
		3:1 + (75 cm x 30 cm)	2.25
		3:1 + (75 cm x 50 cm)	2.50
	Interaction of irrigation and planting distance	Irrigation every 14 days + (150 cm x 30 cm)	2.97
		Irrigation every 14 days + (150 cm x 50 cm)	3.23
		Irrigation every 14 days + (75 cm x 30 cm)	2.22
		Irrigation every 14 days + (75 cm x 50 cm)	2.78
		Irrigation every 18 days + (150 cm x 30 cm)	3.21
		Irrigation every 18 days + (150 cm x 50 cm)	2.97
		Irrigation every 18 days + (75 cm x 30 cm)	2.23
		Irrigation every 18 days + (75 cm x 50 cm)	2.04

Contd....

Table 2. Continued

Yield/plant (g)	Effect of planting distance	150 cm x 30 cm	76.99
		150 cm x 50 cm	87.36
		75 cm x 30 cm	49.14
		75 cm x 50 cm	50.58
	Interaction of row ratio and planting distance	4:1 + (150 cm x 30 cm)	88.15
		4:1 + (150 cm x 50 cm)	98.70
		4:1 + (75 cm x 30 cm)	42.48
		4:1 + (75 cm x 50 cm)	49.22
		3:1 + (150 cm x 30 cm)	65.84
		3:1 + (150 cm x 50 cm)	76.03
		3:1 + (75 cm x 30 cm)	55.80
		3:1 + (75 cm x 50 cm)	51.95
Yield/ha (kg)	Effect of planting distance	150 cm x 30 cm	1253
		150 cm x 50 cm	854
		75 cm x 30 cm	1533
		75 cm x 50 cm	958
	Interaction among row ratio, irrigation and planting distance	4:1 + irrigation every 14 days + (150 cm x 30 cm)	1221
		4:1 + irrigation every 14 days + (150 cm x 50 cm)	1007
		4:1 + irrigation every 14 days + (75 cm x 30 cm)	1693
		4:1 + irrigation every 14 days + (75 cm x 50 cm)	1124
		4:1 + irrigation every 18 days + (150 cm x 30 cm)	1644
		4:1 + irrigation every 18 days + (150 cm x 50 cm)	924
		4:1 + irrigation every 18 days + (75 cm x 30 cm)	1074
		4:1 + irrigation every 18 days + (75 cm x 50 cm)	831
		3:1 + irrigation every 14 days + (150 cm x 30 cm)	1074
		3:1 + irrigation every 14 days + (150 cm x 50 cm)	787
		3:1 + irrigation every 14 days + (75 cm x 30 cm)	1352
		3:1 + irrigation every 14 days + (75 cm x 50 cm)	1056
		3:1 + irrigation every 18 days + (150 cm x 30 cm)	1074
		3:1 + irrigation every 18 days + (150 cm x 50 cm)	699
		3:1 + irrigation every 18 days + (75 cm x 30 cm)	2013
		3:1 + irrigation every 18 days + (75 cm x 50 cm)	821

Note: Mean data provided are only those with significant difference ($P = 0.05$) as shown in Table 1.

pod varies remarkably under different spacing and irrigation levels.

Row ratio, irrigation and planting distance: There was no significant difference of individual plants on the agronomic and yield characters of 'ICPA 2043' except for the yield/ha (Table 1). The higher plant density (75 cm x 30 cm) in 3:1 row ratio with irrigation at 18 days interval recorded the highest seed yield (2013 kg/ha) whereas in row ratio 4:1, plant spacing of 75 cm x 30 cm with irrigation at every 14 days produced the highest seed yield of 1693 kg/ha as compared to wider plant density. The study reveals that the productivity of pigeonpea was further enhanced by the influence of irrigation, which is in association with the findings of Chauhan *et al*. (1987), Chauhan (1990) and Mula *et al*. (2010a). Furthermore, the study showed that at closer spacing, seed yield increases due to higher plant density, which supports the findings of Abrams and Julia (1973) and Mula *et al*. (2010b).

The growth and yield traits of 'ICPA 2043' responded significantly on the effects and interactive effect of row ratios, plant spacing and irrigation treatments. Although at wider spacing, individual plant attributes showed significant advantage on the growth and yield traits over closer spacing however, these advantage have not influenced the increase in total seed yield of 'ICPA 2043' due to lesser plant population in a hectare. The agronomic attributes of 'ICPA 2043' at 150 cm x 50 cm spacing in 4:1 row ratio with irrigation at 14 days interval were more beneficial than the other treatments due to spreading and more number of productive branches/plant, pods/plant, seeds/pod, stem diameter, biomass and yield/plant because of improved light availability. However, these positive effects did not influence the increase in the seed yield as compared with closer spacing due to plant density. The results of this study clearly indicate that 75 cm x 30 cm spacing in row ratio 3:1 with irrigation at every 18 days and row ratio 4:1 with spacing of 75 cm x 30 cm irrigated every 14 days during flower initiation till pod development was the optimum for producing ample quantity seeds of 'ICPA 2043'.

REFERENCES

Abrams R and Julia FJ. 1973. Effect of planting time, plant population, and row spacing on yield and other characteristics of pigeonpeas, *Cajanus cajan* (L.) Millsp. Journal for Agriculture, University of Puerto Rico **57:** 275-285.

Ahlawat IPS and Rana DS. 2005. Concept of efficient water use in pulses. In: G Singh, HS Sekhon and JS Kolar (Eds), Pulses. Agrotech

Publishing Academy, Udaipur, India. Pp. 320.

Ali M and Kumar S. 2000. Problems and prospects of pulses research in India. Indian Farming **50:** 4-13.

Chauhan YS. 1990. Pigeonpea: Optimum agronomic management. In: The Pigeonpea. YL Nene, SD Hall and VK Sheila (Eds), CAB International. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, A.P., India. Pp. 270-271.

Chauhan YS, Venkataratnam N and Sheldrake AR. 1987. Factors affecting growth and yield of short-duration pigeonpea and its potential for multiple harvests. Journal of Agricultural Science **109:** 519-529.

Food and Agriculture Organization. 2008. FAOSTAT FAO Statistical Database. [Online]. Available at http://faostat.fao.org/default.jsp [April 2008].

Kumar Rao JVDK, Johansen C, Chauhan YS, Jain KC and Talwar HS. 2001. An analysis of yield variation among long-duration pigeonpea genotypes in relation to season, irrigation and plant population. Journal of Agricultural Science **136:** 291-299.

Kumar Rao JVDK, Johansen C, Chauhan YS, Jain KC and Talwar HS. 1992. Response of long-duration pigeonpea genotypes to irrigation and spacing in central India. International Pigeonpea Newsletter **16:** 14-16.

Lawn RJ and Troedson RJ. 1990. Pigeonpea: Physiology of yield formation. Pages 181-197. In: The Pigeonpea. Nene YL, Hall SD and Sheila VK (Eds). CAB International. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, A.P., India.

Mula MG, Saxena KB, Kumar RV and Rathore A. 2010a. Effect of spacing and irrigation on seed production of a CMS-based pigeonpea hybrid. Green Farming **1:** 221-227.

Mula MG, Saxena KB, Kumar RV, Mula RP and Rathore A. 2010b. Response of spacing on yield and returns of CMS-based medium-duration pigeonpea (*Cajanus cajan*) hybrid. Green Farming **1:** 331-335.

Price GK, Landes R and Govindan A. 2003. India's Pulse Sector: Results of Field Research. Economic Research Service, U.S. Department of Agriculture, Electronic Outlook Report WRS-03-01, May.

Reddy BVS, Green JM and Bisen SS. 1978. Genetic male-sterility in pigeonpea. Crop Science **18:** 362-364.

Remanandan P. 1990. Pigeonpea: Genetic Resources. In: YL Nene, SD Hall and VK Sheila (Eds), The Pigeonpea. CAB International. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, A.P., India. Pp. 101-102.

Saxena KB. 2006. Hybrid Pigeonpea Seed Production Manual. Information Bullettin No. 74. ICRISAT, Patancheru 502 324, A.P., India.

Saxena KB. 2008. Genetic improvement of pigeonpea - a review. Tropical Plant Biology **1:** 159-178.

Saxena KB, Kumar RV, Srivastava N and Bao S. 2005. A cytoplasmic-nuclear male-sterility system derived from a cross between *Cajanus cajanifolius* and *Cajanus cajan*. Euphytica **145:** 289-294.

Sinha AC, Mandal BB and Jana PK. 1988. Physiology analysis of yield variation in irrigated pigeonpea in relation to time of sowing, row spacing and weed control measures. Indian Agriculturist **32:** 177-185.

Singh L, Gupta SC and Faris DG. 1990. Pigeonpea breeding. In: YL Nene, SD Hall and VK Sheila (Eds), The Pigeonpea. CAB International. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, A.P., India. Pp. 375-420.

Singh L, Maheshwari SK and Sharma D. 1971. Effect of date of planting and plant population on growth, yield, yield components and protein content of pigeonpea (*Cajanus cajan* (L.) Millsp.). Indian Journal for Agricultural Science **41:** 535-538.

www.crnindia.com/commodity/tur. *Tur* or pigeonpea as a commodity traded in Indian commodity exchanges like MCX, NMCE and NCDEX. Analyzing the Indian Stock Market. June 2008.