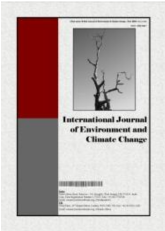

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Evaluation of Blackgram [(*Vigna mungo* (L)] Genotypes for Saline Tolerance at Seedling Stage Using Sea Water

Mukul Kumar Gandhi[1], Abhay Kumar[1*], G. V. Marviya[2] and Prasenjit Paul[3]

[1]Department of Agricultural Biotechnology and Molecular Biology, RPCAU,Pusa Bihar-848125, India.
[2]Departement of Biotechnology, College of Agriculture, J. A. U., Junagadh Gujrat- 362001, India.
[3]Department of Plant Breeding and Genetics, RPCAU, Pusa Bihar-848125, India.

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

Blackgram is one of the most highly prized pulse crops, cultivated in almost all parts of India.Soil salinity is one ofthe major factors responsible for losses in agriculturalproduction in most of the arid and semi-arid regions in theworld leading to loss in yield. The experiment was maintained for 10 days and all the observations from the seedlings namely germination percentage, shoot length, root length, dry matter production, vigour index I and vigour index II were recorded from each replicate and mean was worked out.On the basis of physiological parameters, the blackgram genotypes were discriminated into tolerant, moderate and sensitive to salinity.Germination per cent decreased by 85.5%, root length reduced by 75.68%, shoot length reduced by 61.73% while seedling length decreased by 22.30% in T_4 treatment as compared to the T_1 (control) treatment among all the blackgram genotypes. Seedling dry weight reduced by 40.04 folds in T_4 treatment as compared to the T_1 (control) treatment. Looking to the vigour index, seedling vigour index-I (length basis) and seedling vigour index-II (Dry weight basis) decreased by 0.03 and 1.18 folds, respectively. Out of 20 genotypes, four genotypes *viz.,* IC-204869, TPU-94-2, IC-21485, and IC-214844 were found to be tolerant to salinity. thirteengenotypes were found to be moderately

**Corresponding author: E-mail: mail4abhaykumar@gmail.com;*

tolerant and three genotype *viz.,*SKNU-03-03, SKNU-0703, and SKNU-06-03 are sensitive to salinity.

Keywords: Blackgram; salinity; saline tolerance; sea water.

1. INTRODUCTION

Blackgram belongs to the family *Fabaceae* and the genus *Vigna.* Only seven species of the genus *Vigna* are cultivated as pulse crops, five Asian species of subgenus *Ceratotropis*, *Vigna mungo* (blackgram), *V. radiata* (mungbean*), V. aconitifolia* (mothbean), *V. angularis* (azuki bean) and *V. umbellata* (rice bean) and two African species of subgenus *Vigna, Vigna unguiculata* (cowpea) and *V. subterranean* (ambara groundnut), [1]. Blackgram is a member of the Asian *Vigna* crop group. It is a staple crop in the central and South East Asia; however it is extensively used only in India and now grown in the Southern United States, West Indies, Japan and other tropics and subtropics [2]. Blackgram is native to India [3]. The progenitor of blackgram is believed to be *Vigna mungo* var*. silvestris,* which grows wild in India.Blackgram is one of the most highly prized pulse crop, cultivated in almost all parts of India. It has inevitably marked itself as the most popular pulse and can be most appropriately referred to as the “king of the pulses” due to its mouthwatering taste and numerous other nutritional qualities.

Salinity stress is a serious problem in arid and semi-arid tropics and in the Indo-Gangetic plains in irrigated areas. It is recognized as major constraint in the production of this crop where 50 mM NaCl can cause yield losses ≥70% [4]. The arable land is continuously transforming into saline (1-3% per year) either due to natural salinity or due to human interference which accounts nearly 20% of the irrigated agricultural land. The increased salinity of agronomically important land is expected to have overwhelming global effects by the middle of the twenty-first century [5]. Availability of adequate soil moisture for crop growth depends on rainfall, water holding capacity and depth of soil in rain-fed areas. Salinity is the concentration of dissolved mineral salts (electrolytes of cations and anions) present in the soil and water. Due to global climate change, mungbean also encounters the cumulative adverse effects of other environmental factors as insects, pests, high temperature and pod shattering along with salinity causing high yield loss.

Soil salinity is one ofthe major factors responsible for losses in agriculturalproduction in most of the arid and semi-arid regions in theworld leading to loss in yield [6]. Salt toleranceis a complex mechanism where numerous adaptations suchas osmoregulation and osmotic adjustment, hormonalregulation, activation of the antioxidant defense system andion homeostasis are involved. In grain legumes, tolerance tosalt stress involves ion excretion (or) compartmentalizationto other plant parts [7]. Even though thereare number of reports on saline tolerance in pulses, onlylimited works are reported at seedling stage saline tolerancein black gram. The present study has been carried out with 20 genotypes for screening under different salinity levels using sea water as salt stress agent toevaluate the early seedling stage tolerance in blackgram.

2. MATERIALS AND METHODS

The laboratory work was carried out at the Department of Biotechnology, Junagadh Agricultural University, Junagadh.The seeds of different blackgram [*Vigna mungo (*L.) Hepper] genotypes viz., IC-14520, IC-214845, IC-242677, IC-204869, IC-61100, IC-214844, SKNU-07-01, SKNU-03-03, SKNU-07-06, SKNU-06-03, SKNU-07-03, SKNU-03-04, SKNU-9911, SKNU 2K-3, SKNU-9915, COBG-593, TU-94-2, TPU-4, GJU-1506, and JAWAHAR URD-3 (Table 1) were obtained from Pulse Research Station, Junagadh Agricultural University, Jamnagar were used forevaluation and the experiment was conducted in completelyrandomized design with three replications and with two factors; The first factor was taken as genotypes (twenty) and second as salinity levels (four). Salt solutions were prepared by using sea water with different concentrations. The EC of sea water was measured and by adding distilled water EC was maintained to 0 (DW), 4, 6, and 8 dsm^{-1} which used as Salt stress treatments and seedlings were evaluated after10 days for seedling parameters *viz*., germination percentage, total root length, total shoot length, seedling length,seedling dry weight, seedling vigour index I (on the basis of plant length) and II (on the basis of dry weight of seedling). Four different salinity levels used were presented in Table 2.

The surface sterilization of seeds was performed with 0.1% $HgCl_2$ solution and washed with distilled water.Ten seeds of each genotype were placed at uniform spacing on filter paper lined petri dishes and irrigated with water or salt solution in three replicates as per treatment decided. These petri dishes were kept at room temperature in the laboratory condition for germination. The moisture of the plates was maintained by periodically addition of distilled water and salt solution.The experiment was maintained for 10 days and all the observations from the seedlings namelygermination percentage, shoot length, root length, dry matterproduction, vigour index I and vigour index II were recordedfrom each replicate and mean was worked out. Five normalseedlings were taken randomly at the end of thegerminationtest and the length from the collar region to tip of the primaryroot was measured and the mean value was expressed incentimeter for root length. The length between the collarregion to tip of the primary shoot was measured and themean value was expressed in centimeter for shoot length. The germination percentage was calculated by following formula as prescribed by Ali and Idris [8].

$$Germination\ percentage = \frac{Number\ of\ germinated\ seeds}{Total\ no.of\ seeds\ taken\ up\ for\ sowing} x\ 100$$

Four normal seedlings used for growth measurements were placed in a butter paper cover and dried under shade for 24 hrs. Then kept in a hot air oven maintained at 64^0C for 24 hrs. The dried seedlings were cooled in a desiccator for 30 minutes and then dry weight was recorded for 5 seedlings and expressed in grams. Vigour index values were computed using the formula suggested by Ali and Idris [8].

Vigour index I = Germination percentage x total seedling length in cm.

Vigour index II = Germination percentage x Seedling dry weight in g.

3. RESULT AND DISSCUSION

Lack of suitable varieties and genotypes which adapt to saline conditions is one of the reasons affecting the production. Among all the stages, germination and seedling stages are very crucial under stress conditions, particularly in salinity and the seedlings which survive under seedling stage can thrive well in natural conditions. Hence the seedling parameters *viz.,* germination percentage, shoot length, root length, dry matter production, vigour index I and vigour index II were studied to identify saline tolerant genotypes. All the 20blackgram genotypes were screened *in vitro* with four different EC containing sea water*viz.,* EC0, EC4, EC6, and EC8. The use of sea water for experimental study has been proved to be very effective method for studying the effect of salinity on seed germination and seedling growth characters.

3.1 Germination Percentage

Increase salinity level observed drastic reduction in germination per cent and it was reduced by approximately 40% in T_4 treatment as compared to control (T_1). Among the genotypes, mean germination per cent was significantly highest in genotype IC-14520 (91%), followed by genotypes IC-204869 (89%) while, it was significantly lowest with the genotype SKNU-03-03 (46%).Among the salinity treatments, the mean germination percentage was recorded maximum with T_1- ECe 0 dSm^{-1} (90%), while, significantly the minimum value was observed in the treatment T_4 - ECe 8 dSm^{-1} (60 %).The combined effect of genotypes and salinity treatments were found to be significant for germination percentage. In all the genotypes, germination percentage was decreased with increasing salinity concentration. At higher salinity (T_4 - ECe 8 dSm^{-1}treatment) germination percentage was found highest in IC-14520, IC-204869, SKNU-9915 (80%), while, the lowest recorded in SKNU-03-03 (38%) (Table 3) (Fig. 1A). The considerable higher germination per cent in control as compare to saline water treatments and increasing levels of salinity resulted in decrease of germination [9].

3.2 Root Length

About 75.68% reduction in mean root length of blackgram genotypes was recorded in T_4 treatment as compared to T_1 treatment.The mean value for genotypes showed significantly highest root length in the genotype JAWAHAR URD-3 (8.89 cm) followed by the genotypes GJU-1506 (8.39 cm) while, significantly lowest root length was observed 2.32 cm in SKNU-03-03.Among the salinity treatments, the mean root length was maximum with treatment T_1- control (5.93 cm) and it was significantly lowest in treatment T_4 (3.64 cm).The combined effect of genotypes and treatments were found to be significant for root length. In all genotypes root length was decreased with increasing saline water concentration. At higher salinity (T_4- ECe 8 dSm^{-1} treatment) root length was observed maximum in TU-94-2 (7.74cm) followed by GJU-1506 (7.49 cm) genotype while, minimum was recorded in IC-204869(1.77cm) (Table 4). The root length differed significantly for various treatments. Control treatments like (T_1) had significantly higher root length followed by T_2 (ECe 4 dsm^{-1}), T_3 (ECe 6 dsm^{-1}) and T_4 (ECe 8 dSm^{-1}) (Fig. 1B).

3.3 Total Shoot Length

The mean value for shoot length of genotypes showed significantly in genotype JAWAHAR URD-3 (13.39 cm) followed by the genotypes GJU-1506 (12.12 cm) while significantly lowest value was observed in SKNU-06-03 (4.40 cm).The reduction in shoot length in T_4 treatment was about 24.67 % as compared to T_1 (control) treatment.Among the salinity treatments, the mean shoot length was recorded highest with control T_1 which had 8.50 cm shoot length and the lowest value was observed in treatment T_4 – ECe 8 dSm^{-1} (5.29cm) (Table 5). The combined effect of genotypes and treatments were found to be significant for shoot length. In all the genotypes shoot length was decreased with increased saline water concentration. At higher salinity (T_4 – ECe 8 dSm^{-1}treatment) shoot length was found highest in JAWAHAR URD-3 (12.38 cm) followed by the genotypes GJU-1506 (11.46 cm)while, significantly the lowest was in SKNU-06-03 (2.46 cm) (Table 5) (Fig. 1C). The result of present study is quite relevant with results achieved by [10] in different pearl millets varieties under salinity treatments.

3.4 Seedling Length

The mean value for genotypes showed significantly highest seedling length in genotype JAWAHAR URD-3 (23.50 cm) followed by the genotypes GJU-1506 (20.50 cm) and while significantly lowest in SKNU-03-03 (6.90 cm). Seedling length was found to be decreased by 22.30% in T_4 treatment as compared to T_1 (control) treatment.Among the salinity treatments, the mean seedling length was recorded maximum with control treatment T_1 (14.10cm) it was the significantly lowest in treatment T_4 – ECe 8 dSm^{-1} (9.35cm) (Table 6). The combined effect of genotypes and treatments were found to be significant for seedling length. In all the genotype'sseedling length was declined with increasing saline water concentration. At higher salinity (T_4 – ECe 8 dSm^{-1}) treatment seedling length was found the highest in **JAWAHAR URD-3** (22.2cm) followed by the genotypes GJU- (19.5 cm) while, significantly the lowest 5.4 cm in genotype SKNU-07-01 (Table 6) (Fig. 1D). The result of present study observed same trend of change in seedling length was found by Prakash (2017)in different green gram varieties.

3.5 Seedling Dry Weight

The mean value for seedling dry weight of genotypes observed significantly highest in genotype SKNU-03-03(16.84 mg) followed by the genotypes SKNU-07-06 (13.46 mg) and GJU-1509(13.44 mg) while, significantly the lowest value was in SKNU-06-03(8.37 mg) (Table 7). The seedling dry weight was declined by 1.40 folds in T_4 (ECe 8 dSm^{-1}) treatment as compared to control (T_1) treatment. Among the salinity treatments, the mean seedling dry weight was recorded maximum 13.24 mg in control and it was minimum 9.50 mg in treatment T_4 (ECe 8 dSm^{-1}).The combined effect of genotypes and saline water treatments were found to be significant for seedling dry weight (Table 7) (Fig. 1E). In all the genotype's, seedling length was decreased with increasing saline water concentration. At higher salinity (T_4- ECe 8 dSm^{-1} treatment), seedling dry weight was found highest 14.34 mg in SKNU-03-03 genotype while, significantly lowest 6.04 mg in TPU-94-2 (Table 7) (Fig. 1E). The result of present study revealed that considerable seedling seedling dry weight in control as compare to saline water treatments and increasing levels resulted in decrease seedling seedling dry weight. The same trend of results was also observed in blackgram varieties Dry matter production was also reduced at high salinity levels in another genotype by Kumar et al. [11].

3.6 Vigour Index-I (Length basis)

With respect to salinity levels, genotypes differed significantly for seedling vigor- I. The mean value of seedling vigor index- I was found highest in genotypes, (1833.69 mg) in genotypes JAWAHAR URD-3and while, the lowest was (320.54 mg) in SKNU-03-03 (Table 8). The overall reduction was by 2.21-fold in T_4 (ECe 8 dSm^{-1}) treatment as compared to T_1 (control) treatment. The seedling vigor index- I was found significantly different among the salt treatments. The maximum 1275.51mg with control (T_1) treatment and minimum value 567.90mg was observed in treatment T_4 (ECe 8 dSm^{-1}) (Table 8). The interaction effect of genotypes and treatments were found to be significant for dry weight. In all the genotypes, dry weight was decreased with increased saline water concentration. At maximum salinity level (ECe 8 dSm^{-1}) dry weight was found highest in JAWAHAR URD-3 (1332.00 mg) followed by the genotypesSKNU-9915 (1100.00 mg) while, the lowest value was (216.60) mg in SKNU-03-03 (Table 8) (Fig. 1F). Our results are in good agreement with the result obtained by [12] in blackgram under salinity stress environment.

Table 1. List of genotypes utilized in the present study

Sr. No.	Genotypes	Sr. No.	Genotypes
1	IC-14520	11	SKNU07-03
2	IC-21485	12	SKNU-03-4
3	IC-242677	13	SKNU-9911
4	IC-204869	14	SKNU-2K-3
5	IC-61100	15	SKNU-9915
6	IC-214844	16	COBG-593
7	SKNU-07-01	17	TU-94-2
8	SKNU-03-03	18	TPU-4
9	SKNU-07-06	19	GJU-1506
10	SKNU06-03	20	JAWAHAR URD-3

Table 2. EC levels of the sea water utilized as saline treatment under present study

Treatment	EC (dS m^{-1})	Details of treatment
T_1	0	Distilled water (Control)
T_2	4	Sea Water
T_3	6	Sea Water
T_4	8	Sea water

EC- Electro Conductivity, dS m^{-1} – deci Siemens per meter

Table 3. Effect of saline water stress on germination of blackgram genotypes

Sr. No.	Genotype	Salinity Treatment				Mean
		T_1	T_2	T_3	T_4	
1	**IC-14520**	100	93	90	80	91
2	**IC-214845**	90	83	80	63	79
3	**IC-242677**	90	73	70	60	73
4	**IC-204869**	100	93	83	80	89
5	**IC-61100**	100	93	90	40	80
6	**IC-214844**	90	87	85	70	83
7	**SKNU-07-01**	100	80	60	50	72
8	**SKNU-03-03**	53	50	40	38	46
9	**SKNU-07-06**	83	80	70	50	70
10	**SKNU06-03**	90	73	70	60	73
11	**SKNU07-03**	93	80	73	50	74
12	**SKNU-03-4**	83	72	70	60	71
13	**SKNU-9911**	90	80	70	60	75
14	**SKNU-2K-3**	80	73	72	60	71
15	**SKNU-9915**	100	93	83	80	89
16	**COBG-593**	93	80	73	70	79
17	**TU-94-2**	76	70	60	50	64
18	**TPU-4**	100	93	90	70	88
19	**GJU-1506**	90	70	60	47	66
20	**JAWAHAR URD-3**	100	80	70	60	77
	Overall mean	90	80	73	60	

Table 5. Effect of saline water stress on shoot length (cm) of blackgram genotypes

Sr. No.	Genotype	Salinity Treatment				
		T_1	T_2	T_3	T_4	Mean
1	**IC-14520**	6.78	6.41	4.66	4.56	5.60
2	**IC-214845**	5.86	5.61	5.53	4.41	5.35
3	**IC-242677**	8.38	5.48	4.86	4.61	5.83
4	**IC-204869**	6.34	6.28	5.48	5.01	5.78
5	**IC-61100**	8.78	6.31	5.66	5.53	6.57
6	**IC-214844**	7.03	6.91	5.51	4.81	6.07
7	**SKNU-07-01**	10.48	3.86	3.78	3.78	5.48
8	**SKNU-03-03**	6.68	4.16	4.11	3.41	4.59
9	**SKNU-07-06**	6.63	5.36	4.93	3.68	5.15
10	**SKNU-06-03**	5.26	5.06	4.81	2.46	4.40
11	**SKNU07-03**	6.51	6.03	5.58	3.26	5.34
12	**SKNU-03-4**	11.08	7.86	4.88	3.93	6.94
13	**SKNU-9911**	9.11	7.28	7.18	6.81	7.60
14	**SKNU-2K-3**	6.66	5.28	4.66	3.33	4.98
15	**SKNU-9915**	9.03	8.13	7.01	6.06	7.56
16	**COBG-593**	9.23	7.36	5.16	2.26	6.00
17	**TU-94-2**	10.46	10.33	9.28	7.78	9.46
18	**TPU-4**	8.71	7.31	7.23	6.43	7.42
19	**GJU-1506**	12.53	12.38	12.11	11.46	12.12
20	**JAWAHAR URD-3**	14.46	13.41	13.31	12.38	13.39
	Overall Mean	8.50	7.04	6.28	5.29	

Table 6. Effect of saline water stress on seedling length (cm) of blackgram genotypes

Sr. No.	Genotype	Salinity Treatment				
		T_1	T_2	T_3	T_4	Mean
1	**IC-14520**	10.6	10.0	8.3	7.2	9.0
2	**IC-214845**	9.2	8.7	8.6	7.2	8.4
3	**IC-242677**	13.9	9.8	7.8	7.7	9.8
4	**IC-204869**	10.1	9.3	8.2	6.8	8.6
5	**IC-61100**	15.2	8.7	8.4	8.1	10.1
6	**IC-214844**	10.1	9.6	8.2	7.3	8.8
7	**SKNU-07-01**	15.2	6.3	5.9	5.4	8.2
8	**SKNU-03-03**	9.3	6.7	6.0	5.7	6.9
9	**SKNU-07-06**	10.4	9.4	8.4	6.4	8.7
10	**SKNU06-03**	10.6	9.1	8.9	6.4	8.8
11	**SKNU07-03**	11.5	10.5	10.0	6.5	9.6
12	**SKNU-03-4**	19.6	13.9	8.7	7.7	12.5
13	**SKNU-9911**	15.0	13.6	12.3	12.1	13.3
14	**SKNU-2K-3**	12.2	11.3	9.3	9.1	10.5
15	**SKNU-9915**	17.0	14.4	12.9	11.0	13.8
16	**COBG-593**	14.0	13.1	9.7	6.6	10.9
17	**TU-94-2**	17.9	15.5	15.4	12.9	15.4
18	**TPU-4**	14.2	12.5	12.3	11.2	12.5
19	**GJU-1506**	21.5	21.2	19.9	19.5	20.5
20	**JAWAHAR URD-3**	24.5	23.0	24.5	22.2	23.5
	Overall Mean	14.10	11.83	10.68	9.35	

3.7 Vigour Index- II (Dry Weight basis)

With respect to salinity treatments, genotypes were found significant difference for seedling vigor-II. The mean value of seedling vigor index-II was found the highest in genotypes, SKNU-9915 (1081.75) followed by COBG-593(1050.95and the lowest was in genotype TU-

94-2 (670.30) as presented in (Table 9) (Fig. 1G). The seedling vigor differed significantly among the treatments. The highest vigor index-II was recorded with control (T_1) treatment (1169.28) and the lowest value 567.52 was recorded with T_4 – ECe 8 dSm^{-1} (Table 9). The combined effect of genotypes and treatments were found to be significant for vigor index-II. In all the genotypes, vigor index-II declined with increasing salt concentration. At higher salinity (T_4 – ECe 8 dSm^{-1}treatment) vigor index-II was found maximum in SKNU-9915 (854.00) genotype followed by COBG-593 (750.40) and GJU-1509 (738.50) while, it was minimum in genotype TU-94-2 (302.00) (Table 9).

Table 7. Effect of saline water stress on seedling dry weight (mg) of blackgram genotypes

Sr. No.	Genotype	Salinity Treatment				
		T_1	T_2	T_3	T_4	Mean
1	**IC-14520**	12.34	9.45	8.56	8.12	9.62
2	**IC-214845**	11.23	9.90	9.23	8.23	9.65
3	**IC-242677**	12.34	11.67	11.63	6.33	10.49
4	**IC-204869**	9.34	8.34	8.12	7.67	8.37
5	**IC-61100**	12.45	9.45	9.06	8.99	9.99
6	**IC-214844**	9.12	9.07	8.70	7.34	8.56
7	**SKNU-07-01**	11.09	11.01	10.78	10.67	10.89
8	**SKNU-03-03**	20.13	18.45	14.45	14.34	16.84
9	**SKNU-07-06**	14.54	14.56	13.90	10.85	13.46
10	**SKNU06-03**	16.13	13.12	12.43	12.06	13.44
11	**SKNU07-03**	12.78	12.45	11.10	10.65	11.75
12	**SKNU-03-4**	14.13	13.13	12.11	11.23	12.65
13	**SKNU-9911**	13.12	13.07	12.35	12.00	12.64
14	**SKNU-2K-3**	13.45	12.87	10.34	9.34	11.50
15	**SKNU-9915**	14.33	13.78	12.34	8.54	12.25
16	**COBG-593**	14.37	13.67	13.89	10.72	13.16
17	**TU-94-2**	15.87	9.45	8.35	6.04	9.93
18	**TPU-4**	13.23	12.45	10.47	8.31	11.12
19	**GJU-1506**	12.85	11.72	9.37	9.07	10.75
20	**JAWAHAR URD-3**	11.98	11.68	11.22	9.50	11.10
	Overall Mean	13.24	11.96	10.92	9.50	

Table 8. Effect of saline water stress on vigour Index-I (Length basis) of blackgram genotypes

Sr. No.	Genotype	Salinity Treatment				
		T_1	T_2	T_3	T_4	Mean
1	**IC-14520**	1060.00	933.33	750.75	579.33	830.85
2	**IC-214845**	828.00	722.10	688.00	453.60	672.93
3	**IC-242677**	1251.00	715.40	544.25	462.00	743.16
4	**IC-204869**	1010.00	864.90	680.60	542.00	774.38
5	**IC-61100**	1522.50	809.10	756.00	322.00	852.40
6	**IC-214844**	911.25	833.02	697.00	511.00	738.07
7	**SKNU-07-01**	1520.00	504.00	355.50	270.00	662.38
8	**SKNU-03-03**	491.57	335.00	239.00	216.60	320.54
9	**SKNU-07-06**	868.75	752.00	588.00	320.00	632.19
10	**SKNU-06-03**	954.75	664.30	623.00	385.50	656.89
11	**SKNU07-03**	1069.50	840.00	731.82	322.50	740.96
12	**SKNU-03-4**	1626.80	1000.80	609.00	462.00	924.65
13	**SKNU-9911**	1350.00	1088.00	861.00	726.00	1006.25
14	**SKNU-2K-3**	976.00	828.66	669.60	546.00	755.07
15	**SKNU-9915**	1584.33	1195.83	1032.00	1100.00	1228.04
16	**COBG-593**	1306.66	1048.00	711.33	462.00	882.00
17	**TU-94-2**	1374.25	1085.00	922.50	645.00	1006.69
18	**TPU-4**	1420.00	1162.50	1102.50	784.00	1117.25

19	**GJU-1506**	1935.00	1484.00	1194.00	916.50	1382.38
20	**JAWAHAR URD-3**	2450.00	1836.00	1716.75	1332.00	1833.69
	Overall Mean	1275.51	935.09	773.63	567.90	

Fig. 1. Response of blackgram genotypes at different salinity levels

[A] Germination percentage [B] Shoot length [C] Root length and[D] Total seedling length [E] Dry matter production [F] Vigour Index-I [G] Vigour Index-II, [Numbering (1-20) assigned for the genotypes names (see for details in the Table 1)]

Table 9. Effect of salt stress on vigor index- II (Dry Weight basis) of blackgram genotypes

Sr. No.	Genotype	Salinity Treatment				
		T_1	T_2	T_3	T_4	Mean
1	**IC-14520**	1234.00	882.00	770.40	649.60	884.00
2	**IC-214845**	1010.70	821.70	738.40	518.49	772.32
3	**IC-242677**	1110.60	851.91	814.10	379.80	789.10
4	**IC-204869**	934.30	775.62	673.96	613.60	749.37
5	**IC-61100**	1245.00	878.85	815.40	359.60	824.71
6	**IC-214844**	820.80	789.09	739.50	513.80	715.80
7	**SKNU-07-01**	1109.00	880.80	646.80	533.50	792.53
8	**SKNU-03-03**	1066.89	922.50	578.00	544.92	778.08
9	**SKNU-07-06**	1211.66	1164.80	973.00	542.50	972.99
10	**SKNU-06-03**	1451.70	957.76	870.10	723.60	1000.79
11	**SKNU-07-03**	1188.54	996.00	810.30	532.50	881.84
12	**SKNU-03-4**	1172.79	945.36	847.70	673.80	909.91
13	**SKNU-9911**	1180.80	1045.60	864.50	720.00	952.73
14	**SKNU-2K-3**	1076.00	943.80	744.48	560.40	831.17
15	**SKNU-9915**	1337.46	1148.33	987.20	854.00	1081.75
16	**COBG-593**	1341.20	1093.60	1018.60	750.40	1050.95
17	**TU-94-2**	1216.70	661.50	501.00	302.00	670.30
18	**TPU-4**	1323.00	1157.85	942.30	581.70	1001.21
19	**GJU-1506**	1156.50	820.40	562.20	426.29	741.35
20	**JAWAHAR URD-3**	1198.00	934.40	785.40	570.00	871.95
	Overall Mean	1169.28	933.59	784.16	567.52	

4. CONCLUSION

According to physiological parameters, blackgram genotypes were classified into tolerant, moderately tolerant and sensitive. Genotypes IC-204869, TPU-94-2, IC-21485, IC-214844 are tolerant, TPU-4, JAWAHAR URD-2, SKNU-07-01, SKNU-07-03, JAWAHAR URD-3, IC-14520, IC-242677, IC-61100, SKNU-9915, GJU-1506, SKNU-03-04, SKNU-9911, SKNU 2K-3 and COBG-593are moderately tolerant while SKNU-03-03, SKNU-07-03, GJU-1509 and SKNU-06-03 are sensitive to salinity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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