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Evaluation of morpho-physiological traits at various growth stages and its correlation with seed yield in guar gum genotypes

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Abstract
Field experiment was conducted during *kharif*, 2015-16 at Dry land farm, on sandy loam soils of Sri Venkateswara Agricultural College, Tirupati situated in Southern Agro-Climatic Zone of Andhra Pradesh. The experiment was layout in randomized block design with ten treatments and three replications. Ten guar genotypes were evaluated. The results revealed that there was significant difference between the varieties for plant height, number of branches, total dry matter and leaf area. Among the ten guar genotypes, RGC-986 recorded higher morphological traits viz. plant height and number of branches. However RGG-13-4 and RGG-12-3 recorded higher dry matter accumulation and leaf area compared to other genotypes. The physiological traits CGR, NAR, LAI and total chlorophyll contents were significantly higher in RGG-13-4 and RGG-12-3 genotypes compared to all other genotypes. Correlation studies revealed that seed yield recorded positive correlations with dry matter (R^2 = 0.495) and leaf area index (R^2 = 0.254).

Keywords: guar, plant height, seed yield

1. Introduction
Guar or cluster bean (*Cyamopsis tetragonoloba* L.) an arid legume, belonging to the family papillionaceae. It is commonly known as guar, chavli kayi and khutti. It is grown for fodder purpose, vegetable and green manure in arid and semi-arid regions of India over an area of (2014-15) 0.43 m ha with a production of 0.25 m tones and yield 567 kg ha-1. In India, it is grown in Rajasthan, Gujarat, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh and Orissa. Among the different states, Rajasthan alone occupies an area of 78%.
Guar has become an alternate remunerative crop with high adaptability suited for growing in arid regions of the world. It is a warm weather loving, deep rooted, summer-growing annual legume (www.rirdc.gov.au/pub/hand book/guar.pdf). Very little information on morphological and physiological characterization of guar is present as compared to other crops.
Plant responds to unfavorable conditions by initiating changes in morphological, physiological, and molecular parameters. Plants have developed various strategies to cope with these changes. Guar has been reported to exhibit a large variation in seed yield with changes in environmental factors and seasons (Taneja *et al*., 1995) [18] and coupled with the fact that several varieties of cluster bean differing in pod characters and growth habits are being grown in country (Naidu, 1988) [9], selection of suitable variety and sowing season are the important non-monetary inputs for obtaining higher yields. Hence main objective to study the morpho-physiological traits correlated with seed yield of clusterbean genotypes.

2. Material and Methods
Field experiment was conducted at S.V. Agricultural College Farm, Acharya N.G. Ranga Agricultural University, Tirupati during kharif season, 2015. The experiment was laid out in a Randomized Block Design (RBD) with ten treatments and replicated thrice. The treatments consist of 10 genotypes of gum guar (RGC-986, RGC-936, RGC-1003, GAUG-841, RGG-12-5, RGC-936-1, RGG-12-3, RGG-13-4, GA2G-0503 and GAUG-4703-1). The crop was grown in a plot size of 3.0 x 4.5 m with a spacing of 45 cm x 20 cm. All the morphological attributes were recorded at 20 days interval until harvest to understand the morpho physiological traits at various growth stages.

2.1 Plant Height (cm)
Five plants were selected and labeled in each treatment for non-destructive sampling and plant height was expressed in cm plant^{-1}.

2.2 Number of Branches
The number of branches for all labeled plants was counted and its mean was expressed as number of branches plant^{-1}.

2.3 Total Dry Matter (TDM)
Five plants were randomly selected treatment wise and replication wise and then leaves, stems and pods were separated. The dry weights of oven dried stems, leaves and pods were recorded at 80 ^{0}C for 48 hours when reached constant weight (20, 40, 60, 80 and at harvest) and expressed as g plant^{-1}.

2.4 Crop Growth Rate (CGR)
CGR was calculated by adopting the formula as suggested by Watson *et al*. (1952) [19].

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P} \quad g\ m^{-2}\ d^{-1}$$

Where,
W_1= Dry weight (g) of the plants at time t_1
W_2= Dry weight (g) of plants at time t_2
P = Unit land area occupied by the plant (m^2)

2.5 Net Assimilation Rate (NAR)
The net assimilation rate was calculated by using the formula given below (Gregory, 1926) [4].

$$NAR = \frac{(\log_e A_2 - \log_e A_1)}{(A_2 - A_1)} \times \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where,
W_1 and W_2 are the total plant dry weight and A_1 and A_2 are leaf area at times t_1 and t_2.

2.6 Leaf Area Index (LAI)
Leaf area index was computed taking into account, the area occupied by each plant as per the following formula (Watson, 1952) [19].

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

2.7 Total Chlorophyll content (TCC)
The chlorophyll content was calculated by using the formula given by Arnon (1949) [2].

Chlorophyll a (mg g^{-1}) = 12.7 (D 663) – 2.69 (D 645) × $\frac{V}{1000 \times W}$

Chlorophyll b (mg g^{-1}) = 22.9 (D 645) – 4.68 (D 663) × $\frac{V}{1000 \times W}$

Total Chlorophyll (mg g^{-1}) = 20.2 (D 645) + 8.02 (D 663) × $\frac{V}{1000 \times W}$

Where,
V = Volume made up
W = Weight of leaf sample

2.8 Seed Yield
Seeds were threshed from the plants harvested from a marked area of one m^2 and computed to hectare and expressed in quintals ha^{-1}.

3. Result and Discussion
3.1 Plant Height
Among the ten guar genotypes there was a significant difference between genotypes at harvest shown in table 1. RGC-936 recorded highest plant height (108.14 cm) followed by RGC-12-3 (102.14 cm) whereas GAUG-841 recorded lowest plant height of 93.02 cm followed by RGG-12-5 (94.57 cm) at harvest. Similar variability in plant height among guar genotypes was also reported by Raghuprakash (2006) [15] and Satyavathi *et al*. (2014) [16].

3.2 Number of Branches
Number of branches per plant having less significant difference among genotypes at harvest was shown in table 1. RGC-936 which recorded highest plant height also recorded highest number of branches plant^{-1} (8.4) followed by RGC-936-1 (8.03), whereas RGC-986 (5.63) recorded lowest number of branches plant^{-1} followed by RGC-1003 (5.73). Similar variability in plant height among guar genotypes was also reported by Naik *et al*. (2013) [10], Patil (2014) [12] and Satyavathi *et al*. (2014) [16].

3.3 Total plant dry matter accumulation
Among genotypes total dry matter was varied from 24.14 g plant^{-1} to 38.72 g plant^{-1} at harvest was shown in table 1. The total plant dry matter was significantly higher in RGG-13-4 (38.72 g plant^{-1}), RGC-936 (37.95 g plant^{-1}) and RGG-12-3 (37.06 g plant^{-1}) compared to all other genotypes. The genotypes RGG-12-5 and RGC-1003 recorded lowest total plant dry matter of 24.14 g plant^{-1} and 26.49 g plant^{-1} respectively, as these genotypes were short statured with low branching ability. Similar variability in plant height among guar genotypes was also reported by Jitendra *et al*. (2014) [15], Palankar *et al*. (2014) [11] and Patil (2014) [12].

3.4 Crop Growth Rate (CGR)
Phenotypic variability for crop growth rate among genotypes ranges 2.08 to 7.48 g m^{-2} day^{-1} at harvest was shown in table 1. Among the guar genotypes there was a significant difference between genotypes, GAUG-4703-1 recorded highest CGR value of 7.48 g m^{-2} day^{-1} followed by GA2G-0503 (4.97 g m^{-2} day^{-1}) and lowest CGR value is observed in RGC-986 (2.08 g m^{-2} day^{-1}). Similar results in crop growth rate were also reported by Sawant (2014) [17] in green gram and Kaur *et al*. (2015) [7] in pigeon pea.

3.5 Net Assimilation Rate (NAR)
Net assimilation rate of a genotype denotes its photosynthesizing ability. There was a significant difference among genotypes at harvest as shown in table 1. RGG-13-4 (1.031 mg cm^{-2} day^{-1}) recorded highest NAR value followed by GAUG-841 (1.025 mg cm^{-2} day^{-1}). RGG-12-5 (0.610 mg cm^{-2} day^{-1}) recorded lowest NAR value at harvest compared to all other genotypes. Similar variability in net assimilation rate was also reported by Pranusha *et al*. (2012) [14] in groundnut and Kaur *et al*. (2015) [7] in pigeon pea.

3.6 Leaf Area Index (LAI)

Leaf area index was increased in a sigmoid trend. Leaf area index ranges from 0.440 to 0.868 at harvest and having significant difference among genotypes as shown in table 1. RGG-13-4 (0.868) recorded highest LAI value followed by RGG-12-3 (0.716). RGC-1003 (0.440) having lowest LAI value as compare to other genotypes. Such genotypic variability for leaf area index in guar was reported by Raghuprakash (2006) [15], Kalyani (2006) [6] and Anupam Chakraborty (2007) [1].

Table 1: Evaluation of guar genotypes for plant height, number of branches, total dry matter accumulation, CGR, NAR, LAI, TCC, seed yield at harvest

S. No	Genotypes	Plant height (cm)	No. of branches plant^{-1}	TDM plant^{-1}	CGR (g m^{-2} day^{-1})	NAR (mg cm^{-2} day^{-1})	LAI	TCC (mg g^{-1})	Seed Yield (q ha^{-1})
1.	RGC-986	91.59	5.63	26.80	2.08	0.783	0.495	0.439	12.94
2.	RGG-12-5	88.22	6.09	24.14	2.97	0.610	0.458	0.446	12.41
3.	RGG-13-4	85.43	7.65	38.72	3.34	1.031	0.868	0.443	23.43
4.	RGC-936	99.23	8.4	37.95	3.78	0.951	0.688	0.435	13.39
5.	RGC-936-1	92.06	8.03	33.58	3.22	0.862	0.457	0.442	19.23
6.	GA2G-0503	87.9	6.4	28.35	4.97	0.721	0.466	0.438	15.8
7.	RGC-1003	88.26	5.73	26.49	3.53	0.725	0.440	0.443	12.12
8.	RGG-12-3	89.15	7.76	37.06	2.89	1.013	0.716	0.444	23.47
9.	GAUG-4703-1	91.27	6.53	28.42	7.48	0.888	0.550	0.442	17.37
10.	GAUG-841	87.69	6.88	30.67	4.30	1.025	0.697	0.44	18.13
	Mean	90.08	6.91	31.082	3.78	0.861	0.584	0.4412	16.829
	CD (P=0.05)	2.985	1.354	2.195	2.34	0.201	0.162	0.002	1.508
	SEm±	0.997	0.452	0.733	0.712	0.067	0.054	0.001	0.504

3.7 Total Chlorophyll Content (TCC)

Among the guar genotypes, there was less significant difference between genotypes at harvest was shown in table 1. RGG-12-5 (0.446 mg g^{-1}) recorded numerically higher total chlorophyll content followed by RGG-12-3 (0.444 mg g^{-1}) whereas RGC-936 (0.435 mg g^{-1}) recorded lowest total chlorophyll content. Similar variability in total chlorophyll content among genotypes was also reported by Peter and Satish (2015) and Bera and Ghosh (2015) in green gram genotypes.

3.8 Seed Yield

Seed yields were recorded on square meter basis and were converted to quintals per hectare and shown in table 1. Large variability for seed yield among genotypes was recorded and it was ranged from 12.12 to 23.47 q ha^{-1}. Such genotypic variability for seed yield in guar was reported by Anupam Chakraborty (2007) [1], Jitendra *et al*. (2014) [5] and Patil (2014) [12].

4. Conclusion

Among the ten guar genotypes RGC-986 recorded higher morphological traits viz. plant height and number of branches. However RGG-13-4 and RGG-12-3 recorded higher dry matter accumulation as compare to other genotypes.

The physiological traits CGR, NAR, LAD, LAI and total chlorophyll contents were significantly higher in RGG-13-4 and RGG-12-3 genotypes compared to all other genotypes.

Correlation studies revealed that seed yield recorded positive correlations with dry matter (R^2 = 0.495) and leaf area index (R^2 = 0.254).

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