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Title Salt Stress Responses in Early Seedling Growth Characteristics of Blackgram [*Vigna mungo* (L.) Hepper] Genotypes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In view of increasing salinity and intrusion of salt water into the cultivable land area under coastal saline region, germination and crop establishment is a major problem that influence on decrease in the production and productivity of blackgram. Hence, screening of 101 genotypes under different salt concentrations for growth characters paves way to identify the saline resistant genotypes. The upshot of saline stress on seedling growth characters of 101 genotypes which are collected from different eco geographical regions subjected to Half strength Hoagland and Arnon's solution (T_1), Half strength Hoagland Arnon's solution +NaCl treatment @100mM, 150mM, 200mM and 250mM concentration @7th, 10th, 13th, 16th days (T_2) respectively and Half strength Hoagland and Arnon's solution (control) (T_3) during January 2022. Highly significant variation exhibited among the various genotypes for different seedling growth characters *viz*., leaf area per plant, total number of leaves

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per plant, dry weight of leaves per plant, dry weight of shoot per plant, dry weight of roots per plant and dry weight of the whole plant. Salinity has the adverse effect on the growth characters. Among the genotypes studied, AUB-08-33(G81) and CBG-09-08(G18) showed maximum mean values under different NaCl concentrations (T_2), recommended as donor parent for hybridization as well as candidate genotype in crop improvement for saline soil.

Keywords: Blackgram; salt stress; seedling characters; NaCl.

1. INTRODUCTION

Black gram is scientifically known as V*igna mungo (L*) Hepper, 2n=2x=22 and commonly known as urd in India. Black gram is mainly cultivated and distributed in tropical and subtropical regions of Africa, Asia, America, and Australia [1] whereas majorly grown in South and Southeast Asian countries including Afghanistan, Bangladesh, Pakistan, and Myanmar. About 70 per cent of the world's black gram production comes from India. Worldwide it covers about 23.4 lakh tones of black gram annually from 46.7 lakh hectares of area with an average productivity of 501 kg per hectare in 2020-2021(agricoop.nic.in). India identified as its primary origin [2] and domesticated from the wild species *V. mungo* var. *sylvestris* [3]. India is the largest producer and consumer of black gram with an area account for about 15.7 percent of total pulse acreage and contributes 9.09 per cent of total pulse production. In Kharif 2021-2022, black gram production accounts 20.5 lakh tones in an area of 39.43 lakh hectares (agricoop.nic.in).

In India, states like Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and Tamil Nadu shows upward production in black gram cultivation [4]. The area and production of black gram in Tamil Nadu is about 4.2 lakh hectare and 2.78 lakh tons. (Department of Pulses Development, Bhopal, Annual Report; [5]. There is a declining phase in production and productivity of black gram due to the influence of biotic, abiotic factors and urbanization. Its need of hour to increase the production and productivity to meet out the demands of increasing population [6]. Among the abiotic factors, soil salinity plays an important role in declining the production and productivity of crop plants especially along the coastal region [7]. In India saline soil occupies about 6.73 million hectares [8].

Salt stress hampers the agricultural productivity by lowering the yield of various crops in arid and semi-arid regions of the world [9,10]. Saline soils are present in the states of Gujarat, Bihar, Haryana, Rajasthan, Maharashtra, Odisha, Andhra Pradesh, Kerala, Tamil Nadu, Uttar Pradesh, and West Bengal (agricoop.nic.in).

The effect of salinity on the growth of black gram has been reported occasionally [11,12] also opined the growth retarding effects of various salinity treatment in pulses. However, with increasing (0 to 180Mm of NaCl), decreases germination by 50% in the species of the genus *Phaseolus* reported by Jeannette S Bayuelo – Jimenez *et al*. [13] Increase in salinity causes a decrease in fresh or dry weight of plants also it influences on seedling growth, shoot height and root length which showed most sensitive to salt stress [14].

In the sight of increasing salinity stress, there is a necessary to find out the saline tolerance varieties which can be used to increase the black gram productivity under saline condition. Considering the above facts, the study was undertaken to identify the genotypes against salt stress by observing the growth characters.

2. MATERIALS AND METHODS

Location To investigate the seedling response of black gram under various salinity treatment was conducted at UG laboratory, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu.

Plant materials and methods Seeds of 101 black gram genotypes were collected from various geographical sources and the study was conducted. The list of the evaluated genotypes is presented in Table 1.

Experiment To analyze the growth characters this experiment was conducted at Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University during January, 2022 using Factorial Completely Randomized Design (FCRD) described by

Gomez and Gomez [15] replicated twice Seeds of the 101 black gram genotypes were sown in plastic cup (9.0 x 6.5 cm) @ seven seeds per cup filled with sterilized coir pith. The cups are then placed in plastic trays (40 x 28 x 7 cm) @ 15 cups per tray which was irrigated with half – strength Hoagland and Arnon's nutrient solution (Hoagland and Arnon's, 1950) @ 2 litres per tray by following Asana Matsuura *et al*. [16]. Holes were made at the bottom of the cups to facilitate easy absorption of the nutrient solution by the coir pith. The details of the treatment are given below.

2.1 Observations Recorded

The observations were recorded on the growth characters *viz.*, Leaf area per plant, total number of leaves per plant, dry weight of leaves per plant, dry weight of shoots per plant, dry weight of roots per plant and dry weight of whole plant and the results were analyzed using TNAUSTAT.

2.2 Leaf Area Per Plant

The leaf area was measured using leaf area meter (Model LI- 3100, LT COR, Lincoln, USA) and the mean value was expressed in cm.

2.3 Total Number of Leaves Per Plant

The total number of leaves per seedling in each genotype was counted and the mean value was expressed as whole number.

2.4 Dry Weight of Leaves Per Plant

To measure the dry weights of leaf, shoot and root the seedlings were kept in hot air oven at 60°C for 48 hours after being exposed to 110°C for 30 minutes.

Leaf dry weight per seedling was measured in each blackgram genotypes and the mean value was expressed in grams.

2.5 Dry Weight of Shoot Per Plant

Oven dried shoot weight of seedlings were recorded and the mean value was expressed in grams.

2.6 Dry Weight of Root Per Plant

Oven dried root weight of the seedlings were recorded and the mean value was expressed in grams.

2.7 Dry Weight of Whole Plant

Whole plant dry weight was calculated by adding the dry weight of leaf, shoot and root of the seedlings and the mean value was expressed in grams.

3. RESULTS AND DISCUSSION

The analysis of variance indicated the existence of highly significant difference among all the 101 genotypes for all the traits studied (Table 2).

Total leaf area per plant Diminution in leaf area were noted. The range for this trait was from 0.16 cm^2 to 2.53 cm^2 (G66) in T_1, 2.30 cm^2 to 25.97 cm^2 (G18) in T_2 and 5.60 cm^2 to 75.15 cm^2 (G59) in T_3. The genotype G18 recorded the maximum total leaf area of 25.975 cm^2 in T_2. It was found that out of 101 genotypes, 15 and 27 genotypes had significantly higher values than the general mean in T_2 and T_3 respectively. The leaf area was decreased to 97.54% 0f the control respectively **(**Table 3). In general salinity stress reduces the leaf number, leaf area, shoot and root dry weight leading to low yield. (Li *et al.* [17] Dutta and Bera, [18] Ghosh *et al*. [19] and Udhaya Nandhini *et al*. .[20]. Our results are consistence with Pankaj *et al*. [21] who reported that NaCl highly reduced total leaf area.

Details of the treatment

Code	Treatment	Observations recorded on
T_1	Half strength Hoagland and Arnon's solution	One day before the start of salinity treatment (6DAS) (Fig. 1)
T_2	Half strength Hoagland Arnon's solution +NaCl treatment @100mM ,150mM,200mMand 250mM concentration @7^{th},10^{th},13^{th}, &16^{th} days respectively.	12days after the start of salinity treatment (18 DAS) (Fig. 2)
T_3	Half strength Hoagland and Arnon's solution (control)	18 DAS

Fig. 1. Overview of the blackgram seedlings on 6 DAS

Fig. 2. Response of blackgram seedlings to T_3 and T_2 on 18 DAS

Table 1. List of evaluated black gram genotypes used for the study

Genotypes code	Genotypes	Source
G1	RU -8-701	Indian Institute of Pulse Research, Kanpur
G2	RU-8 703	Indian Institute of Pulse Research, Kanpur
G3	RU-8-704	Indian Institute of Pulse Research, Kanpur
G4	RU-8-705	Indian Institute of Pulse Research, Kanpur
G5	RU-8-706	Indian Institute of Pulse Research, Kanpur
G6	RU-8-707	Indian Institute of Pulse Research, Kanpur
G7	RU-8-711	Indian Institute of Pulse Research, Kanpur
G8	RU 8-708	Indian Institute of Pulse Research, Kanpur
G9	RU-8 -702	Indian Institute of Pulse Research, Kanpur
G10	PLU-621	NPRC, Vamban, Tamil Nadu, India
G11	RU -09-157	Indian Institute of Pulse Research, Kanpur
G12	RU 9-159	Indian Institute of Pulse Research, Kanpur
G13	RU 9- 158	Indian Institute of Pulse Research, Kanpur
G14	RU 9- 156	Indian Institute of Pulse Research, Kanpur
G15	RU 9-155	Indian Institute of Pulse Research, Kanpur
G16	RU 9-154	Indian Institute of Pulse Research, Kanpur
G17	RU 9-153	Indian Institute of Pulse Research, Kanpur
G18	CBG -09-08	Coimbatore , Tamil Nadu, India
G19	CBG- 09-06	Coimbatore , Tamil Nadu, India
G20	CBG-09-15	Coimbatore , Tamil Nadu, India
G21	CBG -09-10	Coimbatore , Tamil Nadu, India
G22	CBG- 09-04	Coimbatore , Tamil Nadu, India
G23	CBG –09-03	Coimbatore , Tamil Nadu, India
G24	CBG-09-02	Coimbatore , Tamil Nadu, India
G25	CBG-09-13	Coimbatore , Tamil Nadu, India
G26	CBG-09-01	Coimbatore , Tamil Nadu, India
G27	CBG-09-09	Coimbatore , Tamil Nadu, India
G28	VBN-5	NPRC, Tamil Nadu, India
G29	VBG-05-014	NPRC, Vamban, Tamil Nadu, India
G30	VBG-05-007(BR)	NPRC, Vamban, Tamil Nadu, India
G31	SD-2-143	NPRC, Vamban, Tamil Nadu, India
G32	RG RU- 448	NPRC, Vamban, Tamil Nadu, India
G33	H-21-40-41	NPRC, Vamban, Tamil Nadu, India
G34	PS-1	NPRC, Vamban, Tamil Nadu, India
G35	NTU –94-6	NPRC, Vamban, Tamil Nadu, India
G36	P-133/19	Punjab, India
G37	P-206	Punjab, India
G38	LU-272	NPRC, Vamban, Tamil Nadu, India
G39	MDU-99-2	Madurai, Tamil Nadu, India
G40	ADT-3	Aduthurai, Tamil Nadu, India
G41	PLU-227	NPRC, Vamban, Tamil Nadu, India
G42	Vanniyur local - 1	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G43	P-47	NPRC, Vamban, Tamil Nadu, India
G44	99-100	Taiwan
G45	Ariyapatti	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G46	Vanniyur local- 2	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G47	T9	NPRC, Vamban, Tamil Nadu, India
G48	VZM- 189/33	NPRC, Vamban, Tamil Nadu, India
G49	NUB-294	NPRC, Vamban, Tamil Nadu, India
G50	NP-7	NPRC, Vamban, Tamil Nadu, India
G51	U- 99-35	NPRC, Vamban, Tamil Nadu, India

Genotypes code	Genotypes	Source
G52	PLU-340	NPRC, Vamban, Tamil Nadu, India
G53	PLS 364/47	NPRC, Vamban, Tamil Nadu, India
G54	LO-217	NPRC, Vamban, Tamil Nadu, India
G55	Atthipatti local-1	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G56	PHM.8	Punjab, India
G57	PLV-554	NPRC, Vamban, Tamil Nadu, India
G58	Atthipatti local 2	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G59	TUS-27- Bold	NPRC, Vamban, Tamil Nadu, India
G60	Co-1	Coimbatore, Tamil Nadu, India
G61	Chidambaram local	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G62	PLU- 446	NPRC, Vamban, Tamil Nadu, India
G63	2KU-53	Uttar Pradesh India
G64	VBN-4	NPRC, Vamban, Tamil Nadu, India
G65	VBG05-02	NPRC, Vamban, Tamil Nadu, India
G66	PLS-254	NPRC, Vamban, Tamil Nadu, India
G67	P-13211	NPRC, Vamban, Tamil Nadu, India
G68	PLS – 364/42	NPRC, Vamban, Tamil Nadu, India
G69	IPU- 917	NPRC, Vamban, Tamil Nadu, India
G70	VBN-3	NPRC, Vamban, Tamil Nadu, India
G71	PLG-47	NPRC, Vamban, Tamil Nadu, India
G72	NLC-8183	NPRC, Vamban, Tamil Nadu, India
G73	Co-5	TNAU Tamil Nadu, India
G74	VBG-05-08	NPRC, Vamban, Tamil Nadu, India
G75	VBG-05-001	NPRC, Vamban, Tamil Nadu, India
G76	VBG-04-0012 (Br)	NPRC, Vamban, Tamil Nadu, India
G77	IPU- 232	NPRC, Vamban, Tamil Nadu, India
G78	VBG-05-0011	NPRC, Vamban, Tamil Nadu, India
G79	VBG-05-006	NPRC, Vamban, Tamil Nadu, India
G80	AUB-08-11	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G81	AUB-08-13	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G82	AUB-08-21	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G83	AUB-08-22	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G84	AUB-08-23	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G85	AUB-08-31	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G86	AUB-08-32	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G87	AUB-08-33	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G88	AUB-08-41	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G89	AUB-08-42	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G90	AUB-08-43	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G91	AUB-08-51	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G92	AUB-08-52	Plant Breeding Farm, Annamalai University,

Genotypes code	Genotypes	Source
		Tamil Nadu, India
G93	AUB-08-53	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G94	AUB-08-61	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G95	AUB-08-62	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G96	AUB-08-63	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G97	AUB-08-71	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G98	AUB-08-72	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G99	AUB-08-73	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G100	AUB-08-121	Plant Breeding Farm, Annamalai University, Tamil Nadu, India
G101	AUB-09-152	Plant Breeding Farm, Annamalai University, Tamil Nadu, India

Table 2. Results of analysis of variance of selected growth characters of black gram genotypes

Source	df	MS					
		Total leaf area per plant	Total number of leaves per plant	Dry weight of leaves per plant	Dry weight of soot per plant	Dry weight of root per plant	Dry weight of whole plant
Genotypes	100	98.14**	2.92**	0.0002**	0.0006*	0.0008**	0.001**
Treatment	2	42662.95**	1066.48**	0.059	0.16**	0.0014**	0.18.**
Genotype x treatment	200	101.08**	3.12**	0.0002**	0.0006**	0.00086**	0.001**
Error	303	3.61	0.40	0.00006	0.0004	0.000021	0.0003
Total	605	192.48	5.24	0.0003	0.0006	0.00044	0.001
G x T	SED	1.9007	0.6359	0.0081	0.0223	0.0045	0.0174
	CD (0.05)	3.7403	1.2513	0.0163	0.4389	0.0089	0.0343
	CD (0.01)	4.9270	1.6483	0.0215	0.0578	0.0117	0.0452

**Significant @5% level*
**Significant @1% level*

Total number of leaves per plant The decline in the number of leaves were noted. The range for this trait was from 0.47 to 2.40 (G18) in T_1, 1.29 to 6.55 (G87) in T_2 and 3.00 to 10.81 (G47) in T_3. Genotype G87 recorded the maximum total number of leaves per pant of 6.55 in T_2. A total of 9 and 14 genotypes that significantly exceeded the general mean for this trait in T_2 and T_3 respectively. The leaf number also shown downward decrease to 95.09% over the control (Table 3). Leaf number was not affected by 25 and 50 mM NaCl concentrations so that there was no significant difference between those treatments in compare with control but increase of salinity to 100 mM significantly decreases leaf number. Similar reports were noticed in soybean [22,4] Reduced number of leaves in plant exposed to excessive salinity was also observed in Curly Kale [23].

Dry weight of leaves per plant The drop in weight of leaves in black gram were observed. The range for this trait was from 0.0004 g to 0.0087 g (G65) in T_1, 0.002 g to 0.0553 g inT_2

(G18) and 0.0070 g to 0.0788 g in T_3 (G61). The genotype G18 was recorded the maximum dry weight of leaves per plant of 0.0553 g in T_2. One genotype in T_2 and 4 genotypes in T_4 stigmatically that exceeded the general mean. The dry weight of the leaves was decreased to 98.05% over the control (Table 4). Indeed, the plant dry weight was significantly decreased by increasing the NaCl levels (El Sabagh *et al.* [22] and Rajasekar *et al.* [14].

Dry weight of shoot per plant Black gram genotypes remarkably reduced the shoot dry weight with increasing the salinity levels. The range for this trait was from 0.0011 g to 0.0285 g (G10) in T_1, 0.0050 g to 0.0495 g (G18) in T_2 and 0.0200g to 0.0626 g (G61) in T_3. It was found that the genotype G 18 (0.0495 g) had significantly higher values than the general mean in T_2. Genotypes *viz*., G 24, G 61 and G 70 had significantly higher values than the general mean in T_3. Dry weight of the shoot decreased to 97.22% of the control respectively (Table 4). The shoot dry weight showed decreased with increasing salinity compared to control observed by El Sabagh et a*l*. [22] Hasan *et al*. [24] and Subroto Kumar Podder *et al*. [25].

Fig. 3. Response of the susceptible blackgram seedlings (RU-8-708) to salinity

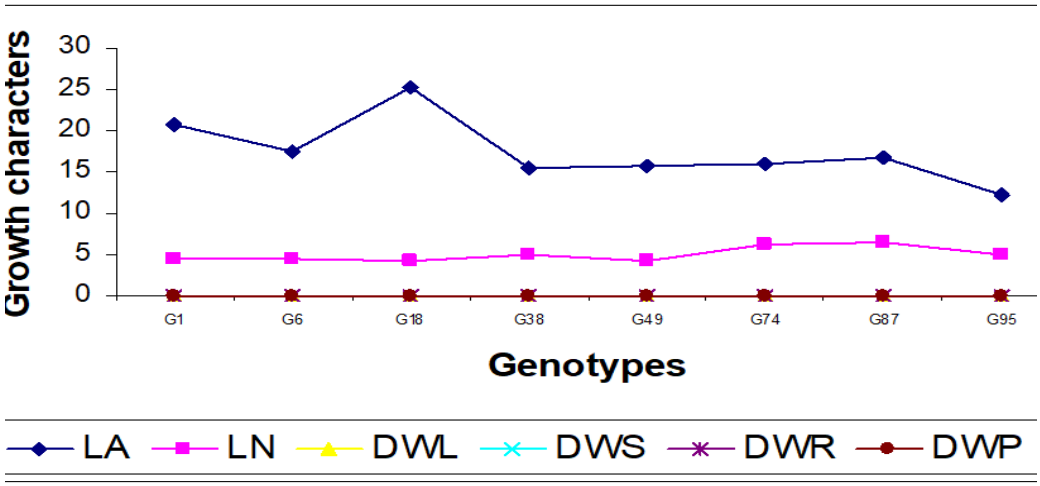

Fig. 4. Performance of saline resistant blackgram genotypes for various seedling growth characters

Table 3. Mean performance of leaf area per plant and total number of leaves per plant for black gram genotypes

Genotypes	Total Leaf area per plant (cm^2)			Total number of leaves per plant		
	T_1	T_2	T_3	T_1	T_2	T_3
G1	1.4000	20.7500**	28.4950	1.4000	4.6000	7.6150*
G2	0.2500	10.0450	38.5250**	0.9000	2.8850	8.8000
G3	0.2500	10.0394	25.3000	0.9000	4.6500	6.9500
G4	0.3500	11.7600	26.4550	0.9000	2.6000	6.9250
G5	0.5000	9.0350	30.1750	1.9000	3.6500	4.5250
G6	1.0000	17.6250**	44.1400	1.9000	4.5500	10.3000**
G7	0.4450	14.6400	24.2850	0.9000	3.5500	5.5150
G8	0.2000	21.0250**	33.0550	0.9000	3.9000	6.3500
G9	0.3000	17.0600**	26.4000	0.9000	4.1000	5.6850
G10	0.6150	12.2350	29.2000	1.2500	3.3600	5.6650
G11	0.6000	21.6600**	27.1950	2.0000	4.6500	5.4350
G12	1.2000	15.1400	16.1750	1.7000	4.6000	4.8900
G13	1.1000	6.7100	38.9400**	1.9000	3.4900	7.5100
G14	0.8500	5.5150	40.8700**	1.9000	1.9250	8.2900**
G15	0.6000	10.0600	26.9000	1.9000	2.6500	6.1250
G16	0.6000	11.1100	29.9900	1.9000	3.7850	7.4100
G17	0.5500	3.6700	32.0700	0.9000	1.2950	5.3900
G18	0.9500	25.3350**	25.9750	2.4000	4.3600	5.6450
G19	1.4000	11.2800	15.1900	1.4000	3.6000	6.5250
G20	0.6000	19.4000	24.3050	1.9000	4.6000	6.7650
G21	0.2000	16.2500*	32.1850	0.9000	4.0500	6.5100
G22	0.4000	13.5150	32.0750	2.0500	4.0250	5.7900
G23	0.5000	16.1500*	31.9800	2.0500	3.0800	5.7750
G24	0.6000	10.4050	39.7250**	1.9000	1.6500	7.4900
G25	0.4300	3.0250	26.1900	1.4000	3.2150	6.6600
			Con...			
G26	0.6000	3.5000	5.6050	1.9000	2.3150	3.5100
G27	0.5000	19.9600**	27.1400	1.9000	4.6000	5.0500
G28	0.8000	16.4000**	23.2400	1.9000	3.3700	4.5100
G29	0.4000	4.3600	37.9750**	1.0000	2.0100	7.5050
G30	0.3500	10.2300	18.9500	0.9000	3.3500	4.6650
G31	0.4500	8.6050	46.5400**	1.4000	2.6500	7.5200
G32	0.7000	3.8600	20.9100	1.7000	1.7500	5.4900
G33	0.5000	6.3850	28.9400	1.9000	3.0500	6.8400
G34	0.9600	6.5350	14.1900	1.9000	2.7500	4.5150
G35	0.6000	10.2050	13.8850	1.9000	3.1500	4.5050
G36	0.6000	18.1450**	25.2200	1.9000	4.6000	6.0350
G37	1.0000	8.4950	15.1850	1.9000	2.9000	8.1200**
G38	1.0000	15.4400*	39.2000	1.9000	5.0000*	6.9500
G39	0.2800	11.3250	36.7850**	1.9000	2.9500	7.1600
G40	1.2250	2.8000	15.9350	1.9000	2.7100	5.4700
G41	0.3000	2.3000	31.6050	0.9000	2.2000	6.5250
G42	0.8000	2.3000	38.1150	1.9000	3.0500	6.8650
G43	0.4400	10.5890	11.6050	1.9000	3.1500	3.3050
G44	0.4000	13.3550	18.1800	1.9000	3.7900	4.0450
G45	0.4500	7.7650	10.0150	1.8750	2.2800	2.5600
G46	0.6500	3.6000	17.7350	1.9000	2.3800	3.6600
G47	0.6500	6.5050	17.7300	1.8750	2.6250	10.8100**
G48	0.5500	10.5250	26.2200	1.9000	3.8750	6.6550

G49	0.2000	15.7850*	33.0700	0.8500	4.2850	6.5100
G50	0.4000	12.1050	27.4300	1.4000	4.6000	5.2150
G51	0.4000	8.7750	19.9850	1.8750	3.2250	4.6550
G52	0.3500	16.5450**	44.8250**	1.9250	4.2700	4.4300
G53	0.3500	9.7150	36.9300	1.3750	3.6000	5.8200
G54	2.1300	9.8850	41.9750**	1.8250	4.1300	4.6650
G55	0.5000	13.8650	14.1200	1.8500	4.3350	4.6950
G56	0.1775	11.6500	32.8150	1.9000	5.0600*	5.1800
G57	0.1650	13.7600	32.0800	0.9000	3.9100	5.8250
G58	0.5500	5.8950	24.0950	1.9000	2.1850	4.8250
G59	0.2500	7.0650	75.1850**	1.9000	3.6000	8.5100**
G60	0.2500	11.6400	25.0100	1.9000	3.8500	5.4900
G61	0.3000	21.7750**	38.9600**	0.9000	4.8000	9.8700**
G62	1.1300	15.0300	24.3050	1.9000	5.5500**	7.0250
G63	0.7000	12.2900	18.4250	1.9000	5.6000**	5.8850
G64	0.7500	5.0000	46.8900**	1.9000	2.7500	6.4900
G65	1.1500	12.4250	41.2350**	1.8500	3.9500	7.4750
G66	2.5300	10.4400	25.4350	1.8500	4.1000	7.4900
G67	0.9000	7.3500	30.2500	1.9000	3.2250	5.9250
G68	0.4500	9.6700	36.5400**	1.9000	3.7000	5.8700
G69	0.4150	8.7850	13.6200	1.7000	4.2650	4.6300
G70	0.3750	11.3700	46.0550**	0.5600	3.3500	8.5150**
G71	0.7000	7.3000	42.3500**	0.9000	2.6500	5.6650
G72	1.4250	12.8400	29.7750	2.1500	5.6500**	6.5250
G73	0.9500	12.1750	17.3400	1.8500	2.9000	3.0050
G74	0.4000	15.9250*	26.9900	1.9000	6.2000**	6.5200
G75	0.6500	12.2850	17.4300	2.1850	3.4250	3.9650
G76	0.5500	12.8000	35.6750**	1.9000	4.0500	6.8150
G77	0.6500	12.8900	34.0250*	1.9000	3.6000	7.2000
G78	0.3500	14.7000	28.5600	1.9000	3.5500	6.5250
G79	0.6000	13.6500	40.8250**	1.2500	4.0500	7.6250*
G80	0.5000	13.0500	30.2150	1.9000	3.6000	5.6200
G81	0.4000	9.2200	31.5000	1.9000	3.2500	7.4900

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G82	0.7000	10.5550	34.3450*	1.4000	4.1000	7.5200
G83	0.5600	11.0050	28.4150	1.9000	3.1500	5.5200
G84	1.1000	12.9100	17.7200	1.9000	5.1000	5.8900
G85	1.1000	14.3450	52.9550**	1.9000	3.9500	8.5250**
G86	0.4500	8.2000	43.2400**	0.4700	3.9000	9.4900**
G87	1.9000	16.6400*	30.5400	1.9000	6.5500**	7.4900
G88	1.3000	12.0550	38.4050**	1.9000	4.0000	5.4900
G89	0.4500	12.2450	30.8750	0.9000	6.1150**	7.5300
G90	0.3300	7.3200	33.7750	0.9000	3.1500	6.1650
G91	1.0000	9.6200	34.2000	1.1000	3.9350	8.2150**
G92	0.6000	11.6300	36.6700**	0.6200	3.7250	6.6750
G93	0.7000	14.0050	51.9550**	0.9000	4.2000	7.7750*
G94	0.5000	11.4600	40.8250**	1.1000	4.6000	7.8750*
G95	0.1545	12.2750	38.9800	1.6000	5.1000*	6.7350
G96	0.4000	13.1150	29.3250	1.5000	3.6500	5.6350
G97	0.3800	13.3900	32.3000	1.6000	4.9000	6.0500
G98	0.1500	7.6650	37.2150**	1.9000	2.4750	7.4900
G99	0.5500	7.8200	26.5550	1.9000	3.8000	6.3000
G100	0.4000	11.6500	24.9500	1.9000	3.9500	10.7200**
G101	0.6500	12.4600	22.3850	1.9000	4.3500	4.6350

Mean	0.6442	11.4321	30.0619	1.6100	3.7157	6.3414
	CD(0.05)= 3.74			CD(0.05)= 1.25		
	CD(0.01)= 4.92			CD(0.01)= 1.64		
	SED= 0.63			SED= 1.9		

**Significant at 5% level*
***Significant at 1%*

Table 4. Mean performance of dry weight of leaves per plant and dry weight of shoot per plant for black gram genotypes

Genotypes	Dry weight of leaves per plant (g)			Dry weight of shoot per plant (g)		
	T_1	T_2	T_3	T_1	T_2	T_3
G1	0.0043	0.0417	0.0525	0.0247	0.0400	0.0485
G2	0.0022	0.0151	0.0436	0.0158	0.0216	0.0344
G3	0.0017	0.0301	0.0304	0.0195	0.0362	0.0383
G4	0.0010	0.0180	0.0309	0.0212	0.0305	0.0396
G5	0.0045	0.0180	0.0355	0.0135	0.0229	0.0302
G6	0.0028	0.0257	0.0425	0.0116	0.0293	0.0420
G7	0.0010	0.0275	0.0286	0.0011	0.0385	0.0400
G8	0.0010	0.0309	0.0400	0.0115	0.0405	0.0494
G9	0.0016	0.0322	0.0340	0.0223	0.0400	0.0432
G10	0.0028	0.0155	0.0165	0.0285	0.0328	0.0331
G11	0.0023	0.0200	0.0245	0.0120	0.0385	0.0412
G12	0.0050	0.0269	0.0309	0.0175	0.0295	0.0339
G13	0.0043	0.0068	0.0218	0.0164	0.0193	0.0278
G14	0.0027	0.0159	0.0300	0.0175	0.0204	0.0400
G15	0.0085	0.0310	0.0325	0.0200	0.0413	0.0506
G16	0.0015	0.0159	0.0354	0.0139	0.0293	0.0367
G17	0.0028	0.0204	0.0280	0.0208	0.0292	0.0375
G18	0.0060	0.0553*	0.0564	0.0235	0.0495*	0.0555
G19	0.0060	0.0075	0.0259	0.0170	0.0240	0.0470
G20	0.0055	0.0389	0.0400	0.0250	0.0391	0.0407
G21	0.0030	0.0316	0.0343	0.0170	0.0293	0.0315
G22	0.0020	0.0434	0.0598	0.0040	0.0162	0.0316
G23	0.0015	0.0199	0.0292	0.0079	0.0316	0.0409
G24	0.0022	0.0107	0.0490	0.0220	0.0285	0.0570*
G25	0.0048	0.0219	0.0284	0.0238	0.0298	0.0379
G26	0.0045	0.0052	0.0114	0.0148	0.0152	0.0251
G27	0.0025	0.0384	0.0390	0.0117	0.0388	0.0470
G28	0.0014	0.0294	0.0330	0.0140	0.0375	0.0384
G29	0.0025	0.0247	0.0364	0.0175	0.0300	0.0360
G30	0.0085	0.0293	0.0305	0.0170	0.0319	0.0422
G31	0.0025	0.0169	0.0320	0.0194	0.0270	0.0343
G32	0.0013	0.0293	0.0300	0.0120	0.0353	0.0365
G33	0.0025	0.0219	0.0303	0.0200	0.0295	0.0404
G34	0.0035	0.0315	0.0362	0.0098	0.0396	0.0414
G35	0.0006	0.0223	0.0249	0.0015	0.0230	0.0271
G36	0.0050	0.0281	0.0301	0.0176	0.0299	0.0312
G37	0.0023	0.0108	0.0205	0.0166	0.0328	0.0425
G38	0.0034	0.0293	0.0305	0.0185	0.0312	0.0451
G39	0.0040	0.0229	0.0345	0.0086	0.0216	0.0546
G40	0.0005	0.0076	0.0365	0.0011	0.0159	0.0295
G41	0.0010	0.0022	0.0525	0.0068	0.0088	0.0315
G42	0.0044	0.0202	0.0395	0.0065	0.0196	0.0306

G43	0.0026	0.0160	0.0216	0.0152	0.0195	0.0362
G44	0.0075	0.0233	0.0293	0.0022	0.0161	0.0205
G45	0.0029	0.0241	0.0328	0.0020	0.0136	0.0201
G46	0.0057	0.0126	0.0309	0.0059	0.0098	0.0193
G47	0.0011	0.0297	0.0302	0.0157	0.0192	0.0288
G48	0.0022	0.0187	0.0220	0.0138	0.0321	0.0350
G49	0.0013	0.0303	0.0340	0.0098	0.0131	0.0235
G50	0.0042	0.0295	0.0305	0.0075	0.0243	0.0351
G51	0.0011	0.0097	0.0139	0.0033	0.0101	0.0273
G52	0.0005	0.0293	0.0617*	0.0033	0.0206	0.0525
G53	0.0005	0.0122	0.0224	0.0033	0.0200	0.0290
G54	0.0041	0.0222	0.0410	0.0236	0.0310	0.0432
G55	0.0027	0.0107	0.0285	0.0186	0.0225	0.0246
G56	0.0071	0.0286	0.0386	0.0093	0.0225	0.0385
G57	0.0017	0.0025	0.0295	0.0060	0.0074	0.0317
G58	0.0020	0.0110	0.0275	0.0104	0.0239	0.0290
G59	0.0038	0.0078	0.0428	0.0075	0.0155	0.0388
G60	0.0042	0.0317	0.0345	0.0075	0.0132	0.0335
G61	0.0010	0.0239	0.0789*	0.0100	0.0210	0.0626*
G62	0.0064	0.0310	0.0320	0.0248	0.0290	0.0310
G63	0.0027	0.0299	0.0298	0.0028	0.0324	0.0355
G64	0.0043	0.0150	0.0501	0.0189	0.0295	0.0543
G65	0.0088	0.0166	0.0390	0.0082	0.0237	0.0305
G66	0.0055	0.0141	0.0201	0.0090	0.0111	0.0127
G67	0.0064	0.0225	0.0410	0.0216	0.0281	0.0526
G68	0.0031	0.0336	0.0454	0.0227	0.0284	0.0433
G69	0.0020	0.0243	0.0253	0.0140	0.0163	0.0253
G70	0.0039	0.0109	0.0619*	0.0219	0.0292	0.0600*
G71	0.0012	0.0212	0.0475	0.0084	0.0110	0.0414
G72	0.0028	0.0290	0.0435	0.0222	0.0229	0.0245
G73	0.0012	0.0171	0.0242	0.0017	0.0219	0.0230
G74	0.0020	0.0435	0.0452	0.0162	0.0255	0.0408
G75	0.0020	0.0230	0.0239	0.0136	0.0245	0.0385
G76	0.0014	0.0280	0.0386	0.0108	0.0289	0.0349
G77	0.0038	0.0292	0.0463	0.0099	0.0230	0.0528
G78	0.0020	0.0329	0.0342	0.0058	0.0327	0.0344
G79	0.0022	0.0245	0.0315	0.0106	0.0289	0.0299
G80	0.0015	0.0070	0.0070	0.0040	0.0050	0.0050
G81	0.0026	0.0245	0.0280	0.0225	0.0254	0.0327
G82	0.0025	0.0099	0.0388	0.0184	0.0237	0.0350
G83	0.0055	0.0175	0.0285	0.0116	0.0254	0.0262
G84	0.0032	0.0224	0.0333	0.0187	0.0295	0.0304
G85	0.0027	0.0279	0.0647*	0.0162	0.0186	0.0516
G86	0.0028	0.0113	0.0565	0.0227	0.0252	0.0439
G87	0.0050	0.0321	0.0350	0.0074	0.0245	0.0252
G88	0.0014	0.0214	0.0522	0.0028	0.0125	0.0407
G89	0.0059	0.0290	0.0424	0.0143	0.0317	0.0360
G90	0.0040	0.0232	0.0390	0.0053	0.0139	0.0159
G91	0.0025	0.0246	0.0400	0.0105	0.0169	0.0232
G92	0.0029	0.0332	0.0386	0.0225	0.0264	0.0321
G93	0.0021	0.0322	0.0439	0.0034	0.0241	0.0505
G94	0.0020	0.0198	0.0450	0.0155	0.0199	0.0362
G95	0.0022	0.0316	0.0361	0.0101	0.0235	0.0435
G96	0.0005	0.0380	0.0407	0.0009	0.0369	0.0450

G97	0.0015	0.0329	0.0392	0.0053	0.0304	0.0345
G98	0.0044	0.0113	0.0380	0.0076	0.0180	0.0352
G99	0.0033	0.0135	0.0151	0.0180	0.0293	0.0312
G100	0.0010	0.0283	0.0302	0.0070	0.0293	0.0303
G101	0.0024	0.0225	0.0284	0.0140	0.0244	0.0255
Mean	0.0031	0.0230	0.0354	0.0130	0.0255	0.0363
	CD(0.05)= 0.0266			CD(0.05)= 0.0202		
	CD(0.01)= 0.0347			CD(0.01)= 0.0265		
	SED= 0.0129			SED= 0.0098		

**Significant at 5% level*
***Significant at 1% level*

Table 5. Mean performance of dry weight of roots per plant and dry weight of whole plant for black gram genotypes

Genotypes	Dry weight of roots per plant (g)			Dry weight of whole plant (g)		
	T_1	T_2	T_3	T_1	T_2	T_3
G1	0.0106	0.0386**	0.0399**	0.0395	0.1203**	0.1409*
G2	0.0021	0.0319**	0.0320	0.0200	0.0686	0.1100
G3	0.0091	0.0297*	0.0327	0.0303	0.0959	0.1014
G4	0.0139	0.0249	0.0251	0.0360	0.0733	0.0956
G5	0.0085	0.0141	0.0224	0.0265	0.0550	0.0881
G6	0.0007	0.0336**	0.0365*	0.0151	0.0886	0.1210
G7	0.0005	0.0125	0.0130	0.0026	0.0785	0.0816
G8	0.0050	0.0205	0.0259	0.0175	0.0919	0.1153
G9	0.0174*	0.0223	0.0232	0.0412	0.0944	0.1003
G10	0.0043	0.0157	0.0164	0.0356	0.0640	0.0660
G11	0.0022	0.0248	0.0305	0.0165	0.0833	0.0962
G12	0.0052	0.0216	0.0230	0.0277	0.0780	0.0877
G13	0.0149	0.0175	0.0375*	0.0355	0.0435	0.0870
G14	0.0060	0.0105	0.0306	0.0262	0.0468	0.1006
G15	0.0050	0.0109	0.0146	0.0335	0.0831	0.0976
G16	0.0127	0.0159	0.0196	0.0280	0.0610	0.0916
G17	0.0025	0.0117	0.0145	0.0260	0.0612	0.0800
G18	0.0050	0.0177	0.0317	0.0345	0.1225**	0.1435**
G19	0.0106	0.0129	0.0321	0.0335	0.0444	0.1050
G20	0.0060	0.0141	0.0161	0.0365	0.0920	0.0968
G21	0.0075	0.0127	0.0139	0.0275	0.0735	0.0797
G22	0.0296**	0.0391**	0.0451**	0.0356	0.0987	0.1364*
G23	0.0029	0.0148	0.0226	0.0123	0.0663	0.0926
G24	0.0050	0.0137	0.0156	0.0292	0.0528	0.1216
G25	0.0030	0.0083	0.0487**	0.0316	0.0599	0.1149
			Con...			
G26	0.0082	0.0087	0.0229	0.0275	0.0291	0.0593
G27	0.0144	0.0205	0.0255	0.0285	0.0977	0.1114
G28	0.0011	0.0266	0.0272	0.0165	0.0935	0.0986
G29	0.0080	0.0175	0.0368	0.0280	0.0722	0.1092
G30	0.0055	0.0105	0.0129	0.0310	0.0716	0.0856
G31	0.0102	0.0132	0.0459**	0.0320	0.0570	0.1122
G32	0.0022	0.0299*	0.0310	0.0155	0.0945	0.0975
G33	0.0061	0.0106	0.0124	0.0285	0.0620	0.0830
G34	0.0153	0.0204	0.0259	0.0285	0.0915	0.1035
G35	0.0005	0.0332**	0.0424**	0.0025	0.0785	0.0943
G36	0.0044	0.0220	0.0246	0.0270	0.0800	0.0859
G37	0.0059	0.0148	0.0293	0.0248	0.0584	0.0923

G38	0.0046	0.0326**	0.0359*	0.0265	0.0931	0.1115
G39	0.0030	0.0266	0.0465**	0.0155	0.0711	0.1356*
G40	0.0002	0.0041	0.0145	0.0017	0.0275	0.0805
G41	0.0056	0.0061	0.0238	0.0133	0.0171	0.1078
G42	0.0041	0.0337**	0.0421**	0.0150	0.0735	0.1122
G43	0.0077	0.0100	0.0142	0.0255	0.0455	0.0720
G44	0.0149	0.0185	0.0236	0.0246	0.0578	0.0734
G45	0.0240**	0.0339**	0.0341	0.0289	0.0715	0.0869
G46	0.0108	0.0161	0.0237	0.0224	0.0385	0.0738
G47	0.0085	0.0195	0.0223	0.0253	0.0683	0.0812
G48	0.0086	0.0307*	0.0327	0.0245	0.0815	0.0897
G49	0.0146	0.0476**	0.0551**	0.0256	0.0909	0.1126
G50	0.0011	0.0125	0.0139	0.0127	0.0663	0.0795
G51	0.0243**	0.0276	0.0300	0.0287	0.0474	0.0711
G52	0.0013	0.0091	0.0295	0.0050	0.0589	0.1436**
G53	0.0321**	0.0364**	0.0448**	0.0359	0.0686	0.0962
G54	0.0081	0.0135	0.0341	0.0358	0.0667	0.1183
G55	0.0150	0.0173	0.0200	0.0363	0.0505	0.0731
G56	0.0031	0.0054	0.0242	0.0194	0.0565	0.1013
G57	0.0126	0.0142	0.0259	0.0203	0.0240	0.0871
G58	0.0009	0.0241	0.0299	0.0133	0.0590	0.0864
G59	0.0048	0.0068	0.0142	0.0160	0.0300	0.0957
G60	0.0098	0.0209	0.0247	0.0215	0.0657	0.0927
G61	0.0015	0.0144	0.0202	0.0125	0.0593	0.1617**
G62	0.0089	0.0204	0.0223	0.0401	0.0823	0.0834
G63	0.0199*	0.0244	0.0264	0.0254	0.0867	0.0917
G64	0.0012	0.0046	0.0358*	0.0243	0.0490	0.1402*
G65	0.0024	0.0103	0.0130	0.0193	0.0505	0.0825
G66	0.0258**	0.0301*	0.0305	0.0403	0.0553	0.0633
G67	0.0071	0.0195	0.0291	0.0350	0.0700	0.1226
G68	0.0030	0.0092	0.0231	0.0287	0.0712	0.1117
G69	0.0006	0.0149	0.0308	0.0166	0.0555	0.0814
G70	0.0155	0.0201	0.0215	0.0412	0.0601	0.1433*
G71	0.0080	0.0203	0.0296	0.0176	0.0525	0.1185
G72	0.0072	0.0147	0.0341	0.0321	0.0666	0.1021
G73	0.0228**	0.0306*	0.0331	0.0256	0.0696	0.0803
G74	0.0080	0.0146	0.0171	0.0262	0.0835	0.1031
G75	0.0010	0.0192	0.0203	0.0165	0.0667	0.0827
G76	0.0006	0.0201	0.0290	0.0128	0.0770	0.1025
G77	0.0023	0.0128	0.0194	0.0159	0.0650	0.1184
G78	0.0037	0.0182	0.0199	0.0115	0.0838	0.0885
G79	0.0122	0.0216	0.0266	0.0250	0.0750	0.0880
G80	0.0302**	0.0385**	0.0386*	0.0357	0.0505	0.0506
G81	0.0054	0.0069	0.0086	0.0305	0.0568	0.0692
G82	0.0125	0.0166	0.0199	0.0334	0.0501	0.0937

Con…

G83	0.0140	0.0179	0.0250	0.0310	0.0607	0.0797
G84	0.0073	0.0212	0.0249	0.0291	0.0730	0.0885
G85	0.0073	0.0160	0.0256	0.0262	0.0625	0.1418*
G86	0.0061	0.0140	0.0221	0.0315	0.0505	0.1225
G87	0.0107	0.0216	0.0311	0.0230	0.0782	0.0913
G88	0.0039	0.0149	0.0297	0.0080	0.0488	0.1225
G89	0.0029	0.0180	0.0198	0.0230	0.0787	0.0982
G90	0.0125	0.0446**	0.0485**	0.0218	0.0816	0.1034
G91	0.0155	0.0289	0.0302	0.0285	0.0704	0.0934

G92	0.0088	0.0114	0.0130	0.0342	0.0709	0.0836
G93	0.0050	0.0338**	0.0399	0.0105	0.0901	0.1343
G94	0.0059	0.0109	0.0294	0.0234	0.0505	0.1105
G95	0.0014	0.0180	0.0231	0.0136	0.0731	0.1027
G96	0.0002	0.0165	0.0207	0.0016	0.0914	0.1064
G97	0.0112	0.0207	0.0212	0.0180	0.0840	0.0949
G98	0.0051	0.0111	0.0258	0.0170	0.0404	0.0990
G99	0.0066	0.0195	0.0207	0.0279	0.0623	0.0670
G100	0.0091	0.0243	0.0272	0.0171	0.0819	0.0877
G101	0.0023	0.0151	0.0168	0.0187	0.0620	0.0707
Mean	0.0082	0.0195	0.0267	0.0243	0.0679	0.0984
	CD(0.05)= 0.0089			CD(0.05)= 0.0343		
	CD(0.01)= 0.0117			CD(0.01)= 0.0452		
	SED= 0.0045			SED= 0.0174		

**Significant at 5% level*
***Significant at 1% level*

Dry weight of roots per plant The range for this trait was from 0.0002 g to 0.0321 g (G53) in T_1, 0.0041 g to 0.0476 g (G49) in T_2 and 0.0086 g to 0.0551 g (G49) in T_3. Genotype, G49 was recorded the maximum dry weight of roots per plant of 0.0476 g in T_2. It was found that out of 101 genotypes studied, 9, 18 and 14 genotypes had significantly higher values than the general mean in T_1, T_2 and T_3 respectively. Dry weight of the root also decreased to 96.74% (G1) of the control (Table 5). Velmani *et al*. [26] reported that the effect of NaCl on root dry weight decreased in black gram with increase in the concentration, compared to control. El-Kafafi *et al*. [27] and Vennila *et al* [28] observed that salinity significantly reduced the root dry weight and root was more affected than shoot.

Dry weight of whole plant The fall of weight of the whole plant were observed. The range for this trait was from 0.0017 g to 0.0412 g (G70) in T_1, 0.0240 g to 0.1224 g (G18) in T_2 and 0.0506 g 0.1616 g (G61) in T_3. The genotype G18 was recorded the maximum dry weight of whole plant of 0.1224 g in T_2. Dry weight of the whole plant decreased to 97.22% over the control (Table 5). It is well documented that under saline condition, the ability of plant species to uptake water is reduced and this leads to rapid decrease in plant growth and productivity [29,30].

4. CONCLUSION

Salt stress imperceptibly reduced the growth characters of black gram genotypes. The genotypes G87 and G49 recorded maximum mean values for total number of leaves per plant and dry weight of roots per plant respectively. Genotype, G18 recorded maximum mean values for characters like leaf area per plant, dry weight of leaves per plant, dry weight of shoot per plant and dry weight of whole plant. Genotypes namely, G1, G18, G74, G81, G96 obtained from diversified regions which shows maximum mean value under salt stress for almost all the growth characters studied (Fig. 4), it was deduced that these genotypes may be utilized as potential donor as well as taken as key candidate in crop improvement programme specifically in coastal saline regions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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