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Yield and yield attributes of hybrid pigeonpea (ICPH 2671) grown for seed purpose as influenced by plant density and irrigation

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

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ABSTRACT

The field experiment was conducted during 2009-10 and 2010-11 cropping seasons in Vertisols at Patancheru, AP, India to evaluate the agronomic viability for large-scale seeds production of hybrid pigeonpea (ICPH 2671) from a cytoplasmic male-sterile (CMS) line ICPA 2043. The experimental treatments include two row ratio (4 male sterile:1 male fertile and 3 male-sterile:1 male fertile), two row spacings (150 cm and 75 cm), two intra row spacing's (50 cm and 30 cm), and two irrigation frequencies (14 and 21 days intervals). Results revealed that no significant difference was noticed during both years of study on the interactive effects of row ratio + spacing, row ratio + irrigation, spacing + irrigation, and row ratio + spacing + irrigation. Individual plants at wider spacing showed significant positive effect on various agronomic traits but this did not translate into increased seed yield due to plant density. However, there was a significant difference on the effect of row ratio and spacing. Row ratio of 4:1 produced the highest seed yield (1306 kg/ha) due to more number of rows of male sterile lines than in 3:1. Aplant spacing of 75 cm x 30 cm provided the highest seed yield (3255 kg/ha) as compared to the other treatments.The study also revealed that the application of 2 to 3 irrigations during flower initiation till pod development is required to develop a good seed yield.

***Keywords*:** Cytoplasmic male-sterility, Pigeonpea , Row ratio, Spacing, Seed production

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 of pigeonpea because it plays an important role in food security, balanced diet and alleviation of poverty (Rao *et al.* 2002). Globally pigeonpea occupies 4.6 m ha area in 21 countries with annual production of 3.4 million tons and a productivity of 893 kg/ha (Mula and Saxena 2010). In India, pigeonpea covers 3.5m ha area with 2.4 million tons production having a low productivity of 685 kg/ha. The productivity of pigeonpea has remained low and stagnant over the last few decades thus this prompted scientists to breed hybrid pigeonpea.

The first hybrid pigeonpea developed by ICRISAT, ICPH 8, could not make any impact due to the genetic control of male-sterility (GMS) whereby its hybrid seed production became tedious and expensive and was not accepted by commercial hybrid seed producers (Reddy *et al.* 1978; Saxena *et al* 1992). However, hybrid pigeonpea has shown to increase yield of more than 40% as compared to its check variety Asha (Saxena and Nadarajan 2010). In this regard, the cytoplasmic male-sterility (CMS) developed by ICRISAT was utilized for the extensive seed production of hybrids and their female parents (Saxena *et al.* 2005). Saxena *et al.* (2006) indicated that the successful hybrid seed production in pigeonpea depends on the efficacy of mass pollen transfer from restorer line (R-line) to male-sterile line (A-line) by pollinators, mainly bees.

Moreover, the variation between agro-climatic conditions and irrigation among different locations and within location likewise affects the growth and development of pigeonpea (Ahlawat *et al.* 2005). Agronomic activities are regarded as important factor in increasing crop production such as soil moisture, light intensity, and inter- and intra-row spacing influence pigeonpeas growth and development (Sinha *et al.* 1988). Therefore, this study was initiated to identify the appropriate row ratio, plant spacing and irrigation frequency for optimizing seed yield of ICPH 2671.

MATERIALS AND METHODS

The experimental material consisted of two parental lines that included female-sterile (ICPA 2043) and its male-fertile restorer line (ICPR 2671) sown in an isolated area of *Vertisols* during 2009-10 (Year 1) and 2010-11 (Year 2) cropping season at Patancheru, Andhra Pradesh, India.

Two row ratio proportion of 4 female-sterile to 1 male-fertile (4:1) and 3 female-sterile to 1 male-fertile (3:1) were used. Within this row ratio, the female-sterile lines have two row spacings (75 cm and 150cm) and two plant to plant spacings (30 cm and 50cm). The restorer line was sown at plant-to-plant spacing of 30 cm. The row length of each treatment was eight meters. In 2009 and 2010, a total 997.59 mm and 1206.29 mm annual rainfall was observed, respectively. For both cropping seasons, less rainfall in the month of November at 44.2 mm and 17.9 mm correspondingly was experienced during pigeonpeas flower initiation and podding phase.Two irrigation treatments, wherein, three irrigation (every 14 days interval) and two irrigation (every 21 days intervals) at field capacity of 50 mm/irrigation during flower initiation to pod development were applied. Irrigation was not required when the pods are at physiological maturity. The different treatments combinations were laid out in Randomized Complete Block

Design (RCBD) with two replications. The recommended fertilizer dose of 100 kg/ha di-ammonium phosphate (18-46-00) was thoroughly applied and normal cultural practices were followed uniformly to raise a good crop for all the experimental units.

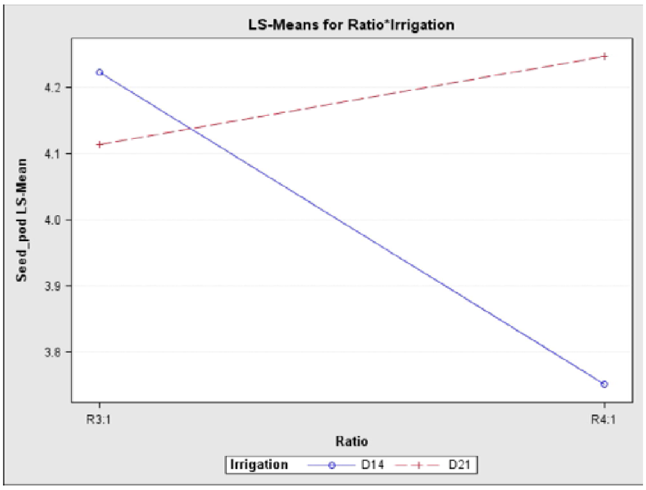
Five plants were selected randomly in each plot and data were recorded on height at 50% flowering (cm), diameter of main stem (cm), weight of dry biomass (kg), number of primary branches, number of secondary branches, pods per plant, seeds per pod, 100 seed weight (g) and seed yield per plant (g/plant). The total seed yield (kg/ha) was computed on plot basis. Analysis of variance using the split plot design was conducted to study the effect of row ratio, spacing, irrigation and their interaction to identify the best treatment combination for the optimum seed production of pigeonpea hybrid ICPH 2671.

RESULTS AND DISCUSSION

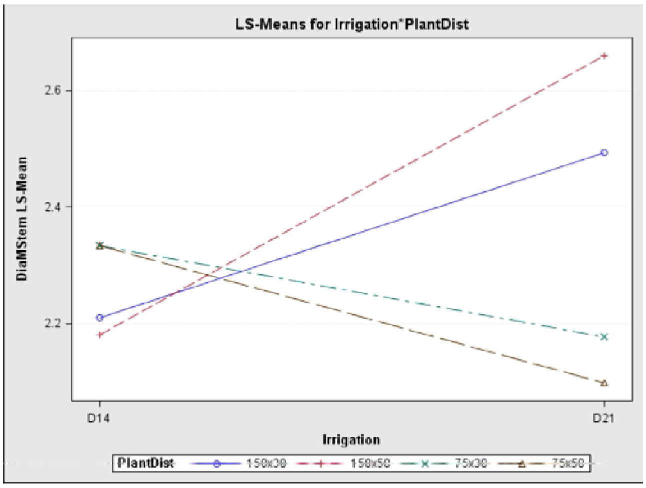
Row ratio effect: No growth and yield contributing traits were significantly influenced by the row ratio in the first year of the study however, the major effect of row ratio (4:1 and 3:1) was found significant (*P*<0.05) on the weight of biomass, yield/plant and seed yield/hectare of ICPA 2043 in the second year (Table 1).The biomass in 3:1 is significantly more (0.26 kg/plant) than in 4:1 row ratio (Table 2) which confirms to the findings of Mula *et al.* (2011) where 3:1 row ratio registered the highest biomass weight however, this has not influenced the yield traits of ICPA 2043 due to population density which was more in 4:1. The maximum yield/plant (78.02 g) and yield/hectare (1306 kg) were recorded in the 4:1 row ratio than the 3:1 (Table 4).These results supported the findings of Saxena (2006) and Mula *et al.* (2010a) where 4:1 was observed as the best row ratio of male:female parent lines for producing optimum seed yield of pigeonpea.

Irrigation effect: During the two years research, only the branches and yield/plant of ICPA 2043 in year 1 were significantly (*P*<0.05) affected by irrigation. Irrigation frequency at 14 days intervals during flower initiation till pod development recorded the highest mean number of branches (47) (Table 1) and yield/plant (129.72 g) (Table 4). However, these findings did not influenced the seed yield/hectare of ICPA 2043 for both irrigation frequencies which corresponds to the findings of Reddy *et al.* (1984) and Kumar Rao *et al.* (1992) where no major interactions were observed between the two irrigation levels and plant densities on the total seed yield.

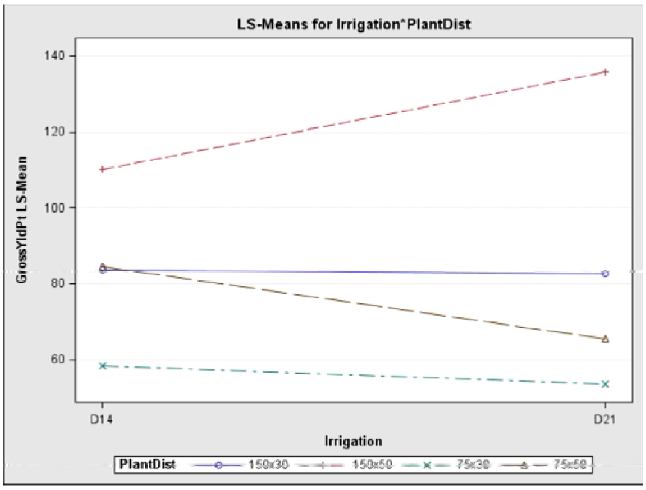
Spacing effect: The effect of spacing on the growth and development of ICPA 2043 varies from year to year as reflected in this two years study. Spacing significantly (*P*<0.05) influenced the stem diameter, biomass weight, branches, pods/plant, yield/plant, and total seed yield/hectare of ICPA 2043 in year one (Table 1). In year two, height at 50% flowering, pods/



Graph 1. Seeds/pod as influenced by row ratio and irrigation in Year 1



Graph 2. Diameter of Stem as influenced by spacing and irrigation in Year 2.



Graph 3. Yield/plant as influenced by spacing and irrigation in Year 2

Table 1. Effect and interactive effect of row ratio, spacing and irrigation on the agronomic and yield traits of ICPH 2671 at 5% level of significance

Treatment effect	Agronomic traits								Yield traits									
	Height at 50% flowering (cm)		Stem diameter (cm)		Biomass (kg)		Branches (no.)		Pods/plant (no.)		Seed/pod (no.)		Weight of 100 seeds (g)		Yield			
															Plant (g)		Hectare (kg)	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
Effect of Row ratio	0.63	0.31	0.11	0.06	0.63	0.02	0.21	0.41	0.54	0.20	0.45	0.07	0.06	0.26	0.57	**0.03**	0.63	**0.05**
Effect of irrigation	0.61	0.44	0.51	0.71	0.64	0.37	**0.03**	0.06	0.74	0.90	0.07	0.79	0.25	0.29	**0.03**	0.61	0.29	0.97
Effect of spacing	0.28	**0.01**	**0.0002**	0.19	**0.0006**	0.08	**0.01**	0.11	**0.005**	**0.01**	0.33	**0.0006**	0.87	**0.02**	**0.002**	**<.0001**	**<.0001**	0.10
Interactive effect of row ratio with spacing	0.47	0.52	0.24	0.48	0.29	0.51	0.32	0.40	0.96	0.17	0.50	0.60	0.60	0.75	0.58	**0.005**	0.75	0.63
Interactive effect of row ratio with irrigation	0.67	0.95	0.91	0.61	0.74	0.84	0.23	**0.03**	0.51	0.22	**0.03**	0.38	0.90	0.35	0.13	0.72	0.96	0.66
Interactive effect of spacing with irrigation	0.45	0.13	0.052	**0.01**	0.19	0.83	0.12	0.56	0.60	0.68	0.53	0.70	0.92	0.52	0.30	**0.005**	0.32	0.39
Interactive effect of row ratio, spacing and irrigation	0.80	0.95	0.78	0.54	0.18	0.98	0.48	0.41	0.51	0.97	0.86	0.26	0.92	0.29	0.37	0.51	0.42	0.61

plant, seeds/pod, weight of 100 seeds, and yield/plant were significantly affected by plant spacing. In 2009-10 cropping season, the research revealed that planting distance 150 cm x 50 cm gave the highest mean diameter of stem at 2.49 cm, weight of biomass at 1 kg/plant (Table 2), pods/plant at 752 (Table 2), yield/plant at 149.07 g and yield/ha of 1432.1 kg (Table 4) while planting distance 75 cm x 30 cm produced the highest number of branches at 47/plant (Table 2).The yield obtained in wider spacing was attributed to the yield traits (pods/plant and yield/plant) which is in conformity to the findings of Venkataratnam *et al.* (1984).

In 2010-11 cropping season, planting distance 150 cm x 50 cm generated the highest mean height of 228 cm at 50% flowering, weight of dry biomass of 0.25 kg/plant (Table 2), 359 pods/plant, 3.32 seeds/pod, 14.55 g of 100 seed weight (Table 2), and yield/plant of 98.61 g (Table 2). However, wider spacing has not influenced the increased in seed yield of ICPA 2043 which confirms to the findings of Sinha *et al*. 1988 and Kumar *et al.* 2001.

Interaction effect of row ratio and spacing: There were no significant (P<0.05) interactive effect of row ratio and spacing in the two year study of ICPA 2043 except for yield/plant in 2010-11 cropping season (Table 1). Row ratio 4:1 with plant spacing of 150 cm x 50 cm produced the highest mean yield/plant at 118.9 g (Table 2), but this factor did not influenced the total seed yield/ha of ICPA 2043 where widely spaced pigeonpea resulted in a gradual decline in yield of pigeonpea (Wilsie 1935 and Abrams and Julia 1973).

Interaction effect of row ratio with irrigation: The data in Table 1 revealed that there were no major significant (P<0.05) difference observed for the agronomic and yield and yield traits of ICPA 2043 in the two year study except for number of branches (Year 2) and number of seeds/pod (Year 1). Row ratio 3:1 with irrigation frequency of 21 days interval during flower initiation till pod development provided the highest mean number of 34 branches/plant (Table 2) while in Year 1, the highest number of 4.25 seeds/pod (Table 2) were observed in the 4:1 row ratio with 21 days irrigation interval which was clearly plotted in Graph 1. This result are in accordance with the findings of Lawn and Troedson (1990) and Kumar Rao *et al.* (1992) where no major interactions were seen between the irrigations and spatial arrangements on the various agronomic and yield traits of pigeonpea.

Interaction effect of spacing with irrigation: The agronomic yield and yield traits of ICPA 2043 were not significantly (P<0.05) influenced by the interactive effects of spacing and irrigation during 2009-10 cropping season (Table 1). However, in 2010-11 cropping season, the interactive effect of spacing and irrigation were found significantly different for diameter of main stem (cm) and yield/plant (g) (Table 1). Results showed that in 2010-11 trial, spacing of 150 cm x 50cm with irrigation frequency at 21 days interval provided the highest diameter of stem (2.66 cm) (Graph 2 and Table 2) and yield/plant of 111.60 g (Graph 3 and Table 2) however, the vegetative and yield characters did not gain any advantage to the total seed yield as compared with closer spacing, the results are in conformity with Sekhon *et al*. (1996).

Table 2. Mean attributes of ICPA 2043 as influenced by the direct and interactive effects of row ratio, spacing and irrigation.

Traits	Year 1			Year 2		
	Factor	**Treatment**	**Mean**	**Factor**	**Treatment**	**Mean**
Height at 50 % Flowering (cm)					150 x 50	228
				Effect of spacing	150 x 30	226.13
					75 x 50	223.10
					75 X 30	216.26
Stem Diameter (cm)		150 x 50	2.49		150 x 50 + every 21 days	2.66
	Effect of spacing	150 x 30	2.26		150 x 30 + every 21 days	2.49
		75 x 50	2.19	Interactive effect of spacing and irrigation	75 x 50 + every 14 days	2.33
		75 X 30	2.00		75 x 30 + every 14 days	2.33
					150 x 30 + every 14 days	2.21
					150 x 50 + every 14 days	2.18
					75 x 30 + every 21 days	2.18
					75 x 50 + every 21 days	2.10
Biomass (kg)		150 x 50	1.00	Effect of row ratio	3:1	0.26
	Effect of spacing	150 x 30	0.88		4:1	0.20
		75 x 50	0.66		150 x 50	0.25
		75 X 30	0.60	Effect of spacing	150 x 30	0.24
					75 x 50	0.23
					75 X 30	0.21
Branches (no.)	Effect of irrigation	Every 21 days	42	Interactive effect of row ratio & irrigation	3:1 + every 21 days	34
		Every 14 days	47		4:1 + every 14 days	30
		150 x 50	42		4:1 + every 21 days	29
	Effect of spacing	150 x 30	43		3:1 + every 14 days	27
		75 x 50	46			
		75 X 30	47			
Pods/plant (no.)		150 x 50	752		150 x 50	359
	Effect of spacing	150 x 30	650	Effect of spacing	150 x 30	291
		75 x 50	492		75 x 50	251
		75 X 30	457		75 X 30	190
Seeds/pod (no.)	Interactive effect of row ratio & irrigation	4:1 + every 21 days	4.25		150 x 50	3.32
		3:1 + every 14 days	4.22	Effect of spacing	150 x 30	3.25
		3:1 + every 21 days	4.11		75 x 50	2.83
		4:1 + every 14 days	3.75		75 X 30	2.75
Weight of 100 seeds (g)					150 x 50	14.55
				Effect of spacing	150 x 30	14.55
					75 x 50	13.89
					75 X 30	14.08
Yield/plant (g)	Irrigation effect	Every 21 days	117.91	Effect of row ratio	4:1	78.02
		Every 14 days	129.72		3:1	56.31
		150 x 50	149.07		150 x 50	98.61
	Effect of spacing	150 x 30	140.67	Effect of spacing	150 x 30	68.72
		75 x 50	101.43		75 x 50	59.23
		75 X 30	104.09		75 X 30	42.09
					4:1 + 150 x 50	118.9
					4:1 + 150 x 30	84.20
				Interactive effect of row ratio & spacing	3:1 + 150 x 50	78.40
					4:1 + 75 x 50	64.90
					3:1 + 75 x 50	53.50
					3:1 + 150 x 50	53.20
					4:1 + 75 x 30	44.00
					3:1 + 75 x 30	40.10
					150 x 50 + every 21 days	111.60
					150 x 50 + every 14 days	85.70
				Interactive effect of spacing & irrigation	150 x 30 + every 14 days	69.00
					150 x 30 + every 21 days	68.50
					75 x 50 + every 14 days	66.50
					75 x 50 + every 21 days	51.90
					75 x 30 + every 21 days	43.20
					75 x 30 + every 14 days	40.90
Yield/ha (kg)	Effect of spacing	150 x 50	1432.10	Effect of row ratio	4:1	1306.29
		150 x 30	2278.90		3:1	934.33
		75 x 50	1903.30			
		75 X 30	3254.90			

Note: Mean data provided are only those with significant difference (P<0.05) revealed in Table 1.

Interaction effect of row ratio, plant spacing and irrigation: The interactive effect of row ratio, spacing and irrigation was non-significant (P<0.05) for all the growth and yield characters of ICPA 2043 in both years (Table 1) which agree with the findings of Mula *et al.* (2010b and 2011a) and Reddy *et al.* (1984) that for any growth and agronomic characters studied there was no interaction between irrigation levels and plant density.

CONCLUSION

The research revealed that agronomic and yield traits of ICPA 2043 were more likely influenced only by the direct effect of row ratio, and spacing rather than the other effects and interactive effect of the three factors (row ratio + spacing + irrigation). Row ratio 4:1 produced the highest seed yield (1306.29 kg/ha) due to more number of rows of female lines than in 3:1. Moreover, spacing of 75 cm x 30 cm accorded the highest seed yield (3254.9 kg/ha) as compared to the other treatments. Because of wider spacing, individual plant attributes showed significant advantage on the growth and yield traits over closer spacing, although, this advantage have not influenced the increase in total seed yield of ICPA 2043 due to lesser plant population. Furthermore, the application of irrigation whether at 21 days interval (2 times) or at 14 days interval (3 times) during flower initiation till pod development is crucial for seed growth. It is further concluded that any of the row ratios, spacing's and irrigation frequency combinations can be adopted to produce ample amount of hybrid seeds.

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