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Evaluation of Blackgram (*Vigna Mungo* L. Hepper) Genotypes for Root Traits as a Measure of Drought Tolerance

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ABSTRACT: *Availability of genetic variation for productivity* per se *traits and responses to economically important production constraints in the working germplasm is a prerequisite for breeding crops and blackgram is no exception to this. The experiment was carried out with 116 blackgram germplasm accessions along with two checks were evaluated in RCBD design during* summer *season at 2014, in the experimental fields of Department of Biotechnology, GKVK, UAS, Bangalore. The genotypes were evaluated for root traits in PVC pipes during 2014* summer. *The accessions differed significantly for all the root traits and could be grouped into five clusters based on K-means clustering. The root trait means and variances of accessions included in the five clusters differed significantly. The genotype LBG-685 manifested higher grain yield coupled with maximum root length.*

Key words: *Drought tolerance, Blackgram, Root study,*

INTRODUCTION

Among the various pulses, blackgram or urdbean (*Vigna mungo* [L.] hepper) is an important grain legume with easily digestible protein. It belongs to the family fabaceace with 2n=22. Blackgram grain contains about 25 per cent protein, 56 per cent carbohydrate, 2 per cent fat, 4 per cent minerals and 0.4 per cent vitamins. Blackgram is believed to have originated in India (Chatterjee and Bhattacharya, 1986). It forms one of the important constituents in the dietary practices of the population depending on vegetarian diet. Slow pulse production growth has substantially reduced the per capita consumption of pulses, especially in predominantly vegetarian countries (from 63.0 g/day in 1961 to 27.3 g in 2010 in India [9].

Being a short duration crop, it fits well in intercropping and crop rotation and it can be used as green manure crop or as a combined cash and soil improvement crop with residues incorporated into a soil after pods are harvested.

India is the world's largest producer as well as consumer of blackgram. It produces about 1.5 to 1.9 million tonnes of blackgram annually from about 3.5 million hectares of area, with an average productivity of 0.5 tonnes per hectare [1]. The major blackgram growing states of the country are Maharashtra, Andhra Pradesh, Rajasthan, Orissa, Tamil Nadu, Karnataka and Bihar. In Karnataka, it is grown in an area of 1.26 lakh hectares with a production of 0.64 lakh tonnes and its productivity is 0.5 tonnes per hectare [1].

Blackgram is normally grown under rainfed conditions and as a result, it often experience drought situation that reduces productivity to a large extent. Among many factors that are associated with drought tolerance in legume crops, root traits have been considered to be the most important attributes enabling the plant to mine water efficiently from deeper soil layer under limited moisture environments. Hence root traits are important for breeding drought tolerance cultivars.

MATERIAL AND METHODS

Experimental material

The experiment was carried out during *summer* season at 2014 , in the experimental fields of Department of Biotechnology, GKVK, UAS, Bangalore, representing the eastern dry zone which is located at the latitude of 12°58' North longitude and 77°35' East and altitude of 930 meters above mean sea level. The material for the present study comprised of 118 germplasm accessions of blackgram that were used for assessing

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root traits. In this method, root growth is studied in a soil medium. PVC tubes were used. The cut PVC tubes are placed vertically in a pit dug in the soil and measuring 1 m deep. This is to ensure that the tops of the tubes are at the surface of the soil (Fig. 1). In this way, the plants that grow in the tubes are at the same level in terms of vapour pressure deficit [8].

Root phenotyping was carried out using PVC pipes measuring 0.9m length and 6 inch diameter. At planting PVC pipes were filled with soil and wetted, seeds planted at a rate of two *per* pipe, later on thinned to 1 plant per pipe. The plants were watered at regular intervals. After maturity plants were uprooted from PVC pipe and washed. 20 data recorded for two plants in each germplasm accessions on the following traits viz., Root length (cm), Shoot length (cm), Plant height (cm), Total plant length (cm), Root dry weight (cm), Shoot dry weight (g), Total plant dry weight (g), Root volume (cc), Pod yield (g) and Seed yield (g). Biomass (g) and Harvest index (%) were also worked out.

The mean values for all the root traits were subjected for statistical analysis ANOVA as per RCBD design was performed using "Window stat" computer programme. The germplasm accessions were classified following model-based "k means" clustering approach [6] to unravel organization of variability using SAS 9.3 version software programme as discussed in section.

RESULTS AND DISCUSSION

Blackgram (*Vigna mungo* L. Hepper), is an important and well known leguminous rainfed crop grown in India. It is popular because of its nutritional quality and its suitability for multiple cropping systems. However, the productivity of blackgram is low. Of the many constraints to yield drought is the major limiting factor.

Analysis of variance revealed highly significant mean squares due to germplasm accessions for all traits. Such as plant height, maximum root length, root volume, root dry weight shoot dry weight, total dry weight, pod yield plant-1, seed yield plant-1, total biomass, and harvest index (Table 1).

The mean values for growth, root and yield traits such as plant height (12.5 cm), maximum root length (19.6 cm), total plant length (29.4 cm), root dry weight (0.89 g), shoot dry weight (3.79g), total dry weight (4.69 g), root volume (16.2 cc), seed yield plant-1 (3.89 g), pod yield plant (5.9 g), biomass (10.6 g) and the harvest index (36.3 %) was recorded (Table 2).

Components of variability, heritability and genetic advance: The accessions were highly variable for plant height, pod yield plant-1, seed yield plant-1, maximum root length, root volume, root dry weight, shoot dry weight, total dry weight, total biomass and harvest index traits as indicated by the estimates of PCV(>20%). The accessions were moderately variable (10.1 d" PCV d" 19.9) for total plant length. However moderate estimates were observed for root length, total plant length. (Jordan *et. al.*, 1983) have shown that deeper rooting would increase crop yield under drought stress. The differences between GCV and PCV estimates were wider for all the traits such as plant height, total plant length, maximum root length, root volume, root dry weight, shoot dry weight, total dry weight, pod yield plant-1, seed yield plant1, total biomass and harvest index (Table 2). The same was reported by Gireesha *et al.* [3]. The presence of large amount of variability might be due to diverse source materials taken as well as environmental influence affecting the phenotypes. These findings are in accordance with the findings of Zheng *et al.,* [10] and Hemamalini [4] who also observed significant variability for grain yield and root related components in rice.

Broad-sense heritability was higher (>60%) for root volume (60.20%), and moderately heritable (29.9 ≤ PCV ≤ 59.9) for all the traits except total plant length (22.3%), root dry weight (20.71%) and harvest index (26.7%). The estimates of GCV and broad-sense heritability were higher for root volume, plant height, maximum root length, shoot dry weight, total dry weight, pod yield plant-1, seed yield plant-1 and total biomass (Table 13). Based on this consideration high heritability coupled with high and moderate genetic advance as per cent mean was registered for plant height, root length and volume [4], thus suggesting preponderance of additive gene action in the expression of these characters. Therefore selection is expected to be effective for these characters.

Moderate heritability with high as genetic advance was per cent mean was observed for shoot dry weight, total dry weight, pod yield plant-1 and seed yield plant-1. Hence, individual plant selection can be followed for improvement of these traits.

The estimates of expected GAM were higher for plant height (31.58%), root volume (61.85%), root dry weight (33.13%), shoot dry weight (72.8%), total dry weight (58.3%), total biomass (59.5%), pod yield plant-1 (61.40%), and seed yield plant-1 (71.45%) while they were lower for total plant length (8.83%) (Table 2).

The studies on phenotypic and genotypic coefficient of variation indicated that the presence of high amount of variance and role of the environment

Table 1
Estimates of genetic variability parameters for growth, root and yield traits in blackgram

Source of variation	*d.f.*	*Plant height (cm)*	*Total plant length (cm)*	*Maximum root length (cm)*	*Root volume (cc)*	*Root dry weight (g)*	*Shoot dry weight (g)*	*Total dry weight (g)*	*Pod yield plant^{-1} (g)*	*Seed yield plant^{1} (g)*	*Total biomass(g)*	*Harvest Index(%)*
Replication	1	3.41	0.264	36.33	10.8	0.019	1.60	7.83	4.30	1.13	0.24	26.2
Accessions	117	14.72**	39.27**	25.54**	169.4**	0.60*	11.3**	22.3**	21.72**	10.79**	59.15**	209.09**
Error	117	6.13	25.09	11.78	65.6	0.40	3.92	10.78	8.17	3.69	19.62	120.9

*Significant at P= 0.05 level **Significant at P= 0.01 level

Table 2
Estimates of genetic variability parameters for growth, root and yield traits in blackgram

Sl. No.	Traits	Mean	Range Lowest	Range Highest	GCV (%)	PCV (%)	h^2(broad sense) (%)	GAM %
1	Plant height (cm)	12.5	8.00	18.5	28.5	37.2	41.2	31.58
2	Total plant length (cm)	29.43	24.00	37.5	10.3	19.4	22.3	8.83
3	Maximum root length (cm)	19.6	10.00	24.5	13.42	22.1	36.87	16.79
4	Root volume (cc)	16.2	4.00	60	45.19	68.03	60.20	61.85
5	Root dry weight (g)	0.89	0.20	1.75	35.34	77.67	20.71	33.13
6	Shoot dry weight (g)	3.79	0.72	11.5	50.06	72.61	48.73	72.8
7	Total dry weight (g)	4.69	0.97	14.9	47.97	81.3	34.82	58.3
8	pod yield plant^{-1} (g)	5.9	2.15	16.0	44.2	65.5	45.0	61.4
9	Seed yield plant^{-1} (g)	3.89	1.20	13.75	49.56	70.82	48.98	71.45
10	Total biomass (g)	10.6	5.40	10.6	48.83	57.63	50.19	59.58
11	Harvest index (%)	36.3	12.7	67.3	18.83	36.45	26.7	20.04

on the expression of these traits. The magnitude of PCV was higher than GCV for all the characters which may be due to higher degree of interaction of genotypes with environment. Similar findings were also observed by Price *et al.*, [7].

Heritability and genetic advance as per cent mean when calculated together would prove more useful in predicting the resultant effect of selection on phenotypic expression Johnson *et al*., [5].

Organization of variability for growth, root and yield parameters The 118 blackgram germplasm accessions were grouped into 5 distinct clusters following model-based "k- means clustering algorithm [6]. Highest number of accessions were included in Cluster 1 (62 accessions) followed by cluster V (24) genotypes, cluster II (15 genotypes), cluster IV (12 genotypes), and cluster III (5 genotypes) (Table 3). The growth, root and yield traits mean differences between clusters were significant for all traits (Table 3). The estimates of the means of the traits such as total plant length, maximum root length, root volume, root dry weight, shoot dry weight; total dry weight, pod weight and seed weight were highest among the accessions included in cluster III and least among the accessions included in cluster I. The trait variances among five clusters were significant for 6 of the 11 quantitative traits such as root volume, root dry weight, shoot dry weight, pod weight, seed weight and total biomass (Table 3). It is desirable to choose germplasm accessions from among those included in cluster III and cluster I for various applications in breeding for drought tolerance in black gram.

Trait-specific accessions identified for selected root and yield traits in Blackgram The accessions such

Table 3
Estimates of growth, root and yield traits mean of blackgram accessions included under five clusters

Sl. No.	Traits	Mean of clusters (C) C1	C2	C3	C4	C5	'F'Statistic	Probability
	Number of accessions	62	15	5	12	24		
1	Plant height (cm)	7.64	8.90	9.97	8.67	10.02	5.74	0.00
2	Total plant length (cm)	27.5	29.9	33.70	32.3	31.3	11.20	0.00
3	Maximum root length (cm)	18.40	19.40	22.60	21.30	21.40	6.16	0.00
4	Root volume (cc)	11.70	14.60	44.50	29.79	16.60	62.65	0.00
5	Root dry weight (g)	0.73	0.75	1.55	0.98	1.27	8.05	0.00
6	Shoot dry weight (g)	2.85	2.08	5.75	4.90	6.39	21.12	0.00
7	Total dry weight (g)	3.58	2.83	7.20	5.90	7.66	23.06	0.00
8	pod yieldplant^{-1}(g)	3.92	8.69	12.13	4.72	9.10	42.84	0.00
9	Seed yield plant^{-1}(g)	2.46	5.90	8.78	2.79	5.82	44.5	0.00
10	Total biomass (g)	7.50	11.50	19.40	10.60	16.96	41.66	0.00
11	Harvest index (%)	33.20	50.90	46.20	26.60	33.52	26.16	0.00

as AKU-10-6,KU-5-546,LBG-685 and DU-1,BDU-1 with maximum root length and LBG-623, IC-282006, IC-436772, IC-282007 and BDU-3-29 with more root volume and IC-343947, LBG-685, IC-436773, IC-436946 and MDU.99.2 for seed yield plant1 as compared to its mean, are useful in breeding drought tolerance cultivars with higher productivity (Table 4).

Table 4
Trait-specific accessions identified for selected root and yield traits in blackgram

Sl. No.	*Characters*	*Identity of Accessions with lowest value*	*Mean*	*Identity of Accessions with Highest value*	*Mean*
1		TNAUBG.CO.6	10.0	AKU-10-6	27.0
2		IC-436784	10.5	KU-5-546	25.0
3	Maximum root length (cm)	AC.43	10.5	LBG-685	24.7
4		KUG-216	11.75	DU-1	24.5
5		GP-553	12.25	BDU-1	24.5
		Mean	**19.67 (CD @ 0.05%=4.78)**		
1		COBG-653	4.00	LBG-623	60.0
2		KUG-216	5.00	IC-282006	50.0
3	Root volume (cc)	PU-40	5.00	IC-436772	45.0
4		GP-553	5.00	IC-282007	42.5
5		2KU-60	5.00	BDU-3-29	40.0
		Mean	**16.22 (CD @0.05%=11.3)**		
1		593/331	0.2	RASHMI	3.0
2	Root dry weight	2PLU-5	0.2	2KU-14	2.75
3	plant^{-1} (g)	K-5-572	0.2	IC-436780	2.5
4		IPU.07.43	0.2	240-PLU-769	2.5
5		AKU-07-4	0.225	PU-31	2.0
		Mean	**0.89 (CD @ 0.05%=0.88)**		
1		703	1.2	IC-343947	13.35
2		TNAUBG.CO.6	1.25	LBG-685	12.01
3	Seed yield plant^{-1} (g)	AKU-07-4	1.4	IC-436773	12.00
4		MASH-114	1.5	IC-436946	11.1
5		IC-436864	1.5	MDU.99.2	10.3
		Mean	**6.62 (CD @0.05%=2.58)**		

Figure 1: Methods used in root studies

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