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RESPONSE OF CLUSTERBEAN [*CYAMOPSIS TETRAGONALOBA* (L) TAUB.] GENOTYPES (GUM) TO PLANT DENSITY AND BIO-INOCULANTS

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ABSTRACT

The field experiment was conducted under rainfed condition during late *Kharif* season of 2014 at Agriculture Resaearch Station Annigeri, University of Agricultural Sciences, Dharwad to study the Response of Clusterbean genotypes (gum) to plant density and bio-inoculants. The experimental field was laid out in split-split plot design with three replications. On the basis of results obtained from present investigation all yield parameters like number of clusters per plant^{-1}(13.77), number of pods cluster^{-1} (4.08), number of pods plant^{-1}(57.08), pod length (5.08 cm), seeds pod^{-1} (4.72) , test weight(3.03 g), seed yield (643 kg ha $^{-1}$) and quality parameters like protein yield (153kg ha $^{-1}$) and gum yield (206kg ha^{-1}) recorded with genotype Gaurishankar-9. Parameters like number of clusters per plant^{-1}(13.68), number of pods cluster^{-1}(3.80), number of pods plant^{-1}(53.32), pod length (4.85 cm), seeds pod^{-1} (4.81), test weight(3.08 g), seed yield (587kgha $^{-1}$) , protein yield (138kg ha $^{-1}$) and gum yield(174kg ha $^{-1}$) observed with a spacing of 45 × 15 cm. Application of *Bradyrizhobium* + PSB + AM fungi realized higher yield parameters like clusters plant^{-1}(14.13), number of pods cluster^{-1} (4.08), number of pods plant^{-1}(59.25), pod length (4.85), number of cluster per plant seeds pod^{-1} (4.81), test weight(3.08g), seed yield(583kg ha $^{-1}$), protein yield (138kg ha $^{-1}$) and gum yield(173kg ha $^{-1}$).

INTRODUCTION

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] or Guar is a drought tolerant legume of family Leguminaseae and grown mainly kharif season in arid and semi arid region of tropical India. Multiple uses of the clusterbean make it as an important component of cropping systems of the region. Of late, it has acquired the status of industrial crop because of high glactomanan content in the endosperm of its seed, which has multiple industrial uses and thus a main foreign exchange earner for the area (Rathore *et al*., 2007). Clusterbean seed is used as a concentrate for animals and for extraction of gum. Seeds of clusterbean contain 22–33% gum (Choudhary *et al.*, 2014). The gum has its use in several industries, *viz*. textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives and oil drilling. In India it is cultivated over an area of 51.51 lakh ha with the production of 24.60 lakh tonnes with an average yield of 478.0 kg per ha (Anon., 2013). India is the leading producer of guar and guar gum in the world and its share is around 80 per cent world production. Bio fertilizers play important role in maintaining the long term soil fertility and sustainability. It may increase yield of crops by 10-30 percent (Khandelwal *et al.,* 2012). Recent investigations, in the cultivation of gum guar have demonstrated commercial possibilities of growing guar under rainfed conditions. This has opened up possibilities of growing new cash crops in the region, although it is yet to find acceptance as a part of the cropping system of northern dry zone of Karnataka, but no systematic work has been conducted on this aspect. The research information on cultivable aspects is lacking and also performance of different genotypes and spacing levels, hence, there is a need to study the response of clusterbean genotypes (gum purpose) to plant density and bio-inoculants.

MATERIALS AND METHODS

Filled

The experiment was conducted at Agricultural Research Station, Annigeri, UAS Dharwad during the late *kharif* seasons of 2014. The soil was clay having initial soil pH of 7.9 and organic carbon 0.49 % and available N, P and K of 220, 21.87and 462 kg ha^{-1} respectively. The field was prepared by employing one deep ploughing. The average rainfall of area was 665.9 mm but during 2014 a rainfall of 771.0 mm was received. The experiment was laid out in split –split plot design with 3 replications. Two genotypes (HG- 365 and Gaurishankar -9), two spacings levels of (30 x 10 cm and 45 x 15 cm) were allotted to main plot , sub plot and four treatments of Bio inoculants (*Bradyrhizobium*. PSB, AM fungi and *Bradyrhizobium* + PSB +AM fungi) were allotted to sub sub plot randomly. The crop was sown on 15 july and harvested on 17 November. Seeds of cluster bean were treated with biofertilizers, *Bradyrhizobium* + PSB @ 750 g ha^{-1} and AM fungi applied at rate of 50 kg ha^{-1}. Five random plants were selected from each plot, excluding the border row, for taking observations. Nitrogen content in the seeds was estimated by

Kjeldahl's method (Jackson, 1967). The protein per cent in the seed was calculated by multiplying the nitrogen content by a factor of 6.25 (Sadasivam and Manickam).Total available carbohydrates content of endosperms were determined as described by Clegg (1958) and procedure is as followed. The galactose 100mg was dissolved in 100 ml distilled water (1mg = 10 ml). Then 10 ml of strong galactose solution was dissolved in 100 ml distilled water to dilute the galactose solution. The same procedure was done to dilute the mannose 100 mg anthrone (0.1%): was dissolved in 100 ml sulphuric acid (270 ml con. H_2SO_4 was dissolved in 300 ml distilled water). One ml from each dilute galactose, mannose and sample was pipetted into a series of test tubes 1, 2 and 3, respectively. Then 5 ml of the Anthrone reagent was added to each test tube, then the content of each test tube was heated in water bath for 12 minutes and cooled to room temperature. Spectrophotometer was set up at 630 nm, so that the scale read zero with distilled water. Then the dilute galactose and mannose and sample were read. The data pertaining to each of the characters of the experimental crops were tabulated and finally analysed statistically by applying the standard technique to draw a valid conclusion. The mean value of sub sub plot was separately subjected to Ducan's multiple range test (DMRT) using the corresponding error mean sum of squares and degrees of freedom values.

RESULTS AND DISCUSSION

Yield and yield parameters

Gaurishankar - 9 recorded higher number of clusters per plant , number of pods per cluster number of pods per plant , number of seeds per pod, pod length, test weight and seed yield (642.78 kg ha $^{-1)}$ compared to HG-365 (Table:1). Gaurishankar - 9 recorded significantly higher seed yield (643 kg ha^{-1}) compared to genotype HG - 365 (506 kg ha^{-1}) which was 21 per cent higher compared to HG – 365 (Table1). Such significant differences in genotypes with respect to seed yield have been reported by Sangeetha Macha (2004), Siddaraju *et al*. (2011) and Lakshmi (2012) in clusterbean .The superior yield obtained by Gaurishankar - 9 was due to superior yield parameters. Among all, the most important yield component test weight (3.03 g), pod length (5.08) and number of seeds per pod (4.72) were significantly higher compared to HG-365. The other parameters *viz*., number of clusters plant^{-1} (13.77), number of pods cluster^{-1} (4.08) and number of pods plant^{-1} (57.08) were also significantly higher in Gaurishankar - 9 compared to HG- 365 .Thus owing to integration of major favorable yield components such as numbers of clusters plant^{-1}, number of pods cluster^{-1}, number of pods plant$^{-1,}$ pod length, number of seeds pod^{-1} and test weight genotype Gaurishankar - 9 realized higher grain yield compared to HG- 365. Similar results were also obtained by Sangeetha Macha (2004), Siddaraju *et al*., 2011 and Lakshmi (2012) in clusterbean crop.

The spacing levels had no significant influence on seed yield. However a wider spacing of 45 × 15 cm produced numerically higher seed yield (587 kg ha^{-1}) which was 4 per cent higher compared to closer spacing of 30 × 10 cm (506 kg ha $^{-1}$). (Table.1). Similar findings were reported by Rawat *et al*. (2013). The spacing had significant influence on stover yield also. The wider spacing of 45 × 15 cm significantly produced higher straw yield (1505 kg ha^{-1}) which was 18 per cent higher compared to closer spacing 30 × 10 cm (1240 kg ha^{-1}). Higher seed yield with a spacing of 45 × 15 cm could be attributed to significantly higher number of clusters plant^{-1} (13.68), number of pods cluster^{-1} (3.80) and number of pods plant^{-1} (53.32), pod length (4.85) and test weight (3.08 g). These values were significantly lowest at 30 × 10 cm (11.27, 3.23, 37.21, 4.62 and 2.83 respectively) might be due to increased competition among plants for the space, light and nutrients. At 45 × 15 cm, individual plant might have received favorable environment to utilize the fully available natural resources resulting in improvements in the yield components when compared to a spacing of 30 × 10 cm. Levels of spacing had no effect on number of seeds pod^{-1} and might be due to genotypic characters. Similar findings were reported by Siddaraju *et al* (2010) in clusterbean crop.

Inoculation of *Bradyrizhobium* + PSB + AM fungi recorded higher seed yield (583 kg ha^{-1}) compared to individual inoculation of *Bradyrizhobium,* PSB and AM fungi (578, 570 and 567 kg ha^{-1}). Higher yield obtained under co inoculation of *Bradyrizhobium* + PSB + AM fungi was due to positive association between yield attributing characters *viz*., numbers of clusters plant^{-1} (14.13), number of pods cluster^{-1} (4.80), number of pods plant^{-1} 59.25, and test weight (3.24g) compared to single inoculated, *Bradyrizhobium* (12.88,3.52, 46.31, 4.57

Table1: Yield and yield parameters of clusterbean as influenced by genotypes, plant density and bio-inoculants.

Treatments	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Number of seeds per pod	Pod length (cm)	Test weight (g)	Seed yield (kg ha $^{-1}$)	Stover yield (kg ha^{-1})	Harvest index (%)
Genotype									
HG-365	11.18b	2.95b	33.46b	4.59a	4.39b	2.88a	506b	1144b	31.05a
Gaurishankar-9	13.77a	4.08a	57.08a	4.72a	5.08a	3.03a	643a	1601a	28.90b
Spacing									
30 x 10 cm	11.27b	3.23b	37.21b	4.50a	4.62b	2.83b	561a	1240b	31.62a
45x 15 cm	13.68a	3.80a	53.32a	4.81a	4.85a	3.08a	587a	1505a	28.33b
Bio inoculants									
Bradyrhizobium	12.88b	3.52b	46.31b	4.57b	4.77a	3.03ab	578a	1395b	29.59ab
PSB	11.73c	3.25b	38.84c	4.52b	4.67a	2.86bc	570a	1280bc	31.22a
AM fungi	11.15c	3.22b	36.67c	4.53b	4.58a	2.70c	567a	1245c	31.69a
Bradyrhizobium + PSB + AM fungi	14.13a	4.08a	59.25a	5.00a	4.93a	3.24a	583a	1570a	27.40b

Table 2: Quality parameters of clusterbean as influenced by genotypes, plant density and bio-inoculants

Treatments	Protein content in seed (%)	Protein yield (kg ha $^{-1}$)	Gum content (%)	Gum yield (kg ha $^{-1}$)
Genotype				
HG-365	22.31b	113b	25.59b	129b
Gaurishankar-9	23.77a	153a	31.93a	206a
Spacing				
30 x 10 cm	22.79a	128a	28.32a	161a
45x 15 cm	23.30a	138a	29.20a	174a
Bio inoculants				
Bradyrhizobium	23.45ab	136a	28.93ab	170a
PSB	22.71ab	130a	28.57ab	165a
AM fungi	22.50b	128a	28.26b	162a
Bradyrhizobium + PSB + AM fungi	23.51a	138a	29.27a	173a

Table3: Yield and yield parameters of clusterbean as influenced by genotypes, plant density and bio-inoculants

	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Number of seeds per pod	Pod length (cm)	Test weight (g)	Seed yield (kg ha $^{-1}$)
Number of clusters per plant	1	0.966**	0.987**	0.853**	0.903**	0.34	0.705
Number of pods per cluster	0.966**	1	0.992**	0.815*	0.965**	-0.134	0.828*
Number of pods per plant	0.987**	0.992**	1	0.857**	0.938**	-0.045	0.766*
Number of seeds per pod	0.853**	0.815*	0.857**	1	0.654	0.268	0.37
Pod length (cm)	0.903**	0.965**	0.938**	0.654	1	-0.287	0.934**
Test weight (g)	0.34	-0.134	-0.045	0.268	-0.287	1	0.934**
Seed yield (kg ha $^{-1}$)	O.705	0.828*	0.766*	0.37	0.934**	0.934**	1

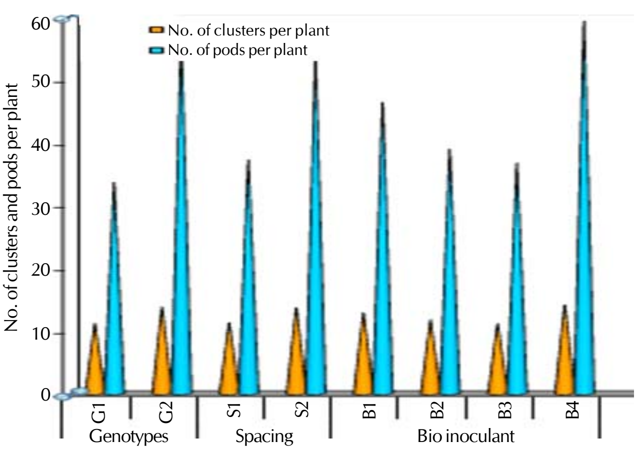

Figure 1: Number of cluster and number pods per plant and of clusterbean as influenced by genotypes, plant density and bio-inoculants

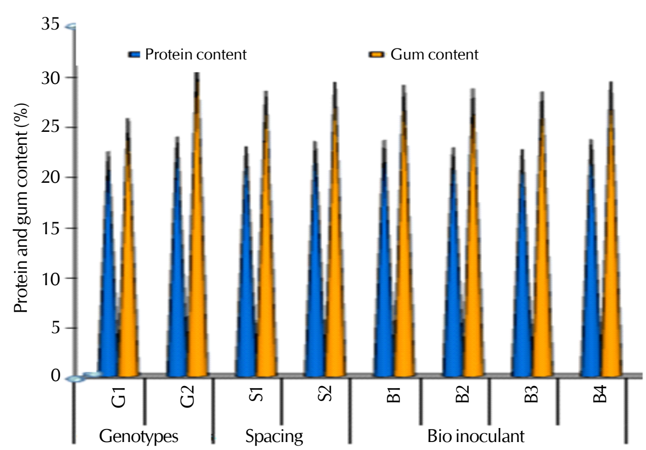

Figure 2: Protein content in seed (%) and gum content (%) of clusterbean as influenced by genotypes, plant density and bio-inoculants

and 3.03 respectively) PSB (11.73, 3.25, 38.84, 4.52 and 2.86 respectively) and AM fungi (11.15, 3.22, 36.67, 4.53 and 2.70 respectively). This might be due to increase in nitrogen availability in soil due to symbiotic nitrogern fixation by *Bradyrizhobium* and had augmented the growth of clusterbean. These findings were similar with Rathore *et al.*, 2007 and Sammauria *et al.*, 2009 in clusterbean. Better nodulation of clusterbean roots owing to increased availability of phosphorus and the improvement in nodulation with inoculation of P-solubilizer might have resulted in higher nitrogen fixation and consequent increase in vegetative growth and dry matter production by PSB and activity of the AM fungi in transporting extra phosphorus solubilized by PSB from and beyond the root zone into the plant roots which in the absence of AM hyphae gets refixed by soil constituents during the course of slower diffusion towards plant roots. These results are in accordance with the findings of Suri *et al.* (2011) and Chitale *et al.* (2012) with the application of VAM fungi in soybean and Aruna and Lakshman (2007).

Quality parameters

Significantly higher protein content (23.77%) in the seeds of Gaurishankar – 9 compared to HG- 365 (22.31 %). Protein yield also recorded significantly higher with Gaurishankar- 9

(153 kg ha^{-1}) compared to HG- 365 (113 kg ha^{-1}) and this might be due to higher protein content and seed yield under this treatment. These results are in accordance with the findings of Madhu (2013) in mungbean and Prbhamani (2014) in cowpea who reported that seed protein content is genotype character which is genetically control. Significantly higher gum content (31.93 %) was recorded with the Gaurishankar – 9 compared to HG- 365 (25.59 %). Gum yield also recorded significantly higher with Gaurishankar- 9 (206 kg ha^{-1}) compared to HG- 365 (129 kg ha^{-1}) and might be attributed to higher gum and seed yield under this treatment.

Evaluating the effects of planting geometry revealed that spacing levels had no significant influence on seed protein content and gum content of the genotypes. However spacing of 45 × 15 cm recorded higher protein content in seed (23.30 %) and gum content (29.20 %) because this was genotypic character which is genetically controlled rather than modification in planting geometry.Bio fertilizers had significant effect influence on the content and yield of seed protein.Co inoculation of biofertilizer, *Bradyrizhobium* + PSB + AM fungi recorded significantly higher protein content (23.50 %) when compared to *Bradyrizhobium* (23.45 %), PSB (22.70 %) and AM fungi (22.50 %). Protein yield also recorded significantly higher with *Bradyrizhobium* + PSB + AM fungi (138 kg ha^{-1}) when compared to Bradyrizhobium (136 kg ha^{-1}), PSB (130 kg ha^{-1}) and AM fungi (128 kg ha^{-1}) might be due to higher protein and seed yield under these treatments. These results are in accordance with the findings of Rathore *et al.,* 2007 in clusterbean with inoculation of *Rhizobium* and PSB .Bio fertilizers had significant effect on the content and yield of gum. Co inoculation of biofertilizer, *Bradyrizhobium* + PSB + AM fungi recorded significantly higher gum content (29.27 %) when compared to *Bradyrizhobium* (28.93 %), PSB (28.57 %) and AM fungi (28.26 %). Similar trend was also noticed with respect to gum yield. The treatment with *Bradyrizhobium* + PSB + AM fungi realized significantly higher gum yield of 173 kg ha^{-1} when compared to *Bradyrizhobium* (170 kg ha^{-1}), PSB (165 kg ha^{-1}) and AM fungi (162 kg ha^{-1}) might be due to higher gum content and seed yield under these treatments (Table 2 and Fig. 2). These results are in accordance with the findings of Rathore *et al.,* 2007 in clusterbean with inoculation of *Rhizobium* and PSB.

All yield parameters like number of clusters per plant, number of pods per cluster , number of pods per plant, number of seeds per pod, number seeds per pod, pod length, test weight and positively correlated to the seed yield of clusterbean. Where, number of clusters per plant, number of pods per cluster , number of pods per plant, pod length, test weight are significantly positively correlated to the seed yield of clusterbean at 0.01 probability level. Where pod length and test weight negatively correlated.

Conclusion: Genotype Gaurishankar - 9 recorded significantly higher grain yield (643 kg ha^{-1}) over the HG - 365 (506 kg ha^{-1}). All the yield attributing parameters like number of clusters plant^{-1}, number of pods cluster^{-1}, number of pods plant^{-1}, pod length, seeds pod^{-1} and test weight were observed significantly higher with Gaurishankar - 9 than genotype HG - 365. Significantly higher seed protein content and gum content was realised with Gaurishankar – 9. Between spacing levels, 45 × 15 cm spacing recorded higher seed yield. Significantly higher values of yield components *viz*., number of clusters plant^{-1} , number of pods cluster^{-1} and number of pods plant^{-1} pod length and test weight at harvest were associated with spacing of 45 × 15 cm. Application of bio inoculant, *Bradyrizhobium* at 750g + PSB at 750g + AM fungi 50 kg ha^{-1} recorded higher seed yield .All the yield attributing parameters like numbers of clusters plant^{-1} , number of pods cluster$^{-1,}$ number of pods plant^{-1} and test weight were recorded significantly higher with application of *Bradyrizhobium* at 750g + PSB at 750g + AM fungi 50 kg ha^{-1} compared to the other treatments. All yield parameters like number of clusters per plant, number of pods per cluster , number of pods per plant, number of seeds per pod, number seeds per pod, pod length, test weight and positively correlated to the seed yield of clusterbean.

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