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Morphological and Yield Attribute of Blackgram Genotypes under Different Salinity Stress Conditions

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ABSTRACT

Background: Blackgram is one of the important grain legumes in India. Pulses are the important source of protein for the vegetarian people. To meet out the current demand of pulses, there is a crucial need to increase the blackgram production. Mostly this crop is cultivated in marginal lands where the abiotic stresses like drought and salinity are predominant. The area under salinity in India is 6.73 million hectares and in blackgram no variety was identified as suitable for saline areas.

Methods: This experiment was carried out to study the salinity tolerance levels of balckgram genotypes at vegetative and reproductive stages during *Rabi* season of 2018-20. A total of six blackgram genotypes were used to screen its performance under saline environment at vegetative and reproductive stage. All the genotypes were raised in pot with the size of 20 cm height and 15 cm width with four replications and salinity were stimulated artificially *viz*., 4.0 EC, 11.0 EC and 16.0 EC ds/m, its growth habits were observed.

Conclusion: Salinity impact adversely affects blackgram genotypes under study. The number of days to survival of the plant and plant height were decreased by increasing salinity level and number of irrigation with saline water and it was reduced to ½ at 16 EC ds/m as compared to control. Days to 50% flowering, chlorophyll content and single plant yield were severally affected by increasing salt concentration. Increasing salt concentration was found directly proportionate to increasing number of days taken for flower initiation and at high level of salinity (16.0 EC ds/m) the plants dried before flowering. The plant yield was much affected by slight increase in salt concentration. At 4.0 EC ds/m level the yield was reduced to ¼ as compared to control. The 100 grain weight was not much affected by increasing salt concentration; Chlorophyll content also reduced 2/3 by increasing salt concentration after 15 DAS. The genotypes VBG-14-016 performed better under 4.0 EC ds/m level and survived for more number of days followed by the variety VBN 8.

Key words: Blackgram, EC level, Germination, Plant height, Salinity tolerance, Single plant yield.

INTRODUCTION

Blackgram [*Vigna mungo* (L.) (Hepper] is the third important pulse crop next to chickpea and pigeonpea and widely cultivated in India. The protein content is three times higher as compared to cereals, further it plays a crucial role in sustaining the productivity of a cropping system by adding atmospheric nitrogen to the soil. In India, it is cultivated around 5.44 million hectares with the production of 3.56 million tonnes and the productivity is 655 kg/ha. In Tamil Nadu, it is cultivated around 3.41 lakh hectares with the production of 1.21 lakh tonnes (https://farmer.gov.in/ Success Report 2018-19). The current production is insufficient to fulfil the demand of growing population, because pulse is the only source of protein for vegetarian diet. Hence there is a need to increase the production either by increasing cultivation area or by increasing productivity per unit area. There is more scope to increase area by cultivating blackgram in underutilized areas, where salinity is a major problem. In Tamil Nadu the salt affected area is 3.63 lakh hectares, out of which 3.52 lakh hectares are affected due to inland salinity and 13.2 thousand hectares affected due to coastal salinity (Ministry of Agriculture, 2016). Worldwide the salinity stress hinders the agriculture productivity and due to lesser the yield in semi arid regions (Kapoor and Srivastava, 2010). Most of the salt affected areas, the crop is raised only in rainy season and the remaining period are left as fallows due to non availability of saline tolerant varieties. Since blackgram is a highly sensitive crop to salinity and the inadequate information on varietal performance under salt affected soils the farmers are unable to choose the tolerant variety suitable for saline environment. In pulses Germination, vegetative, flowering and maturity are the important and critical stages; increased salinity during these stages directly affects the yield. (Hasan *et al*., 2019) reported, in blackgram vigorous growth during the vegetative stage under saline environment has been used as a criterion for screening salt tolerance. More number

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of studies are carried out at germination phase in blackgram (Hasan *et al*., 2019; Shanthi *et al*., 2020; Priyadharshini *et al.,* 2019) the studies at vegetative, flowering and maturity stages are very negligible. Flowering and maturity stages are the important critical stages which affect directly to the yield. Due to blocking of xylem and phloem vessels by sodium, carbonate and bicarbonate salts the plants unable to absorb the essential nutrients necessary for its growth (Cassaniti *et al.,* 2012). Considering the above facts, this study was undertaken to assess the morphological and yield attributes at vegetative, flowering and maturity stages under different salinity stress condition.

MATERIALS AND METHODS

This experiment was conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Kudumiyanmalai in Pudukkottai district of Tamil Nadu. For screening artificially at vegetative, flowering and maturity phases, a total of six genotypes based on its tolerance and susceptibility at germination stage under different levels of salinity condition *viz*., VBG14-16, VBN (Bg) 4, VBN 8, VBN 11, VBN 10 and VBG13-003 (Shanthi *et al.,* 2020) were selected for this study. The selected genotypes were raised in plastic pots (one feet width and height) in two replications and four different saline treatments were imposed *viz*. 0.0 EC, 4.0 EC, 11.0 EC, 16.0 EC ds/m under glass house condition to avoid rain water that will affect the salinity level. Each pot was filled with 10 kg of red soil (with neutral pH and 0 EC ds/m) mixed with FYM and seeds of selected genotypes were sown at the rate of five seeds per pot. The different EC level of salinity were created by dissolving the combination of salts *viz*., NaCl, Na_2SO_4, KCl, K_2SO_4, $MgCl_2$, $MgSO_4$ and $CaCl_2$ in the ratio of 2:1:1:1:1:1:1, respectively in deionized water of 100 ml solution to create different concentration. For EC of 4.0 ds/m level, 0.075 g of NaCl and 0.037 g for the remaining salts dissolved in the 100 ml of deionised water. Similarly for 11.0 ds/m EC, 0.175 g of NaCl and 0.0875 g of other salts were dissolved in the 100 ml of deionised water, 16.0 ds/m EC was achieved by dissolving 0.25 g of NaCl and 0.125 g of remaining salts were dissolved in the 100 ml of deionised water and deionised water is used as control (0.00 EC) with no salts (Singh *et al.,* 2009; Shanthi *et al*., 2020). Artificially prepared saline waters of different EC level (4.0 EC, 11.0 EC, 16.0 EC ds/m) were used to irrigate pots in alternate days and the control was irrigated with deionised water. The necessary nutrients were added in liquid form on 15 and 30 Days after sowing (DAS). The biometrical observations recorded were Days to 50% flowering, plant height, number of leaves on 15 Days after sowing (DAS), number of pods per plant, 100 grain weight, single plant yield and chlorophyll content (25 DAS) using SPAD-502 meter, Number of days taken for whole plant drying (25-55 DAS) and Chlorophyll content using chlorophyll meter (SPAD- 502 meter). The two-way ANOVA is probably the most popular layout in the Design of Experiments. This data were analysed using TNAUSTAT software (https://sites.google.com/site/tnaustat).

RESULTS AND DISCUSSION

The present experiment results clearly indicated that the germination of blackgram was affected slightly due to lower level of salinity and this character was affected severely in higher level of salinity *i.e*. under 16.0 EC ds/m level. Whereas seedling, vegetative, flowering and maturity stages were highly sensitive when exposed to different level of salinity. Increasing salinity level leads to mortality of the plants. The mortality increased significantly due to increasing number of saline water irrigations from vegetative to pod formation similar results was found by Shanti *et al.* (2014).

Analysis of variance revealed that mean squares among the genotypes at all the four salt concentrations were significant for all the parameters studied (Table 1). Coefficient of variation was found maximum for number of days taken by the genotype to dry completely (6.06) followed by Plant height (1.26) (Table 1). These results clearly indicated that the genotypes and treatments taken for this experiment were significantly different and effective.

Survival of plants under salinity

The plants in pots were irrigated with different levels of saline water (4.0 EC, 11.0 EC and 16.0 EC ds/m level). Increasing

Table 1: Analysis of variance of different characters and various salt concentrations in blackgram genotypes.

Characters		Genotypes (6)	Salt concentrations (3)	Interaction 15	Error 24	Total 47	Coefficient of variation
Number of days	MS	32.36**	3007.86**	12.49**	1.25	6324.97	6.06
to dry completely	SEM	0.811	1.0859	0.711			
Plant height	MS	1.233**	108.514**	1.81**	0.605**	373.42	1.26
	SEM	0.286	0.37	0.33			
Number of leaves	MS	0.0375	1.688	0.038	0.062	7.313	0
15 DAS	SEM	-	-	-			
Chlorophyll content	MS	0.0007**	0.03**	0.0002**	0.0005	0.103	0.005
20 DAS	SEM	0.007	0.003	0.005			

*, ** Significance at 1% and 5% level respectively.

MS: Mean standard; SEM: Standard error of mean.

salinity level the number of day's survival of plants were reduced (Table 2). Under 16.0 EC ds/m level among the six genotypes, the average number of days to complete drying was 22 days and under 4.0 EC level complete drying of plant was observed on 53rd DAS. In 16.0 EC ds/m level, the genotype VBG-14-16 survived maximum of 25 days where as the genotype VBN 10, VBN 11 and VBN (Bg) 4 were completely dried on 20 DAS whereas under 4.0 EC ds/m level the genotype VBG-14-016 has survived for 58 DAS the lowest survival days was recorded by VBN 10 (50 days). Under 11 EC ds/m level VBN-14-016 and VBN 8 survived maximum of 35 DAS followed by VBN 4 (34 DAS). This clearly indicated that salinity is extremely harmful to the crops belonging to Fabaceae family such as blackgram and this result was also confirmed by Munns and Tester, (2008).

Days to flowering

Some genotypes survived under higher EC of 11.0 and 16.0 EC ds/m level for up to 58 days failed to produce flowering (Table 3). Compare to 0.0 EC ds/m (control) level increasing salinity level delayed the flowering. Under 4.0 EC ds/m level VBN (Bg) 4 and VBN 8 recorded 50 per cent flowering on 43 DAS as against the control flowered 35 Days and VBN 11 and VBG-13-003 had recorded 50 per cent flowering of 47 days against the control 37 days. Under 11.0 and 16. EC ds/m level none of the genotype was survived up to flowering.

Plant height

The plant height was recorded at 20 DAS and noticed that the height reduction by increasing salinity level (Table 4). Based on average height the 16.0 EC ds/m level recorded the half of the height as compared to check (0.0 EC ds/m). Under 16 EC ds/m the genotype VBG14-016 recorded maximum height of 5.90 cm and the genotype VBN 11 recorded the minimum plant height of 4.75 cm. In 11.0 EC ds/m levels the maximum plant height was recorded by the genotype VBN 10 (9.50 cm) and the minimum plant height was recorded by VBG -13-003 (8.75 cm). In 4.0 EC level VBN11 had recorded the minimum plant height of 8.75 cm and VBG-14-016 had recoded the maximum plant height of 11.25 cm. Under control VBN 11 had recoded the maximum plant height of 13.25 cm and VBN 10 recorded the minimum height of 10.25 cm. (Hasan *et al.,* 2019) also reported the same impact on height in blackgram due to salinity.

Number of leaves and leaf area

This results of this experiment cleared that most of the biometrical characters studied were affected severely due to salinity except the number of leaves per plant (Table 5), hence the number of leaves per plant may not taken as a trait for selection to identify the salinity tolerant genotype. Even though the number of leaves not affected the size of the leaves, the leaf area was reduced due to increasing salinity level.

Pod development and yield

Under 4.0 EC level only two genotypes *viz*., VBN 8 (4 Nos) and VBG-14-016 (6 Nos) set few pods (Table 6). Under control condition VBG-14-016 recorded the maximum of

Table 2: Number of days to whole plant drying.

Genotypes	0 EC (No salt)		4 EC ds/m		11 EC ds/m		16 EC ds/m	
	Drying initiation	Complete drying	Drying initiation	Complete drying	Drying initiation	Complete drying	Drying initiation	Complete drying
VBN 4	All are survived till harvest		25	51	15	35	10	20
VBN 8			28	55	15	34	10	24
VBN 10			23	50	11	28	7	20
VBN 11			23	55	10	29	7	20
VBG 13-003			26	52	11	28	8	20
VBG 14-016			30	58	15	35	10	25
Grand Mean			26	53	13	31	9	22
SD			2.78	3.01	2.40	3.50	1.50	2.58
CV (%)			10.71	5.69	18.47	11.31	16.72	11.73

Table 3: Days to 50 per cent flowering.

Genotypes	0 EC	4 EC ds/m	11 EC ds/m	16 EC ds/m
VBN 4	35	43		
VBN 8	34	43		
VBN 10	38	45	They have not flowered.	
VBN 11	36	47	Before flowering all the genotypes	
VBG 13-003	36	47	Were dried.	
VBG 14-016	38	45		
Grand Mean	36	45		
SD	1.60	1.79		
CV(%)	4.45	3.98		

35 pods per plant and VBN 4 recorded the minimum of 25 pods per plant. In control VBG-14-016 has recorded the maximum of 25.25 grams per plant and VBN 4 has recorded the minimum of 20.8 grams per plant (Table 8). In 4.0 EC ds/m level the single plant yield of VBG-14-016 was 6.50 gram followed by VBN 8 (5.50).

100 seed weight

The pod development was observed only up to 4 EC dsm^{-1} level. It was observed that the 100 seed is the character not affected more due to salinity (Table 7).

Chlorophyll content

Chlorophyll content level was recorded 20 DAS, increasing salinity level automatically reduced the chlorophyll content of genotypes. Grand mean value of 0.31 µmol/m^2 was recorded by 0.0 EC ds/m level and 0.20 µmol/m^2 was recorded by 16 EC ds/m salinity level (Table 9). Under control the chlorophyll content was ranged between 0.30 to 0.33 µmol/m^2 and at 16.0 EC ds/m reduced to one by four compare to 0.0 EC ds/m level. Chlorophyll content also reduced two by three by increasing salt concentration after 20 DAS clearly indicated that increasing salt concentration reduce chlorophyll content and ultimately reduce the photosynthesis this leads to reduction in growth characters and drying of plants. Win and Oo (2017); Shanthi *et al*. (2011) and Shanti *et al*. (2014) reported similar findings. Neera and Ranju, 2004 reported in Bengal gram irrigation with 6.0 and 8.0 EC (ds/m) when compared to best available water.

The growth characters *viz*., plant height, chlorophyll content, days to 50 percent flowering and single plant yield were severally affected by increasing salt concentration and increasing number of irrigations with saline water. Plant height is reduced to half at 16.0 EC ds/m level compare to control (0.0 EC ds/m level) and the increasing salt

Table 4: Plant height (cm) at 20 DAS.

Genotypes	0 EC ds/m	4 EC ds/m	11 EC ds/m	16 EC ds/m
VBN 4	12.00	10.75	9.25	5.75
VBN 8	12.25	11.00	9.25	4.75
VBN 10	10.25	11.00	9.50	4.75
VBN 11	13.25	8.75	9.00	4.50
VBG 13-003	12.25	11.50	8.75	5.40
VBG 14-016	12.25	11.25	9.25	5.90
Grand Mean	12.04	10.75	9.17	5.18
SD	12.042	10.71	9.17	5.18
CV (%)	0.98	0.99	0.26	0.59

Table 5: Number of leaves at 15 DAS.

Genotypes	0 EC ds/m	4 EC ds/m	11 EC ds/m	16 EC ds/m
VBN 4	3	3	3	3
VBN 8	3	3	3	3
VBN 10	3	3	3	2
VBN 11	3	3	3	2
VBG 13-003	3	3	3	2
VBG 14-016	3	3	3	3
Grand Mean	3	3	3	2
SD	0	0	0	0.55
CV(%)	0	0	0	27.39

Table 6: Number of pods per plant.

Genotypes	0 EC ds/m	4 EC ds/m	11 EC ds/m	16 EC ds/m
VBN 4	25	0	0	0
VBN 8	29	4	0	0
VBN 10	32	0	0	0
VBN 11	28	0	0	0
VBG 13-003	29	0	0	0
VBG 14-016	35	6	0	0
Mean	29.67	2	0	0
SD	3.45	2.53	0	0
CV(%)	11.61	126.49	0	0

Table 7: Hundred seed weight (g).

Genotypes	0 EC ds/m	4 EC ds/m	11 EC ds/m	16 EC ds/m
VBN 4	4.25	0	0	0
VBN 8	3.35	3.2	0	0
VBN 10	3.1	0	0	0
VBN 11	3.35	0	0	0
VBG 13-003	3.3	0	0	0
VBG 14-016	3.55	3.75	0	0
Mean	3.48	1.7	-	-
SD	0.40	1.87		
CV(%)	11.54	110.13		

Table 8: Single plant yield (g).

Genotypes	0 EC ds/m	4 EC ds/m	11 EC ds/m	16 EC ds/m
VBN 4	20.8	0	The plants were not survived till maturity	
VBN 8	22.65	5.5		
VBN 10	23.85	0		
VBN 11	21.85	0		
VBG 13-003	22.9	0		
VBG 14-016	25.25	6.5		
Mean	22.88	2.83	-	
SD	1.54	3.14		
CV(%)	6.77	110.86		

Table 9: Chlorophyll content (µmol/m^2) 20 DAS.

Genotypes	0 EC ds/m	4 EC ds/m	11 EC ds/m	16 EC ds/m
VBN 4	0.32	0.26	0.23	0.19
VBN 8	0.33	0.26	0.23	0.20
VBN 10	0.31	0.27	0.22	0.20
VBN 11	0.32	0.26	0.23	0.20
VBG 13-003	0.30	0.26	0.23	0.20
VBG 14-016	0.31	0.28	0.23	0.19
Grand mean	0.31	0.27	0.23	0.20
SD	0.011	0.008	0.004	0.005
CV(%)	0.010	0.008	0.004	0.004

concentration the plant do not flower at all and number of days to initiate flowering also delayed by increase salinity level. These findings clearly indicated that even though the water is available the plants unable to take the nutrient and water from soil due to blocking of salts to the phloem and xylem vessels and prevent uptake of nutrient and water by the plants. This ultimately leads to growth retardant and drying of plants by increasing salt concentration, similar finding was also reported by Shanti *et al*. (2014).

CONCLUSION

Based on the results in pot culture the advanced culture VBG-14-016 performed better under 4.0 E ds/m C level and survived for more number of days followed by the variety blackgrm VBN 8. These genotypes could be utilized as a donor for the development of salt tolerant varieties.

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Conflict of interest

All authors declare that they have no conflict of interest.

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