Impact of moisture deficit stress on growth, biomass and yield parameters of cluster bean (Cyamopsis tetragonoloba L.Taub.) genotypes

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Abstract: Drought stress is considered as one of the most adverse abiotic stresses which is a threat to majority of the plant growth and productivity. Therefore, the aim of the present study was to identify the drought tolerant genotype/s of Cluster bean (*Cyamopsis tetragonoloba* L.Taub.) for the semi-arid regions. Abiotic stresses have considerable influence on biomass and seed yield parameters of crop plants. A field experiment was conducted to evaluate the moisture deficit stress on biomass and seed yield parameters of three cluster bean genotypes RGC-1025, RGC-936 and HGS-563 during winter season 2014. The stress was imposed during the initiation of flowering stage and the observations were recorded at the time of harvest for growth, biomass and seed yield parameters. All the selected genotypes recorded reduction under stress condition as compared with well watered condition for morphological, biomass and seed yield traits, however the magnitude of reduction varied with genotype. Among the three genotypes, the total biomass at harvest was highest with HGS-563 while with RGC-936 under stress. The seed yield was highest with RGC-936 under both moisture levels while HGS-563 recorded lowest seed yield as well as highest reduction with stress. Among all the three genotypes assessed, the genotype RGC-936 performed best in both moisture levels for biomass and seed yield parameters.

Key words: Guar, genotypes, biomass, water deficit stress, seed yield, HI

Introduction

Cluster bean (*Cyamopsis tetragonoloba* L. Taub.), is also known as *guar*, is an important commercial crop which is grown both in arid and semi-arid region. Cluster bean is a drought resistant annual legume crop. Being a leguminous crop, it fixes the atmospheric nitrogen and enriches the soil fertility. The crop is mainly grown during rainy season as well as under irrigated condition in summer season.

Drought stress impairs the plants growth and yield. Drought can be defined as the lack of required amount of moisture which is necessary for a plant to grow healthy (Zhu 2002). Even though cluster bean is a minor crop but due to its gum qualities it is considered as an important cash crop for industrial gum production. The discovery of the galactomannan gum in the endosperm during 1948, led to this hitherto insignificant plant gaining importance as an industrial crop. The gum is utilized for many food items like ice creams, baked and dairy products etc. Moreover, its gum also used in many other industries like pharmaceuticals, cosmetics, mining, textile, paper, oil drilling, explosive industry etc. The productivity of this crop can be significantly increased with the use of improved production technologies. Owing to the significant applications in industries there is an obvious need to undertake studies in cluster bean to identify suitable genotypes for semi-arid regions in order to expand its area under cultivation.

Materials and Methods:

Field experiments were conducted with 3 genotypes of cluster bean- RGC-1025, RGC-936 and HGS-563 during winter season of 2014, and their yield potentials were quantified both under irrigated and moisture deficit stress conditions. The germplasm was obtained from Rajasthan Seed Corporation and raised at CRIDA (HRF), Hyderabad. The selected genotypes were sown in 2.25m × 2.0m plots maintaining 15cm space between plants and 45cm between rows with three replications for both irrigated and moisture deficit stress treatments. The crop was maintained moisture and nutrient stress free by irrigating at regular intervals and applying recommended dose of fertilizers. Moisture deficit stress was imposed during the initiation of flowering stage by withholding irrigation till wilting symptoms appeared then stress was released and maintained stress free till harvest. The observations were recorded at the time of harvest for growth, biomass and seed yield parameters such as stem length (SL, cm); stem dry weight (SDW, g/plant); number of clusters (NOC); number of pods (PN); pod weight (PW, g/plant); fodder dry weight (FDW, g/plant); vegetative biomass (VBM, g/plant); total biomass (TBM, g/plant); seed yield (SY, g/plant); test weight (TW, g/plant) and harvest index (HI, %) under each treatment.

The data was statistically analyzed using a two-way analysis of variance (ANOVA) to test the significance of genotypes, moisture levels and their interactions

Results and Discussion

Based on ANOVA, it was observed that there was highly significant ($p< 0.01$) difference for genotypes for all the traits- plant height, number of clusters, pod number, stem dry weight, pod weight, seed yield, vegetative biomass, total biomass, harvest index and significant ($p< 0.05$) for test weight, while non-significant for fodder biomass (Table 1). The moisture levels were highly significant ($p< 0.01$) for all the parameters except for stem weight, seed weight and vegetative biomass. The interaction of genotypes x seasons were highly significant ($p< 0.01$) for all the parameters while stem length, number of pods, pod weight and vegetative biomass were significant.

The per se values of the parameters studied were presented in Table 2 and the % of reduction of these parameters due to stress was presented as Fig.1.

The cluster bean genotypes response for growth and biomass parameters were significant for moisture levels. Moisture deficit stress reduced growth and biomass parameters such as stem length, number of clusters, number of pods, stem weight, pod weight, seed weight, test weight and total biomass at the time of harvest. The results are in line with earlier reports of Baroowa et al. (2016) who observed reduced growth and biomass parameters under stress condition in black gram and green gram genotypes. Siddiqui et al. (2015) also reported that the growth parameters of Faba Bean were reduced due to drought stress.

The stem length of the cluster bean genotypes under well watered condition ranged from 49.2 cm (RGC-936) to 45 cm (RGC-1025) with genotypic mean of 47.7cm whereas it ranged from 38.1cm (HGS-563) to 32.2cm (RGC-1025) with a mean of 34.4cm under moisture stress. Dahanayake et al. (2014) also observed significant reduction in stem length under water stress condition in black gram.

The highest number of clusters per plant under both well watered and stress condition were recorded by HGS-563 (23.2 & 15.6) while the genotypes RGC-1025 and RGC-936 maintained similar number of clusters (19.8) under irrigated conditions and recorded similar reduction with moisture deficit stress. The highest number of pods per plant under well watered condition were recorded by RGC-1025 (65.6) and lowest by HGS-563 (58.6), while under moisture deficit stress it was RGC-936 (53.8) and HGS-563 (50.6) respectively, revealing that though the pod number of genotype HGS-563 was lowest its reduction due to stress was also minimum (13.65 %). Moisture deficit stress reduced pod weight of all the genotypes and significant variation was observed for genotypes, treatments and their interaction. RGC-936 (14.42g/pl) recorded maximum pod weight at well watered condition and minimum by HGS-563 (11.48 g/pl). Whereas RGC-936 (11.72g/pl) recorded maximum and RGC-1025 (8.51g/pl) minimum pod weight under water deficit condition.

The seed weight of RGC-936 was highest under irrigated (8.1g/pl) and stress condition (6.6g/pl) followed by RGC-1025 (6.16 g/pl 5.23 g/pl) and HGS-563 (5.6g/pl & 4.3g/pl). Among the three genotypes, RGC-1025 recorded highest seed yield under both moisture levels with lowest reduction due to moisture stress (15.1%). In White bean, Habibi (2011) also recorded reduced number of pods and seed yield with drought stress. There was a significant variation in genotypes, moisture levels and their interaction for test weight. The test weight of genotypes was 3.12g under stress and 3.47g under well watered periods showing the stress impacted the seed filling. Among the genotypes, RGC-1025 (3.6g) maintained highest test weight under well watered condition while HGS-563 (3.32g) under drought stress. Under moisture deficit stress, the reduction in the seed yield of cluster bean genotypes was due to the reduction in number of pods, seed number and test weight.

There was a significant variation in genotypes, moisture levels and their interaction for HI. Among all the genotypes, RGC-1025 recorded an improvement of 18.58% in HI with stress as compared with its performance under irrigated condition, revealing that though biomass and seed yield was reduced with stress the impact was higher on biomass than seed yield of this genotype. The genotypes HGS-563 (69.87 g/pl & 69.88 g/pl) recorded maximum and RGC-936 (54.45g/pl & 56.31g/pl) recorded minimum fodder biomass under both well watered and drought stress periods. While the genotype HGS-563 maintained the fodder biomass in both the conditions. Maximum vegetative biomass was observed in HGS-563 (41.17g/pl) and minimum in RGC-1025 (24.75 g/pl) under well watered period whereas in stress RGC-1025 (32.58 g/pl) recorded maximum and RGC-936 (22.07g/pl) recorded minimum.

From the results it can be concluded that the genotype RGC-936 is ideal to grow under semi arid regions as it recorded better seed yield under both irrigated and moisture deficit stress conditions. The genotype HGS-563 is suitable for biomass production even under stress conditions.

Table 1. ANOVA of morphological, biomass and yield parameters of guar genotypes under irrigated and stress conditions- Winter Season 2014

Parameter	Genotypes	Moisture levels	G×ML
Stem Length	**	**	*
Number of Clusters	**	**	**
Number of pods	**	**	*
Stem weight	**	NS	**
Pod Weight	**	**	*
Seed Weight	**	NS	**
Test Weight	*	**	**
Total Biomass	**	**	**
Harvest Index	**	**	**
Vegetative Biomass	**	NS	**
Fodder Biomass	NS	**	**

Table 2. The *per se* values of morphological, biomass and yield parameters of guargenotypes under irrigated and stress conditions- Winter Season 2014

Parameters	Stem length (cm)		No. of Clusters		No. of Pods	
Genotypes	**Irrigated**	**Stress**	**Irrigated**	**Stress**	**Irrigated**	**Stress**
RGC 1025	45.00	32.2	19.8	13.8	65.6	52.4
RGC 936	49.2	32.8	19.8	14.2	62.6	53.8
HGS 563	49	38.1	23.2	15.6	58.6	50.6
	Stem Wt. (g/pl)		**Pod Wt. (g/pl)**		**Total Biomass (g/pl)**	
RGC 1025	4.06	3.39	14.26	8.51	17.79	12.63
RGC 936	5.34	2.59	14.42	11.72	17.74	15.04
HGS 563	7.01	3.26	11.48	9.71	18.57	14.30
	Seed Wt. (g/pl)		**Test Wt. (gl)**		**HI (%)**	
RGC 1025	6.16	5.23	3.62	3.01	35.49	42.08
RGC 936	8.08	6.57	3.16	3.04	46.22	44.29
HGS 563	5.59	4.31	3.54	3.32	32.03	30.23
	Vegetative biomass (g/pl)		**Fodder Biomass (g/pl)**			
RGC 1025	24.75	32.58	65.37	58.58		
RGC 936	29.62	22.07	54.45	56.31		
HGS 563	41.17	32.10	69.87	69.88		

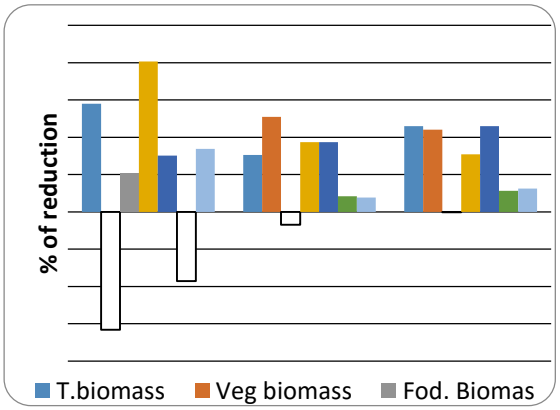

Fig. 1 The reduction in different biomass and yield parameters of cluster bean genotypes due to moisture deficit stress

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