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Response of A x B and A x R CMS-Lines of hybrid pigeonpea [*Cajanus cajan* (L.) Millspaugh on spacing in late sown condition

M.G. MULA[1*], K.B. SAXENA[2], A. RATHORE[3] and R.V. KUMAR[4]

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru - 502 324 (Andhra Pradesh)

ABSTRACT . An experiment was carried out during 2009-2010 cropping season at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru to find out the performance of ICPA 2043 in A x B and A x R in producing seeds of ICPH 2671 in Alfisols and Vertisols, respectively as influenced by spacing during late sowing. The treatments composed of two row ratios (4:1 and 3:1) of male sterile (MS):male fertile (MF) lines; two row-to-row distances (60 cm and 120 cm); and two plant-to-plant spacings (40 cm and 50 cm). The research showed that the direct and interactive effect of row ratio and the different plant spacing did not influence the seed yield of ICPA 2043. Even though row ratio 4:1 with plant spacing of 60 cm x 40 cm produced more seed yield of ICPA 2043 for A x B (1,908.78 kg/ha) and ICPA 2043 for A x R (2,053 kg/ha), the difference was not significant among the other treatments.

Keywords : *Alfisols, Cajanus cajan, late sowing, pigeonpea, spacing, vertisols.*

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] or red gram has a reputation as a crop well-adapted to drought prone environments and is an important food legume crop grown in the tropics and sub-tropical regions of Asia, Africa and the America's and Caribbean under subsistence farming. It is considered as one of the most valuable legumes for vegetarians due to its high protein content (20-24%). In India, pigeonpea is cultivated in 3.58 million hectares with production of only 2.50 million tons due to poor yield at 686 kg/ha (FAO Stat., 2008). To abate the problem of low productivity, Reddy *et al.* (1978) worked on the discovery of pigeonpea hybrid through two genetic male-sterility (GMS) systems. This system have increased seed yield of up to 30-34% as compared to the traditional cultivars. However, seed multiplication of this hybrid was so tedious and problematic. To overcome this limitation, ICRISAT develop the hybrid through the cytoplasmic-nuclear male-sterility (CMS) system, which made possible the large-scale seed production of hybrids and their female parents (Saxena *et al.*, 2005). The success of this system principally depends on the efficiency and effectiveness of natural mass pollen transfer process of parent R- to A- line (Saxena, 2006). The major insect pollinators that are responsible for transferring pollen in pigeonpea at Patancheru are the *Megachile* spp. and *Apis mellifera* (Williams, 1977).

The backbone of the hybrid breeding technology is in the efficient seed production system that will provide quality seeds at economically feasible cost. Likewise, the benefits of hybrids cannot be fully realized until sufficient quantities of pure and healthy seeds are commercially produced through appropriate agronomic management (Ali and Kumar, 2000). This study therefore provides an avenue to look into the possibility of producing seeds of hybrid with the optimum plant spacing during delayed planting due to prolong drought. In 2008 and 2009 cropping season, the change in climate in India has drastically altered the pigeonpea-cropping schedule of poor farmers and left large portion of agricultural land as idle. Drought stress is more aggressive particularly in south and west part of India where 70% of pigeonpea growing areas are rainfed, and it becomes a massive constraint for pigeonpea seed production and productivity.

[1]Scientist *(m.mula@cgiar.org), [2]Principal Scientist,
[3]Scientist, [4]Lead Scientific Officer

MATERIALS AND METHODS

Field research was conducted during rainy season of 2009-2010 at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India. Crops were sown in Alfisols for A x B lines (referred as maintainer seed production) and in Vertisols for A x R lines (referred as hybrid seed production) on July 10, 2009. In Alfisols, two parental lines include male-sterile (ICPA 2043) and maintainer line (ICPB 2043 – male-fertile restorer line) while in Vertisols, two parental lines consists of male-sterile (ICPA 2043) and male-fertile restorer line (ICPR 2671). The A x B/R lines were having two row ratios of 4 ICPA 2043 to 1 row of ICPB/R (4:1) and 3:1 in an isolated area of 2,100 m^2 for each soil type. In each planting ratio, are two row-to-row spacings (60 cm and 120 cm) and two plant-to-plant spacings (40 cm and 50 cm) of male-sterile plants. The B/R lines were sown at plant-to-plant spacing of 30 cm. The length of each treatment was 8 m. The different treatments were laid out in randomized complete block design (RCBD) having four replications. A basal dose of 100 kg/ha di-ammonium phosphate was applied and irrigation every 14 days (Alfisol) and 21 days (Vertisols) during flower initiation to pod development was followed at field capacity of 50 mm/irrigation. Other agronomic management was followed uniformly to all the treatments. Data on plant height at 50% flowering (cm), diameter of main stem (cm), weight of dry biomass (kg), number of branches, pods/plant, seeds/pod, 100-seed mass (g), and seed yield (g/plant) were collected on 5 randomly selected competitive plants within each treatment. The total seed yield (kg/ha) was calculated on plot basis. To find out the effect and interactive effect of row ratio and plant spacing, analyses of variance using the split plot design (SP) were employed to achieve the best treatment combination in producing seeds of ICPA 2043 during late sowing.

RESULTS AND DISCUSSIONS

A x B Seed production : Effect of row ratio. There was a significant difference ($P<0.05$) on plant height at 50% flowering, biomass, number of pods/plant, and weight of 100 seeds as influenced by the effect of row ratio on ICPA 2043 (**Table 1**) which refutes the findings of Mula et al. (2010). Row ratio 4:1 had the highest plant height (165.80 cm), biomass (0.22 kg), number of pods/plant (413), number of seed/pod (3.79), and weight of 100 seeds (13.80 g) as revealed in **Table 2**.

Effect of plant spacing : Plant spacing significantly influenced ($P<0.05$) the diameter of stem, biomass, pods/plant, number of seed/pod, and seed yield/plant of ICPA 2043 (Table 1). As shown in Table 2, plant spacing 120 cm x 40 cm obtained the highest stem diameter (2.32 cm), biomass (0.22 kg), seeds/pod (3.76), and seed yield/plant (117.70 g) while plant spacing 120 cm x 50 cm had the highest number of pods at 429/plant which is similar to the findings of Mula *et al.* (2010).

Row ratio and plant spacing : The results showed that there were no significant differences ($P<0.05$) on the agronomic and yield traits of ICPA 2043 as influenced by the interaction of row ratio and planting distance during late sowing as revealed in Table 1 which conforms with the findings of Mula *et al.* (2011). However, the highest seed yield recorded was in row ratio 3:1 for plant spacing 120 cm x 40 cm (2,008.05 kg/ha) and 4:1 with plant spacing of 60 cm x 40 cm (1,908.78 kg/ha).

A x R Seed production

Effect of row ratio : Plant height, stem diameter, biomass, pods/plant, seeds/plant, weight of 100-seed mass and yield/plant and yield/ha showed no significant difference among row ratio. However, there was a significant ($P<0.05$) difference on the number of branches as revealed in **Table 3**. Row ratio 4:1 produced the highest number of branches at 33/plant (**Table 4**) which conforms to the findings of Mula *et al.* (2010a) where productive branches were observed more in 4:1 row ratio than in 3:1.

Effect of plant spacing : Plant spacing did not significantl influence plant height, stem diameter, biomass, branches seeds/pod, 100-seed weight, and yield/ha. However, significantl ($P<0.05$) higher pods/plant and yield/plant was observed in plar spacing of 120 cm x 40 cm and 120 cm x 50 cm, respectively a compared to the other treatments (Table 3). Plant spacing at 12 cm x 40 cm produced the highest number of pods at 457/plar while planting distance of 120 cm x 50 cm give the highest yield c 115.38 g/plant (Table 4). Results reveal that at wider spacin individual yield traits of ICPA 2043 was more than at close spacing but did not influence increase in total seed yield which

Table 1. Effect and interactive effect of row ratio and planting distance on the growth and yield traits of 'ICPA 2043' (A x B)

Particulars	Plant height at 50% flowering (cm)	Diameter of stem (cm)	Biomass (kg)	Branches (no.)	Pods/plant (no.)	Seeds/pod (no.)	Weight of 100 seeds (g)	Yield per plant (g)	ha (kg)
Effect of row ratio	0.004**	0.10ns	0.017*	0.57ns	0.009**	0.05*	0.02*	0.12ns	0.37ns
Effect of plant spacing	0.78ns	0.003**	0.049*	0.55ns	0.0004**	0.013*	0.38ns	0.003**	0.12ns
Interaction effect of row ratio and planting distance	0.61ns	0.58ns	0.21ns	0.77ns	0.56ns	0.75ns	0.48ns	0.90ns	0.14ns

Table 2. Mean attributes of 'ICPA 2043' as influenced b the direct and interactive effect of row ratio and spacing (A x B)

Agronomic trait	Factor	Treatment	Mea
Plant height at 50% flowering (cm)	Effect of row ratio	4:1	165.8
		3:1	140.7
Diameter of stem (cm)	Effect of plant spacing	120 cm x 40 cm	2.3
		120 cm x 50 cm	2.1
		60 cm x 40 cm	1.8
		60 cm x 50 cm	1.8
Biomass (kg)	Effect of row ratio	4:1	0.2
		3:1	0.1
	Effect of plant spacing	120 cm x 40 cm	0.2
		120 cm x 50 cm	0.1
		60 cm x 40 cm	0.1
		60 cm x 50 cm	0.1
Pods/plant	Effect of row ratio	4:1	41
		3:1	25
	Effect of plant spacing	120 cm x 40 cm	41
		120 cm x 50 cm	42
		60 cm x 40 cm	24
		60 cm x 50 cm	25
Seeds/pod	Effect of row ratio	4:1	3.7
		3:1	3.3
	Effect of plant spacing	120 cm x 40 cm	3.7
		120 cm x 50 cm	3.7
		60 cm x 40 cm	3.4
		60 cm x 50 cm	3.4
Weight of 100 seeds (g)	Effect of row ratio	4:1	13.8
		3:1	12.4
Yield/plant (g)	Effect of plant spacing	120 cm x 40 cm	117.7
		120 cm x 50 cm	110.9
		60 cm x 40 cm	61.8
		60 cm x 50 cm	69.5

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

Table 3. Effect and interactive effect of row ratio and planting distance on the growth and yield traits of 'ICPA 2043' (A x R)

Treatment effect	Agronomic traits (P (<0.05)			Yield traits (P (<0.05)					
	Plant height at 50% flowering (cm)	Stem diameter (cm)	Biomass (kg)	Branches (no.)	Pods/ plant (no.)	Seeds/ pod (no.)	Weight of 100 seeds (g)	Yield per plant (g)	Hectare (kg)
Effect of row ratio	0.09ns	0.39ns	0.57ns	0.048*	0.88ns	0.97ns	0.39ns	0.75ns	0.93ns
Effect of plant spacing	0.08ns	0.46ns	0.88ns	0.71ns	0.02*	0.68ns	0.21ns	0.01*	0.16ns
Interaction among row ratio and plant spacing	0.51ns	0.12ns	0.57ns	0.06ns	0.91ns	0.97ns	0.05*	0.16ns	0.43ns

Note : *, ** – significant; ns – not significant

Table 4. Mean attributes of 'ICPA 2043' as influenced by the direct and interactive effects of row ratio and spacing (A x R)

Agronomic trait	Factor	Treatment	Mean
Branches (no.)	Effect of row ratio	4:1	33
		3:1	28
Pods/plant (no.)	Effect of plant spacing	120 cm x 40 cm	457
		120 cm x 50 cm	407
		60 cm x 40 cm	340
		60 cm x 50 cm	248
Weight of 100 seeds (g)	Interaction among row ratio and plant spacing	4:1 + (120 cm x 40 cm)	14.48
		4:1 + (120 cm x 50 cm)	14.34
		4:1 + (60 cm x 40 cm)	13.75
		4:1 + (60 cm x 50 cm)	13.70
		3:1 + (120 cm x 40 cm)	13.29
		3:1 + (120 cm x 50 cm)	13.91
		3:1 + (60 cm x 40 cm)	13.89
		3:1 + (60 cm x 50 cm)	13.94
Yield/plant (g)	Effect of plant spacing	120 cm x 40 cm	109.54
		120 cm x 50 cm	115.38
		60 cm x 40 cm	62.26
		60 cm x 50 cm	56.12

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

agree to the findings of Sekhon *et al.* (1996) and Mula *et al.* (2010a) due to less plant density.

Row ratio and plant spacing : Results indicated that among the agronomic and yield traits of ICPA 2043, only the 100-seed weight was significantly (P<0.05) influenced by the interactive effect of row ratio and plant spacing (Table 3). Row ratio 4:1 with plant spacing of 120 cm x 40 cm produced the highest weight of 100-seed at 14.48 g/plant (Table 4) which refutes the findings of Mula *et al.* (2010a) where weight of 100-seeds was registered the highest at closer spacing in row ratio 4:1 with 75 cm x 30 cm plant spacing.

CONCLUSION

Seed yield of ICPA2043 either by A x B or A x R was not totally influenced by any of the direct and interactive effects of row ratio and plant spacing during late sowing. For both researches, agronomic traits of ICPA 2043 were highest in wider spacing with row ratio of 4:1 over closer spacing but did not influenced the increase in total seed yield. It is further concluded that the tremendous response of yield to plant spacing is of great importance and that the loss of part of the stand could greatly affect yield estimates. Even though at closer spacing for both researches, the study show that row ratio 4:1 with plant spacing of 60 cm x 40 cm produced more seed yield of ICPA 2043 for A x B (1,908.78 kg/ha) and ICPA 2043 for A x R (2,053 kg/ha) however, the difference was not significant among the other treatments. It is further concluded that any of the spacing used in this study can be adopted to produce ample quantity of hybrid seeds even during late sowing.

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