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Growth and Development Analysis of Clusterbean [*Cyamopsis tetragonaloba* (L). taub.] Genotypes (gum) as Influenced by Plant Density and Bio-Inoculants

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A B S T R A C T

The field experiment was conducted under rainfed condition during late *Kharif* season of 2014 at Agriculture Research 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 Gaurishankar – 9, genotype recorded higher absolute growth rate, leaf area ratio and specific leaf area. HG-365 recorded higher leaf weight ratio.Spacing level of 45 × 15 cm recorded higher absolute growth rate, relative growth rate, leaf area ratio. Spacing level of 30 × 10 cm recorded higher crop growth rate and specific leaf weight. Application of *Bradyrizhobium* + PSB + AM fungi recorded higher absolute growth rate, relative growth rate and crop growth rate.

Introduction

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] or Guar is a drought tolerant legume 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

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 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. Five plants were separated into leaf, stem and reproductive parts and dried in an oven at 70°C until a constant weight is obtained. Total dry matter was calculated by adding the dry weights of different plant parts and expressed as grams per plant.

Absolute growth rate

Absolute growth rate (AGR) was calculated by using the formula proposed by Radford (1967) and expressed in gram per day per plant (g day^{-1} $plant^{-1}$).

$$AGR = \frac{W2 - W2}{t2 - t1}$$

Where,

W2 and W1 = Dry weight of whole plant (g) at time t2 and t1 respectively.

t2 and t1 = Time intervals (days).

Crop growth rate

Crop growth rate (CGR) is defined as the rate of dry matter produced per unit land area per unit time. It is worked out by the formula proposed by Watson (1952) and expressed as g per cm^2 per day.

$$CGR = \frac{W2 - W2}{t2 - t1} \times \frac{1}{P}$$

Where,

W2 and W1 = Dry weight of whole plant (mg) at time t2 and t1 respectively.

t2 and t1 = Time intervals (days).

P = Land area (cm^2).

Relative growth rate

Relative growth rate (RGR) is the rate of increase in dry weight per unit dry weight of the plant per unit time and expressed as g per g per day (g g^{-1} day^{-1}). It was calculated by the following formula proposed by Radford (1967).

$$RGR = \frac{Loge\ W2 - Loge\ W1}{t2 - t1}$$

Where,

W2 and W1 = Dry weight of whole plant (mg) at time t2 and t1 respectively.

t2 and t1 = Time intervals (days).

Loge = Logarithm to base "e".

Specific leaf area (SLA)

Specific leaf area is the ratio of leaf area to leaf mass. It is a measure of relative spread of leaf. It is expressed in cm^2/g.

$$SLA = \frac{Leaf\ area}{Leaf\ dry\ weight}$$

Specific leaf weight (SLW)

The specific leaf weight is the ratio of leaf dry weight to leaf area. It indicates the leaf thickness and density and expressed as g $/cm^2$.

$$SLA = \frac{Leaf\ dry\ weight}{Leaf\ area}$$

Leaf area ratio (LAR)

Leaf area ratio is the ratio of leaf area to total plant biomass. It is a measure of leafiness or photosynthetic surface relative to respiratory mass. It is expressed in (cm^2/g)

$$LAR = \frac{Leaf\ area\ of\ plant}{Total\ dry\ weight\ of\ plant}$$

Leaf weight ratio (LWR)

Leaf weight ratio is the ratio of mass of leaf to total dry mass of plant. It measure of allocation of leaf biomass

$$LWR = \frac{Mass\ of\ leaf}{Total\ mass\ of\ plant}$$

The data recorded on various parameters were subjected to Fisher's method of analysis of variance and interpretation of the data as given by Gomez and Gomez (1984).The level of significance used in 'F' and 't' test was P = 0.05. Critical difference (CD) values were calculated where the 'F' test was found significant. In case of non-significant effects, values of standard error of means alone were presented in Tables.

The mean value of sub sub plot and interaction were 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

Absolute growth rate (AGR) of clusterbean, genotypes was found significant at 30- 60 DAS (Table 1). Gaurishankar - 9 recorded significantly higher AGR compared to the genotype HG – 365. At 30- 60 DA, a spacing of 45 × 15 cm (0.57 g day^{-1} $plant^{-1}$) recorded significantly higher AGR when compared to at spacing of 30 × 10 cm. At 30 DAS application of *Bradyrhizobium* + PSB + AM fungi recorded significantly higher AGR (0.59 g $plant^{-1}$) when compared to other

treatments. Relative growth rate (RGR) of clusterbean, genotypes was found significant at 30- 60 DAS, a spacing level of 45 × 15 cm (0.026 g g^{-1} day^{-1}) recorded significantly higher RGR when compared to at spacing of 30 × 10 cm (0.024 g g^{-1} day^{-1}). Crop growth rate (CGR) of clusterbean at 30- 60 DAS a spacing level of 30 × 10 cm (0.0081 g cm^{-2} day^{-1}) compared to at spacing of 45 × 15 cm (0.0039 g cm^{-2} day^{-1}).

Leaf area ratio of clusterbean, genotypes was found significant at 90DAS, HG – 365 (18.88 cm^2 g^{-1}) recorded significantly higher leaf area ratio compared to the genotype Gaurishankar - 9 (16.23 cm^2 g^{-1}). Leaf weight ratio of clusterbean, genotypes was found significant at 90DAS, Gaurishankar - 9 (0.294 cm^2 g^{-1}) recorded significantly higher leaf weight ratio compared to the genotype HG – 365 (0.260 cm^2 g^{-1}).

Table.1 Absolute growth rate, relative growth rate and crop growth rate at different growth stages of cluster genotypes (gum) as influenced by plant density and bio-inoculants

Treatments	AGR 30-60DAS	AGR 60-90DAS	AGR 90 DAS-Harvest	RGR 30-60DAS	RGR 60-90DAS	RGR 90 DAS-Harvest	CGR 30-60DAS	CGR 60-90DAS	CGR 90-Harvest
Genotype									
HG-365	0.44b	0.11a	0.12a	0.025a	0.0028a	0.0026a	0.0058a	0.0006a	0.0007a
Gaurishankar-9	0.59a	0.10a	0.12a	0.026a	0.0020a	0.0020a	0.0061a	0.0005a	0.0005b
S. Em±	**0.02**	**0.02**	**0.02**	**0.001**	**0.0004**	**0.0005**	**0.0003**	**0.0002**	**0.0001**
Spacing									
30 x 10 cm	0.46b	0.11a	0.12a	0.024b	0.0026a	0.0026a	0.0081a	0.0007a	0.0009a
45x 15 cm	0.57a	0.11a	0.12a	0.026a	0.0023a	0.0021a	0.0039b	0.0003b	0.0003b
S. Em±	**0.02**	**0.01**	**0.02**	**0.0003**	**0.0002**	**0.0003**	**0.0001**	**0.0001**	**0.0001**
Bio inoculants									
Bradyrhizobium	0.52b	0.10a	21.87a	0.025a	0.0023a	0.0023a	0.0059a	0.0005a	0.0006a
PSB	0.48b	0.11a	20.64a	0.025a	0.0027a	0.0028a	0.0059a	0.0006a	0.0007a
AM fungi	0.46b	0.11a	19.98a	0.024a	0.0027a	0.0022a	0.0057a	0.0007a	0.0006a
Bradyrhizobium + PSB + AM fungi	0.59a	0.10a	24.19a	0.026a	0.0020a	0.0019a	0.0063a	0.0004a	0.0005a
S. Em±	**0.02**	**0.02**	**0.65**	**0.001**	**0.0005**	**0.0005**	**0.0002**	**0.0001**	**0.0001**

Table.2 Specific leaf area and specific leaf weight at different growth stages of cluster genotypes (gum) as influenced by plant density and bio-inoculants

Treatments	Specific leaf area (cm^2/g) at 30 DAS	Specific leaf area cm^2/g) at 60 DAS	Specific leaf area (cm^2/g) at 90 DAS	Specific leaf area (cm^2/g) at Harvest	Specific leaf weight (g /cm^2) at 30 DAS	Specific leaf weight (g /cm^2) at 60 DAS	Specific leaf weight (g /cm^2) at 90 DAS	Specific leaf weight (g /cm^2) at harvest
Genotype								
HG-365	94.89b	85.07a	66.74a	85.99b	0.0107a	0.0120a	0.0164a	0.0119a
Gaurishankar-9	102.59a	87.02a	65.35b	96.61a	0.0100b	0.0117a	0.0157b	0.0107b
S. Em±	**4.89**	**3.97**	**1.23**	**1.19**	**0.0005**	**0.0005**	**0.0001**	**0.0001**
Spacing								
30 x 10 cm	95.82b	83.83b	65.83a	87.85b	0.0107a	0.0121a	0.0163a	0.0117a
45x 15 cm	101.67a	88.27a	66.26a	94.75a	0.0100b	0.0116b	0.0159b	0.0109b
S. Em±	**3.04**	**1.37**	**1.43**	**2.48**	**0.0003**	**0.0002**	**0.0003**	**0.0003**
Bio inoculants								
Bradyrhizobium	94.32a	86.09a	68.58a	92.76ab	0.0107a	0.0118a	0.0159a	0.0110ab
PSB	97.66a	84.00a	62.24a	83.63b	0.0104ab	0.0124a	0.0163a	0.0123a
AM fungi	106.48a	87.15a	68.79a	87.45b	0.0097a	0.0116a	0.0155a	0.0116ab
Bradyrhizobium + PSB + AM fungi	96.50a	86.95a	64.58a	101.36a	0.0108a	0.0117a	0.0167a	0.0103b
S. Em±	**4.99**	**3.44**	**4.11**	**4.13**	**0.0005**	**0.0005**	**0.0009**	**0.0006**

Table.3 Leaf area ratio and leaf weight ratio at different growth stages of cluster genotypes (gum) as influenced by plant density and bio-inoculants

Treatments	Leaf area ratio (cm^2 / g) at 30 DAS	Leaf area ratio (cm^2 / g) at 60 DAS	Leaf area ratio (cm^2 / g) at 90 DAS	Leaf area ratio (cm^2 / g) at Harvest	Leaf weight ratio (g/palnt) at 30 DAS	Leaf weight ratio (g/palnt) at 60 DAS	Leaf weight ratio (g/palnt) at 90 DAS	Leaf weight ratio (g/palnt) at Harvest
Genotype								
HG-365	54.09a	32.33a	16.23b	3.65a	0.571a	0.381a	0.260a	0.043a
Gaurishankar-9	54.10a	31.85a	18.88a	3.82a	0.531a	0.368a	0.294b	0.040a
S. Em±	**4.52**	**1.68**	**0.21**	**0.10**	**0.019**	**0.021**	**0.003**	**0.001**
Spacing								
30 x 10 cm	52.31b	32.40a	17.42a	3.71a	0.549a	0.387a	0.274a	0.042a
45x 15 cm	55.88a	31.78a	17.69a	3.76a	0.552a	0.363a	0.280a	0.040a
S. Em±	**1.58**	**1.77**	**0.48**	**0.10**	**0.004**	**0.015**	**0.011**	**0.001**
Bio inoculants								
Bradyrhizobium	53.13a	32.87a	18.24a	3.70a	0.563a	0.381a	0.284ab	0.040b
PSB	53.70a	30.70a	16.76a	3.78a	0.550a	0.371a	0.269ab	0.045a
AM fungi	56.11a	31.55a	16.95a	3.62a	0.531a	0.363a	0.254b	0.042ab
Bradyrhizobium + PSB + AM fungi	53.43a	33.24a	18.27a	3.84a	0.558a	0.384a	0.301a	0.039b
S. Em±	**2.27**	**1.22**	**0.93**	**0.17**	**0.013**	**0.011**	**0.012**	**0.001**

Specific leaf area of clusterbean, genotypes was found significant at 30DAS, Gaurishankar - 9 (102.59 cm^2 g^{-1}) recorded significantly higher specific leaf area compared to the genotype HG – 365 (94. 89 cm^2 g^{-1}), a spacing of 45 × 15 cm (101.67 cm^2 g^{-1}) recorded significantly higher specific leaf area when compared to at spacing of 30 × 10 cm (95.82 cm^2 g^{-1}). At the time of harvest Gaurishankar - 9 (96.61 cm^2 g^{-1}) recorded significantly higher leaf specific area compared to the genotype HG – 365 (85.99 cm^2 g^{-1}), a spacing of 45 × 15 cm (94.75 cm^2 g^{-1}) recorded significantly higher leaf specific area when compared to at spacing of 30 × 10 cm (87.85 cm^2 g^{-1}). Application of *Bradyrhizobium* + PSB + AM fungi recorded significantly higher specific leaf area (101.36 cm^2 g^{-1}) when compared to other treatments at the time of harvest. Specific leaf weight of clusterbean, HG – 365 (0.0107 g cm^{-2}) genotypes was found significant at 30DAS, recorded significantly higher specific leaf area compared to the genotype Gaurishankar - 9 (0.0100 g cm^{-2}), a spacing of 30 × 10 cm (94.75 g cm^{-2}) recorded significantly higher specific leaf weight when compared to at spacing of 45 × 15 cm (87.85 g cm^{-2}). At 90 DAS Specific leaf weight of clusterbean, HG – 365 (0.0164 g cm^{-2}) genotypes was found significant recorded significantly higher specific leaf weight compared to the genotype Gaurishankar - 9 (0.0157 g cm^{-2}), a spacing of 30 × 10 cm (0.0163 g cm^{-2}) recorded significantly higher specific leaf weight when compared to spacing level of 45 × 15 cm (0.0159 g cm^{-2}). At the time of harvest, HG – 365 (0.0107 g cm^{-2}) genotypes was found significant and recorded higher specific leaf weight compared to the genotype Gaurishankar - 9 (0.0100 g cm^{-2}), a spacing of 30 × 10 cm (94.75 g cm^{-2}) recorded significantly higher specific leaf weight when compared to at spacing of 45 × 15 cm (87.85 g cm^{-2}) (Tables 2 and 3).

Gaurishankar - 9 and spacing level of 45 × 15 cm recorded higher absolute growth rate. The spacing level of 30 × 10 cm recorded crop growth rate at different growth stages. Gaurishankar – 9 genotype recorded higher leaf area ratio. Gaurishankar – 9 genotype recorded higher specific leaf area at different growth stages. The spacing level of 45 × 15 cm recorded significantly higher specific leaf area at different growth stages. HG-

365genotype recorded higher specific leaf weight at different growth stages. The spacing level of 30 × 10 cm recorded significantly higher specific leaf weight at different growth stages.

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