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Effects of Levels of Primary Plant Nutrients and Row Spacing on Growth and Yield Attributes of Some Promising Varieties of Cluster Bean (*Cyamopsis tetragonoloba* L.)

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A B S T R A C T

A field experiment consisting of 2 fertility levels *viz.* 50% of recommended dose of fertilizer (RDF) and 100% RDF (20: 40: 20 kg ha^{-1} of N: P_2O_5: K_2O); 2 row spacings (30 and 45 cm) and 3 genotypes [HG-100, HG-8-1 and HG-563(c)] was conducted at the Research Farm, College of Agriculture, Gwalior, India during *kharif* 2010 to find out their effects on growth and yield attributing characters of cluster bean. The experiment was laid out in factorial randomized block design of 2 x 2 x 3 with 12 treatment combinations and 3 replications. Application of 100% RDF had better response on growth and yield attributing characters viz. plant height, number of branches, plant-biomass, LAI, number of pods plant^{-1} and seeds pod^{-1} than 50% RDF. These parameters had also shown positive results under wider row spacing of 45 cm than 30 cm. Among the tested cultivars cv. HG-100 was the most promising compared to cv. HG-8-1 and cv. HG-563(c). The combined effects of growth and yield contributing characters were ultimately reflected in production of the highest seed yield by sowing of cluster bean cv. HG-100 at 45 cm row spacing and with 100% RDF which should be recommended for the farmers of Gird region of Madhya Pradesh, India during *kharif*.

Keywords

Cluster bean, Fertility level, Row spacing, Varieties, Growth and yield attributing characters.

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Introduction

Cluster bean (*Cyamoposis tetragonoloba* L. Tabu), an annual *kharif* arid legume, commonly known as '*guar*', was traditionally grown for cattle feed, fodder, medicine and soil improvement. Apart from its present uses as green fodder, vegetable, green manure and grain purposes, its utility in explosive, textile, paper, food, gum and cosmetic industries also fetches foreign currencies. This crop plays great role in nitrogen (N) economy of the succeeding crops though N-fixation from atmosphere and also by addition of organic matter.

Although cluster bean can be grown in nutrient starved soils and in areas of erratic rainfall but growing of improved genotypes with judicious nutrient management have been effective in improving its productivity. Better performance of cluster bean with application of N and P_2O_5 @ 20 and 40 kg ha^{-1} was reported by Yadav *et al.*, (1991). Rajput (2002) and Priyadarshini *et al.*, (2017) have reported higher yield with recommended dose of fertilizers (RDF) @ 20: 40: 20 kg ha^{-1} of N: P_2 O_5: K_2O than 50% RDF. Proper plant population is the main key for higher yield of cluster bean and thus higher yield and quality could be achieved with proper row spacing and plant stand. Rana *et al.*, (1991) and Taneja *et al.*, (1982) reported higher seed yield in 30 cm row spacing due to more number of plants per unit area and pods plant^{-1}. But, crop height, 1000' seed weight and number of seeds pod^{-1} did not differ due to varying row spacing. Though the genotypes have their own ability for growth, development and yield, yet some promising genotypes of *guar* have shown considerable variations particularly in yield potentials under varying levels of soil fertility. No such work has yet been done to elucidate such interactions between soil fertility, row spacing and genotypes of *guar* in Gird region of Madhya Pradesh. In view of above scenario, a field experiment was laid out to study the effects of the levels of soil fertility and row spacing on the growth and yield attributing characters of some promising varieties of cluster bean.

Materials and Methods

Experimental site and climate

The experiment was conducted during *kharif* 2010 at the Research Farm of the College of Agriculture, Gwalior, Madhya Pradesh, India located 208 m above sea level and exactly at 26^0 13'north latitude and 74^0 4' east longitude with sub-tropical climate. The summer is extremely hot (46^0C) and winter is chilled reaching at below 1^0C. The annual rainfall ranges from 650 to 751 mm with maximum downpour during last week of June to last week of September and drought has been a common phenomenon. The soil was sandy loam having pH, organic carbon, available nitrogen, phosphorous and potash of 8.0, 0.045 %, 212.5, 14.7 and 282 kg ha^{-1}, respectively. The cropping history of the site indicated *guar*-wheat cropping system for last 3 consecutive years.

Experimental design and treatments

Among the 3 treatments *viz.* nutrients, spacing and genotypes, the primary plant nutrients (N: P_2O_5: K_2O) were applied at 2 levels *viz.* F_1: 50% RDF (10: 20: 10 kg ha^{-1}) and F_2: 100% RDF (20: 40: 20 kg ha^{-1}); 2 row spacing *viz.* S_1: 30 cm and S_2: 45 cm; and 3 genotypes *viz.* V_1: HG-100, V_2: HG-8-1 and V_3: HG-563(c). The experiment was laid out in factorial randomized block design (2 x 2 x 3) with 3 replications. All fertilizers as per treatment were applied at the time of sowing as basal and the crop was raised rainfed without any irrigation to simulate with the irrigation practice being followed by the farmers of that locality.

Agronomic practices

The land was ploughed followed by harrowing in criss-cross manner and the recommended dose of chemical fertilizers were added to each plot just before the final land preparation and levelling. Seeds of 3 genotypes were sown in solid rows at spacing of 30 and 45 cm between lines depending on different treatment combinations. Seedlings were thinned at 15 days after sowing (DAS) at 10 cm intra-row spacing. Two gentle hoeing and manual weeding operations were carried out at 26 and 40 DAS. No chemical plant protection measure was adopted due to lack of disease-pest incidence superseding economic threshold level. The plant population was counted at 15 DAS and at harvesting for yield estimation. No irrigation was applied to the experimental field so as to simulate the prevailing water management practices by the farmers of this region.

Biometric observations

The biometric observations were taken from the 5 selected plants in the either side of 3rd row of each plot demarcated with proper pegging. The growth parameters like plant height and number of branches were recorded from these plants at regular intervals. However, for plant-biomass and leaf area index (LAI) destructive sampling procedure was followed averaging out the observations for 5 uprooted plants from the 3rd row at opposite side of the plots meant for measuring plant height and branches.

Crop growth rate (CGR) was calculated by adopting the following formulae as suggested by Watson (1952).

$$\text{CGR (g day}^{-1}\text{ m}^{-2}) = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{A}$$

Where,
W_1 = Dry weight of plant (g) at time t_1
W_2 = Dry weight of plant (g) at time t_2
$t_2 - t_1$ = Time interval in days
A = Unit area occupied by plants (m^2)

The LAI at pod development was estimated by using the formulae suggested by Sestak *et al.,* (1971) as follows.

$$\text{LAI} = \frac{\text{Leaf area plant}^{-1}\ (m^2)}{\text{Ground area occupied by plant } (m^2)}$$

Before harvesting of the crop 5 tagged plants in each plot were taken out for recording the yield contributing characters. The grain yield was recorded by carefully harvesting the crop and subsequently threshing after its drying in the cemented floor.

Statistical analysis

The data collected were arranged in appropriate tables and analysed statistically by applying analysis of variance technique (AVNOVA) (Gomez *et al.,* 1984). Standard error of means i.e. S.Em (+) were used in all cases. The significance of variance was tested by 'Error mean square' method of Fisher Snedecor's F-test at the probability level of 0.05 for appropriate degrees of freedom (P=0.05).

Results and Discussion

Growth attributing characters

Plant height

The plant height of cluster bean went on increasing with the advancement in crop age, irrespective of the treatments and reached its maximum at maturity (Table 1 and Fig.1). The rate of increase in plant height was the highest during 30 to 60 DAS and that were ensued by the rates during 60 to 90 DAS and 90 DAS to maturity in descending order. The main effect of fertility levels and varieties with respect to plant height was found significant at all the stages of crop growth except at 30 DAS.

Plants with 100% RDF (20:40:20 kg ha^{-1}) were taller than 50% RDF (10:20:10 kg ha^{-1}) of N: P_2O_5: K_2O at 60, 90 DAS and maturity. Row spacing had no significant influence on the plant height throughout the crop growth stages. However, plants with wider row spacing (45 cm) were relatively taller than closer row spacing (30 cm) at all the growth stages under observation. The cluster bean cv. HG-100 was the tallest among the 3 tested cultivars at 60, 90 DAS and maturity. There was no significant difference in plant height between cv. HG-100 and cv. HG-8-1 at maturity. Furthermore, cv. HG-563(c) was the shortest among 3 cultivars at all dates of observation.

Number of branches

The number of branches $plant^{-1}$ was influenced significantly by fertility levels, row spacing and varieties at all the stages of cluster bean growth (Table 1 and Fig.1). There was continuous increase in the number of branches plant^{-1} up to 90 DAS and thereafter it remained static till maturity. Number of branches plant^{-1} increased significantly with increase in the levels of fertility. More branches were observed with 100% RDF (20:40:20 kg ha^{-1}) than 50% RDF (10:20:10 kg ha^{-1}) of N: P_2O_5: K_2O at all growth stages. Significantly more branches plant^{-1} were observed under row spacing of 45 cm compared to 30 cm at each crop growth stage. The cv. HG-100 recorded significantly the maximum number of branches plant^{-1} among 3 cultivars at all stages of crop growth. However, at 30 and 60 DAS, it was at par with cv. HG-8-1.

The interaction effect of variety × spacing (V×S) on number of branches plant^{-1} was found significant at 60 DAS (Table 1a). Cv. HG-100 sown with 45 cm row spacing i.e. V_1S_2 produced the maximum number of branches plant^{-1} (5.80) among all treatment combinations.

Plant biomass

The plant-biomass of cluster bean increased continuously up to maturity under all treatments (Table 2 and Fig.1) and the rate of increase was more rapid between 60 to 90 DAS as compared to 30 to 60 DAS and 90 DAS to maturity.

Application of 100% RDF recorded significantly the higher plant-biomass of 2.05, 7.83, 28.08 and 46.39 g at 30, 60, 90 DAS and maturity, respectively compared to 50% RDF. The plant-biomass with 45 cm row spacing was significantly higher than 30 cm spacing at all crop growth stages. Significant superiority of cv. HG-100 over HG-8-1 and HG-563 (c) in biomass plant^{-1} was noticed at different stages of crop growth.

Crop growth rate

The crop growth rates (CGR) as influenced by different treatments at successive intervals of cluster bean crop growth have been presented in Table 2. The CGR increased up to 60 to 90 DAS of crop growth interval, but reduced remarkably beyond that.

The CGR during 0 to 30 DAS, 30 to 60 DAS, 60 to 90 DAS and 90 DAS to maturity of crop were significantly influenced by fertility levels. Application of 100% RDF recorded significantly the higher CGR than 50% RDF at all crop growth stages. The CGR did not vary statistically due to row spacing at all intervals of crop growth.

However, the crop with 30 cm row spacing recorded more CGR than 45 cm at latter crop growth intervals. Among the 3 varieties, cv. HG-100 registered relatively more CGR than cv. HG-8-1 and cv. HG-563 (c) throughout the crop growth intervals and the latter 2 cultivars did not differ statistically during 30 to 60 DAS and 60 to 90 DAS.

Among all interactions between experimental variables, the F×V at 30 and 60 DAS were found significant with respect to CGR (Table 2a and 2b). At 30 DAS, cv. HG-100 recorded higher CGR than cv. HG-8-1 and HG-563(c) at both fertility levels. Significantly the highest CGR (3.009 g day^{-1} m^{-2}) was registered with cv. HG-100 when fertilized with 100% RDF. At 60 DAS, cv. HG-8-1 with 100% RDF (F_2V_2) recorded the maximum CGR which was at par with F_2V_3 and F_1V_1.

Leaf area

The leaf area index (LAI) at pod development stage of cluster bean was influenced significantly due to fertility levels, row spacing and varieties (Table 2 and Fig.1).

Table.1 Effect of fertility levels, row spacings and varieties on plant height and branches plant^{-1} of cluster bean at successive crop growth stages

Treatments	*Plant height (cm) at*				*Branches plant^{-1} at*			
	30 DAS	**60 DAS**	**90 DAS**	**Maturity**	**30 DAS**	**60 DAS**	**90 DAS**	**Maturity**
Fertility levels								
F_1: 50% RDF	17.43	90.36^{b}	102.48^{b}	112.49^{b}	2.10^{b}	4.73^{b}	9.31^{b}	9.31^{b}
F_2: 100% RDF	18.97	94.02^{a}	108.46^{a}	119.82^{a}	2.44^{a}	5.26^{a}	9.84^{a}	9.84^{a}
S.Em (±)	0.53	0.84	1.64	2.19	0.05	0.09	0.12	0.12
CD (P=0.05)	NS**	2.46	4.80	6.43	0.13	0.26	0.35	0.35
Row Spacings								
S_1: 30 cm	17.78	90.99	103.83	115.12	2.19^{b}	4.78^{b}	9.10^{b}	9.10^{b}
S_2: 45 cm	18.62	93.38	107.10	117.19	2.36^{a}	5.21^{a}	10.06^{a}	10.06^{a}
S.Em (±)	0.53	0.84	1.64	2.19	0.05	0.09	0.12	0.12
CD (P=0.05)	NS	NS	NS	NS	0.13	0.26	0.35	0.35
Varieties								
V_1: HG-100	18.85	101.38^{a}	115.13^{a}*	122.41^{a}	2.35^{a}	5.33^{a}	10.47^{a}	10.47^{a}
V_2: HG-8-1	18.28	89.97^{b}	103.02^{ab}	117.19^{a}	2.32^{ab}	5.07^{a}	9.33^{b}	9.33^{b}
V_3: HG-563(c)	17.47	85.22^{c}	98.25^{b}	108.87^{b}	2.15^{b}	4.58^{b}	8.93^{c}	8.93^{c}
S.Em (±)	0.65	1.03	2.00	2.69	0.06	0.11	0.15	0.15
CD (P=0.05)	NS	3.01	5.88	7.88	0.17	0.32	0.43	0.43

* Means followed by common letters did not differ significantly up to 5% level

** NS: Non-significant

Table.1a Effect of V× S on number of branches plant^{-1} at 60 DAS

Treatments		**Varieties**		
		V_1	**V_2**	**V_3**
Row spacings	**S_1**	4.87^{bcd}*	4.97^{bc}	4.50^{d}
	S_2	5.80^{a}	5.17^{b}	4.67^{cd}
S.Em (±)			0.15	
CD (P=0.05)			0.45	

* Means followed by common letters did not differ significantly up to 5% level

Table.2 Effect of fertility levels, row spacings and varieties on biomass plant^{-1}, CGR and LAI of cluster bean at successive crop growth stages

Treatments	*Biomass plant^{-1} (g) at*				*CGR (g day^{-1} m^{-2})*				*LAI at pod development*
	30 DAS	**60 DAS**	**90 DAS**	**Maturity**	**0 to 30 DAS**	**30 to 60 DAS**	**60 to 90 DAS**	**90 to maturity**	
Fertility levels									
F_1: 50% RDF	1.72^{b}	7.20^{b}	25.57^{b}	42.26^{b}	1.870^{b}	5.950^{b}	20.046^{b}	13.698^{b}	0.853^{b}
F_2: 100% RDF	2.05^{a}	7.83^{a}	28.08^{a}	46.39^{a}	2.285^{a}	6.515^{a}	22.664^{a}	15.359^{a}	1.030^{a}
S.Em (±)	0.05	0.14	0.41	0.65	0.058	0.079	0.290	0.271	0.030
CD (P=0.05)	0.15	0.40	1.21	1.90	0.169	0.231	0.850	0.794	0.089
Row Spacings									
S_1: 30 cm	1.58^{b}	6.48^{b}	23.20^{b}	38.36^{b}	2.039	6.335	21.577	14.679	0.881^{b}
S_2: 45 cm	2.18^{a}	8.55^{a}	30.45^{a}	50.28^{a}	2.117	6.130	21.133	14.378	1.002^{a}
S.Em (±)	0.05	0.14	0.41	0.65	0.058	0.079	0.290	0.271	0.030
CD (P=0.05)	0.15	0.40	1.21	1.90	NS**	NS	NS	NS	0.089
Varieties									
V_1: HG-100	2.30^{a}	8.03^{a}	28.23^{a}	48.84^{a}	2.550^{a}	6.393^{a}	22.514^{a}	17.234^{a}	1.021^{a}
V_2: HG-8-1	1.78^{b}	7.45^{b}*	26.63^{ab}	43.08^{b}	1.952^{b}	6.271^{ab}	21.148^{b}	13.692^{b}	0.945^{ab}
V_3: HG-563(c)	1.58^{c}	7.08^{b}	25.63^{b}	41.06^{b}	1.732^{c}	6.033^{b}	20.402^{b}	12.660^{b}	0.859^{b}
S.Em (±)	0.06	0.17	0.51	0.79	0.071	0.097	0.355	0.331	0.037
CD (P=0.05)	0.18	0.49	1.48	2.33	0.207	0.283	1.041	0.972	0.109

* Means followed by common letters did not differ significantly up to 5% level

** NS: Non-significant

Table.2a Effects of F × V on CGR at 30 DAS

Treatments		Varieties		
		V_1	V_2	V_3
Fertility levels	F_1	2.091^{b}	1.832^{bc}*	1.688^{c}
	F_2	3.009^{a}	2.072^{b}	1.775^{c}
S.Em (±)			0.100	
CD (P=0.05)			0.293	

* Means followed by common letters did not differ significantly up to 5% level

Table.2b Effect of F×V on CGR at 60 DAS

Treatments		Varieties		
		V_1	V_2	V_3
Fertility levels	F_1	6.487^{ab}*	5.801^{c}	5.561^{c}
	F_2	6.300^{b}	6.741^{a}	6.506^{ab}
S.Em (±)			0.137	
CD (P=0.05)			0.401	

* Means followed by common letters did not differ significantly up to 5% level

Table.3 Effect of fertility levels, row spacings and varieties on yield attributing characters of cluster bean

Treatments	***Pods plant^{-1}***	***Pod length (cm)***	***Seeds pod^{-1}***	***1000'seed weight (g)***	***Seed yield (g plant^{-1})***	***Seed yield (kg ha^{-1})***
Fertility levels						
F_1: 50% RDF	85.82^{b}	5.44	8.08^{b}	34.42	9.46^{b}	2204^{b}
F_2: 100% RDF	92.46^{a}	5.46	8.50^{a}	34.83	10.03^{a}	2314^{a}
S.Em (±)	1.94	0.06	0.13	0.42	0.12	30.59
CD (P=0.05)	5.68	NS**	0.38	NS	0.36	89.72
Row Spacings						
S_1: 30 cm	85.52^{b}	5.42	8.27	34.40	9.38^{b}	2021^{b}
S_2: 45 cm	92.76^{a}	5.48	8.31	34.85	10.11^{a}	2497^{a}
S.Em (±)	1.94	0.06	0.13	0.42	0.12	30.59
CD (P=0.05)	5.68	NS	NS	NS	0.36	89.72
Varieties						
V_1: HG-100	95.77^{a}	5.63^{a}	8.47	35.23	10.60^{a}	2476^{a}
V_2: HG-8-1	87.73^{b}*	5.36^{b}	8.33	34.55	9.93^{b}	2204^{b}
V_3: HG-563(c)	83.92^{b}	5.36^{b}	8.07	34.10	8.73^{c}	2097^{b}
S.Em (±)	2.37	0.07	0.16	0.51	0.15	37.46
CD (P=0.05)	6.96	0.21	NS	NS	0.44	109.88

* Means followed by common letters did not differ significantly up to 5% level
** NS: Non-significant

Fig.1 Growth attributes as influenced by different treatments

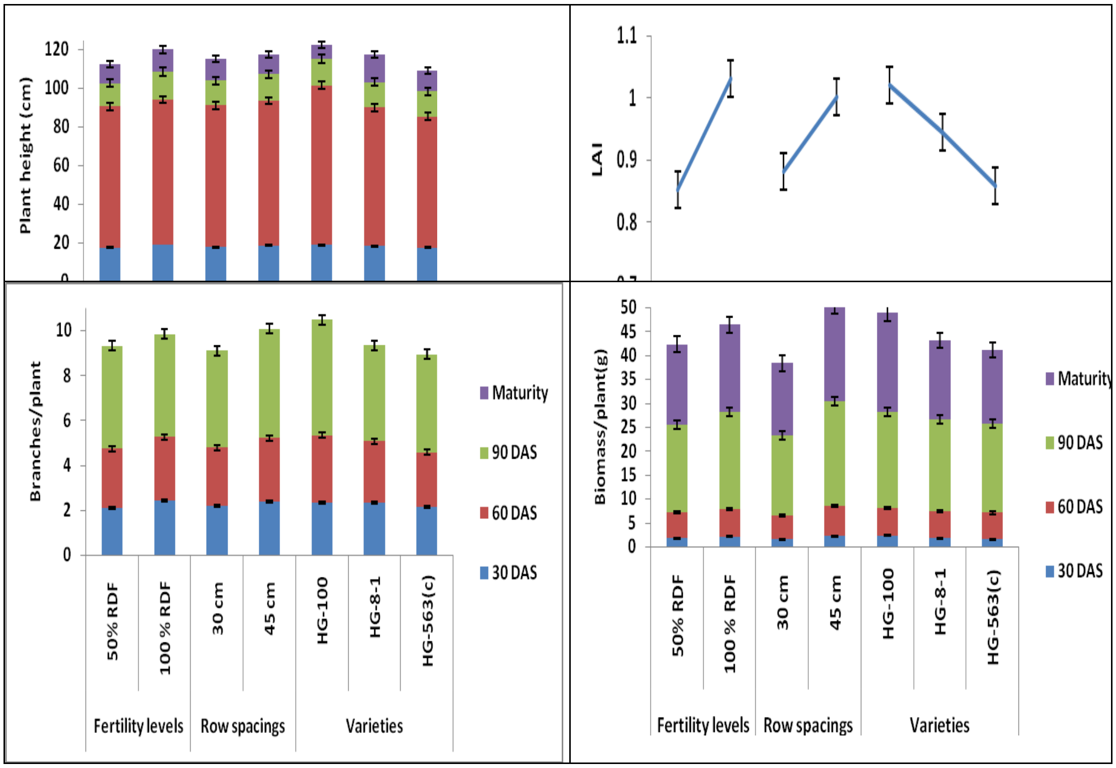
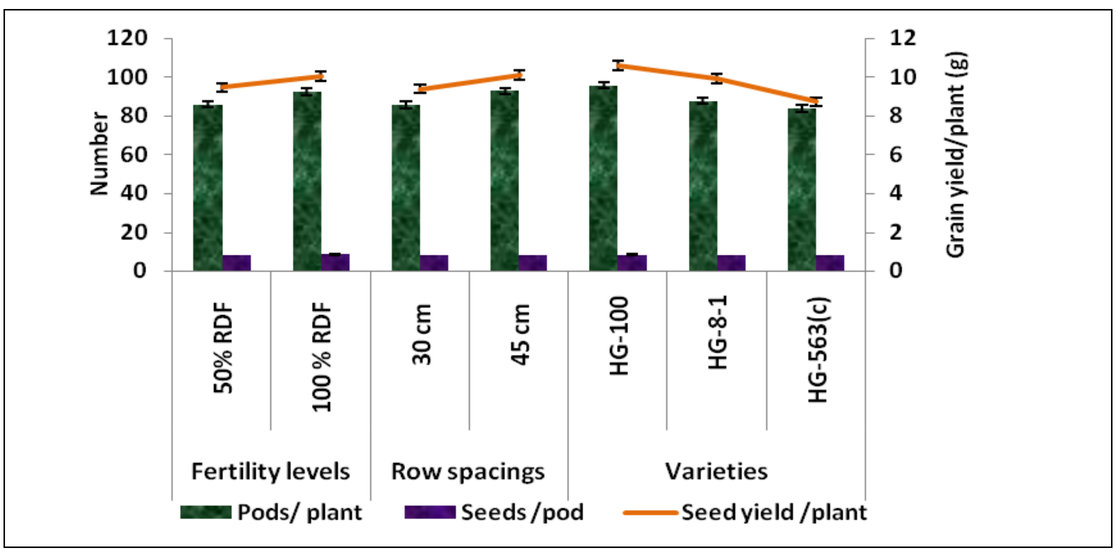


Fig.2 Yield attributes as influenced by different treatments



Application of 100% RDF recorded the maximum LAI of 1.03, which was 20.75 % more than that of 50% RDF. Crop sown with 45 cm row spacing resulted in significantly higher LAI than crop spaced at 30 cm rows. The cv. HG-100 registered significantly higher LAI than cv. HG-563 (c) but was at par with cv. HG-8-1.

Yield attributing characters

Number of pods

Cluster bean applied with 100% RDF recorded significantly more number of pods plant^{-1} (92.46) than 50% RDF (Table 3 and Fig.2). Row spacing of 45 cm significantly enhanced the pods plant^{-1} over 30 cm spacing. Among 3 cultivars, cv. HG-100 being at par with cv.HG-8-1 produced significantly higher number of pods plant^{-1} than cv. HG-563(c).

Pod length

Application of 100% RDF produced longer pods than 50% RDF but without significant difference (Table 3). Crop sown with 45 cm row spacing produced relatively longer but at par pods compared to crop sown at 30 cm spacing. Cv. HG-100 produced significantly longer pods than cv. HG-8-1 and cv. HG-563 (c) having same pod length of 5.36 cm.

Number of seeds pod^{-1}

Application of 100% RDF resulted in significantly more number of seeds pod^{-1} (8.5) than 50% RDF (Table 3 and Fig.2). However, row spacings and varieties had no significant effect on seeds pod^{-1}.

1000' seed weight

The study of 1000' seed weight (Table 3) revealed no significant difference due to the effect of fertility levels, row spacing and varieties of cluster bean under consideration.

Seed yield plant^{-1}

The seed yield of cluster bean (10.03 g plant^{-1} and 2314 kg ha^{-1}) was significantly higher in plots receiving 100% RDF than the crop grown with 50% RDF (Table 3 and Fig.2). Wider row spacing of 45 cm resulted in significantly better seed yield (10.11 g plant^{-1} and 2497 kg ha^{-1}) compared to 30 cm spacing. The 3 varieties of cluster bean had significantly different seed yield with diminishing order of cv. HG-100, cv. HG-8-1 and cv. HG-563 (c). Cv. HG-100 had the highest seed yield (10.6 g plant^{-1}and 2476 kg ha^{-1}) and cv. HG-563 (c) had the lowest. The grain yield of HG-100 was 12.34 % and 18.07 % higher than HG-8-1 and HG-563(c), respectively.

The overall improvement in the growth of cluster bean at higher level of fertility could be ascribed to their pivotal role in several physiological and biochemical processes, viz., root development, photosynthesis, energy transfer reaction and symbiotic biological N-fixation process. The earlier observations in this line by Rathore *et al.,* (2007) and Yadav *et al.*, (1991) in cluster bean, by Patra (1991) and Arya and Singh (1996) in horse gram and by Shubhra *et al.*, (2003), Bhadoria and Kushwah (2005) and Muhammad *et al.*, (2009) in legume crops influenced by soil fertility were in conformity with the present results.

More number of branches and higher plant-biomass, greater CGR and LAI of cluster bean with wider row spacing (45 cm) might be due to availability of larger area for better crop growth and supply of plant nutrients in adequate quantities. Similar results have been reported by Rajput (2002), and Bhadoria and Kushwaha (2005).

Significant varietal differences were noticed for plant height, number of branches plant^{-1}, biomass plant^{-1}, CGR and LAI at all the stages of observation except plant height at 30 DAS. Cv. HG-100 had the highest value of all these growth characters followed by cv.HG-8-1. The differential behaviour of cluster bean varieties with respect to these characters could be explained solely by the variation in their genetic makeup and adaptability to soil and climatic conditions. The results are in close conformity with the findings of Vyas (2002) who reported that the late genotypes had better vegetative growth in terms of plant height.

Each plant passes through the vegetative as well as reproductive phases of growth to complete its life cycle. Yield can be considered to be the final expression of the physiological and metabolic activities of plants and is governed by various factors. These yield attributing factors viz. number of pods plant^{-1}, pod length, number of seeds pod^{-1}, 1000' seed weight and seed yield plant^{-1} have direct bearing on plant productivity and for increasing the yield that play important roles.

Application of 100% RDF could have influenced such yield attributes due to efficient availability of suitable plant nutrients in adequate quantities, better partitioning of metabolites and adequate translocation of photosynthates to developing reproductive structures. However, the yield attributing characters like pod length and 1000' seed weight remained unchanged due to fertility levels possibly due to genetic makeup. These results confirmed the findings of Patra (1991), Rafey and Srivastava (1989), Yadav *et al.,* (1991), Arya and Singh (1996), Choudhary *et al.,* (2003), Meena and Naagar (2004), Bhadoria and Kushwah (2005), Rathore *et al.,* (2007) and Muhammad *et al.,* (2009).

Wider row spacing of 45 cm resulted in significantly higher number of pods plant^{-1}, number of seeds plant^{-1} and seed yield plant^{-1} as compared to closer row spacing (30 cm). This might be due to better penetration of light, free air circulation to the lower layers of the crop canopy and reduction of inter-row crop competition (Rana *et al.,* 1991; Yadav *et al.,* 1992; Bhadoria and Chauhan, 1994; Singh and Tiwana, 1995; and Sheoran and Rana, 2007).

Superiority of cv. HG-100 over other 2 cultivars in recording better yield attributes could be ascribed to inherent genetic ability for efficient utilization of available resources and further translocation of such nutrients and photosynthates to reproductive parts. The present result corroborated the earlier findings of Yadav *et al.,* (1992), Bhadoria and Kushwah (2005), Choudhary *et al.,* (2005), Singh *et al.,* (2005) and Sheoran and Rana (2007). Application of 100% RDF had better response on growth and yield attributing characters viz. plant height, number of branches, plant-biomass, LAI, number of pods plant^{-1} and seeds pod^{-1} than 50% RDF in cluster bean. These parameters had also shown positive results under wider row spacing of 45 cm than 30 cm and cv. HG-100 was observed to be the most promising variety irrespective of fertility levels and row spacings compared to cv. HG-8-1 and cv. HG-563(c). The combined effects of growth and yield contributing characters were ultimately reflected in production of the highest seed yield by sowing of cluster bean cv. HG-100 at 45 cm row spacing and with 100% RDF which should be recommended for the farmers of Gird region of Madhya Pradesh, India during *kharif*.

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Abbreviations

RDF: Recommended dose of fertilizers
DAS: Days after sowing

Conflict of interest

There is no conflict of interest among the 3 authors.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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