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RESEARCH ARTICLE

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Assessment of Salinity Tolerance in Greengram [*Vigna radiata* (L.) Wilczek]

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ABSTRACT

Background: Greengram is one of the important and salt sensitive food legume crops with high nutritional quality. The area under salinity is increasing gradually due to various reasons like global warming, continues irrigation of bore well water and use of more organic fertilizers *etc*. Identification of salinity tolerant genotype in greengram is highly essential to improve the production and productivity. Salinity stress condition increases the absorption of more Na^+ whereas the reduction of K^+ absorption was noticed, which thus decreases the K^+/Na^+ ratio. The first visible symptom due to salinity stress was retarded growth because of more uptake of Na^+ ions leads to reduction of physiological activities. The next important character affected by salinity stress was radical growth.

Methods: A total of 20 greengram genotypes were evaluated for salinity tolerance under four EC levels. Screening was done by roll towel method with two replications. The roll towels were placed in different buckets filled with different EC level of saline water and observations were recorded on the 8th day of germination.

Result: The salinity level of more than 4.0 EC dsm^{-1} causes gradual reduction in radicle length and at 12.0 EC level almost in all the genotypes the radicle length was reduced to half as compare to control. The correlation analysis indicated that the plumule length and radicle length were the important criteria for selection to salinity tolerance. While observing the other growth parameters like plumule and radical length reduction, dry matter weight and salinity tolerance and susceptible index the genotypes IPMD 14-10 and VGG 17-038 were identified as more tolerant genotypes and DGGV 80, PUSA-BM5 and VBN 4 were more sensitive genotypes.

Key words: Dry matter, Greengram, Plumule length, Radicle length, Salinity tolerance, Salt injury index, Salt tolerant index.

INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] is one of the important food grain legume with high nutritional quality, high digestibility (Siemonsma and Na Lampang, 1992) with short duration (55-80 days) and helps to improve soil fertility level by its nitrogen fixation ability leads to sustainable agriculture production. It is grown in different ecologies and seasons across India invariably in most of the states. In Tamil Nadu this greengram crop is grown as irrigated crop during *kharif* and summer seasons and as rainfed crop during *rabi* season. Food and nutritional security are in question mark day by day in the increasing trend of global population and decreasing arable lands due to abiotic stresses. Among the abiotic stresses drought and salinity are the most important stresses. Presence of high concentration of soluble salts in the agriculture soils especially in the root zones refers to soil salinity. Worldwide the cultivable area affected due to salinity is 23 per cent and sodicity is 37 per cent (Khan and Duke, 2001). Soil salinity arises due to geo-historical process or man-made one. Sea water intrusion is the main reason for coastal salinity and also increasing the salt concentration in ground water, the interior areas become saline due to continuous irrigation of borewell water with more salt concentration.

Salinity reduces more than 50 per cent of the yield in pulses including greengram. Presence of more salts in soil increases the osmotic pressure in the seed, which restricts the water absorption of the seeds (Tester and Davenport, 2003) and also the enzyme called α-amylase is inhibited. This ultimately affects the germination of seeds followed by the growth of the plants. Salinity delays the nucleic acids and RNAase synthesis leads to reduce the chlorophyll content of the plant. Increase in salt concentration affects germination percentage, shoot and root length, photosynthesis and yield attributes (Ghosh *et al*., 2016) in greengram. On this note the present experiment was carried out to identify the salinity tolerance genotypes in greengram during germination and young seedling stage.

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MATERIALS AND METHODS

A total of 20 greengram genotypes were evaluated for salinity tolerance under four EC levels. This experiment was carried out at Agriculture College and Research Institute, Kudumiyanmalai, Pudukkottai District of Tamil Nadu during

2019-21. The evaluation was done on the basis of morphological characterization of young seedlings traits since germination is one of the important stages to maintain plant population and initial vigor. A total of 20 different greengram genotypes were used for this experiment. Four levels of salinity (4.0 EC, 8.0 EC, 12.0 EC and 16.0 EC dsm^{-1}) were compared with control (0.0 EC). Since salinity is not due to the single salt stress the experiment solution with different EC levels were prepared using 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 dissolved in deionized water (Singh *et al*., 2009; Shanthi *et al*., 2021). Screening was done by roll towel method with two replications and 20 seeds per replication were placed for germination in each treatment. The roll towels were placed in different buckets filled with different concentration of saline water till observations were recorded. To screen the genotype for salt tolerance, germination and seedling characters *viz*., Germination percentage, Plumule length, radicle length, Plumule-Radicle Ratio and Dry weight were taken into consideration. The observations were recorded on the 8th day of germination. The observations recorded from the genotypes in both the replications were subjected to two factor analysis of variation (Gomez and Gomez, 1984). ANOVA was carried out using STAR package and correlation was calculated. Salt tolerance index (STI) was calculated as (Goudarzi and Pakniyat, 2008) by the following formula.

$$\text{Salt tolerance index} = \frac{\text{Variable measured under stress condition}}{\text{Variable measured under normal condition}}$$

RESULTS AND DISCUSSION

The plants grown under salt stress condition were unable to absorb adequate water for its metabolic processes or maintain turgidity due to low osmotic potential (Shrivastava *et al*., 2015). Salinity stress condition increases cations uptake such as Mg, Na, Ca and causes different kinds of nutritional imbalances finally leads to different ranges of toxicity. Among the cations, the most important one is NaCl toxicity, plants absorb more amount of Na^+, which thus decreases the K uptake by plants (Ahmad and Prasad, 2012). The greengram genotypes grown under different salinity conditions affect its biochemical mechanism and leads to reduction in growth (Shanthi *et al*., 2011).

The two way ANOVA (Table 1) results clearly revealed that the main effects of salinity, genotypes and its interaction were highly significant in all parameters studied. Hence the greengram genotypes taken for this study were varied in their response to different levels of salinity in germination and other characters in its seedling stage. The coefficient of variation varied among different characters and the maximum was recorded by the plumule radicle length ratio (15.39) and the minimum was recorded by dry matter weight (2.06). Similar result was also reported in blackgram (Shanthi *et al*., 2021a). This was also confirmed by the critical difference (CD) for all characters taken for this experiment were compared for different factorial plots and subplots with their interactions.

The reduction in germination percentage was noticed for increasing salinity levels invariably in all the genotypes (Table 2). The genotypic difference was observed within and among the salinity levels. In overall performance, while compared with control (0.0 EC level), the reduction in germination percentage was very less at 4.0 EC level and very high at 16.0 EC level. Similar results were observed in greengram (Prakash, 2017) and Shanthi *et al*. (2021a) in blackgram. Variability in salinity tolerance among rice varieties was reported by (Shanthi *et al*., 2011) and variation in germination has also been reported by Hakim *et al*. (2010).

Plumule length is the most important seedling character which affected due to salinity. Kumar *et al*. (2021) reported that the s*alinity* is a major abiotic *stress* that *significantly affects* the *plant growth* by causing osmotic *stress* and inducing ionic and nutrient imbalance. The first visible symptom due to salinity is retarded growth (Shanthi *et al*., 2021b) prolonged salinity the plumule length was reduced. The maximum plumule length after 8 days of germination was recorded by the genotype IPMD 14-10 (18.9 cm) (Table 3) and it was reduced to half in most of the genotypes studied under 8.0 EC level and the length was reduced high at 16.0 EC level. This character can be considered as one of the important criteria for identification of salinity tolerant genotype(s). These results were in accordance with the findings of Prakash (2017) in greengram.

The radicle length is another important parameter for salinity screening in seedling stage. Beyond the 4.0 EC level the gradual reduction in radicle length was observed and under 12.0 EC level almost in all the genotypes the radicle length was reduced to half as compare to control (0.0 EC) (Table 4). Under 16.0 EC salinity condition all the genotypes recorded below 2.75 cm of radical length. These results indicated that the plumule length was more under control condition and reduced under stress conditions; whereas the radicle length was slightly increased up to 8.0 EC level and at 12.0 and 16.0 EC level both plumule and radicle lengths were reduced. The plumule length was severely affected by salinity and the radicle length was increased by slight increase in salt concentration to increase the water absorption rate and later at high salinity level (12.0 and 16.0 EC level) the radicle growth was also affected. The results were in accordance with Hanumantha Rao *et al*. (2016).

The average dry matter weight of single seedling under control is less than the seedling under salinity stress condition. The salinity level the dry matter weight also increased gradually and under higher saline concentration of 16.0 EC (Table 5). Due to high level of salinity the sodium salt absorption by the plant may be increased that leads to accumulation in plants. Similar findings were also confirmed in blackgram by Shanthi *et al*. (2021b) and Priyadharshini *et al*. (2019).

Salt tolerance index and salt injury index were used to determine the degree of tolerance for different genotypes towards salinity. Salt tolerant index for plumule length, radicle length and dry matter weight were calculated. The salt tolerance index was reduced by increasing salt concentration for both plumule and radicle length and salt injury index was increased vice a versa. This results clearly showed that the increasing salt concentration affect the plant height. While comparing root length the damage due to salinity was comparatively low in root compare to shoot. Similar result was recorded by Shanthi *et al*. (2021a). Salinity stress significantly reduces the net photosynthetic rates, due to salt exclusion mechanism the energy losses was increased, nutrient mobilization largely decreased, cell division and cell elongation also reduced all this activity finally reduced the plant growth (Seeman and Sharkey, 1986).

Simple linear correlation

The linear correlation analysis was carried out for germination percentage, plumule length, radicle length, plumule radicle length percentage and dry matter weight under different EC level. The significant and positive

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

Characters		Genotypes (19)	Salt concentration (4)	Interaction (76)	Error (80)	Total (199)	Coefficient of variation
Germination (%)	MS	157.78	3094.21	13.06	4.0836	81.41	2.41
	SED	0.90	0.45	2.02			
	CD	1.78	0.89	4.00			
Plumule length (cm)	MS	29.80	460.68	3.89	0.468	2.4	8.59
	SED	0.22	0.11	0.68			
	CD	0.45	1.01	1.35			
Radicle Length (cm)	MS	18.93	268.36	2.73	0.16	5.1	8.01
	SED	0.18	0.09	0.41			
	CD	0.36	0.18	0.80			
Dry matter production (g)	MS	541.34	473.02	60.60	0.52	19.85	2.06
	SED	0.32	0.16	0.72			
	CD	0.63	0.31	1.42			
Plumule/radical length	MS	0.62	1.79	0.19	0.03	9.50	15.39
	SED	0.08	0.04	0.19			
	CD	0.17	0.08	0.38			

Table 2: Mean germination percentage of greengram genotypes at different levels of salt concentration.

Genotype	0 EC dsm^{-1}	4 EC dsm^{-1}	8 EC dsm^{-1}	12 EC dsm^{-1}	16 EC dsm^{-1}
AKM1801	96.5ab	92.5abc	87.5ab	81.5abc	74.0ab
COGG1912	92.5abc	93.5abc	84.0abc	77.5bcde	70.0 bc
DGGV80	92.5abc	90.5abcd	84.0abc	82.5abc	77.5a
IGKM 05-18-27	95.5ab	89.0bcd	84.0abc	81.5abc	74.0ab
IPM2-14	94.0ab	88.5bcd	84.0abc	77.5 bcde	72.5ab
IPMD 14-10	99.0a	94.0ab	89.0a	84.5ab	75.0ab
JLPM504-20-27	86.5c	82.5 de	74.0e	72.5ef	67.5bc
LGG609	94.0ab	89.0bcd	79.0cde	74.0def	69.0bc
MGG389	92.5abc	93.5abc	86.5ab	74.0 def	67.5bc
MH1703	94.5 ab	95.5ab	86.0abc	84.0ab	69.0bc
ML2482	94.0ab	83.5de	76.5de	67.5f	65.0c
NDMK17-10	94.0ab	91.5abc	89.0a	84.0ab	77.5a
OBGG104	94.0ab	89.0bcd	84.0abc	82.5abc	74.0ab
PM1618	94.5ab	93.5abc	84.0abc	76.5 cde	67.5bc
PM1623	96.5ab	88.5bcd	82.5abcd	76.5cde	67.5bc
PUSA-BM5	91.5bc	90.0bcd	83.5abcd	79.0bcde	73.5ab
PUSA-M1971	94.0ab	91.5abc	89.0a	87.5a	77.5a
VBN 4	95.0ab	90.0 bcd	85.5abc	80.5abcd	74.5ab
VGG17-038	96.5ab	95.5ab	89.0a	82.5abc	77.5a
VGG17-043	91.0 bc	86.5cd	81.5bcd	74.0def	67.5bc

Values with the same letter are not significantly different. Data represent means of five independent plants.

correlation was recorded for germination percentage with plumule length at 4.0 EC level and 8.0 EC level and radicle length of control and 4.0 EC level. These results clarify that the lower level of salinity (up to 4.0 EC level) the germination percentage, plumule length and radicle length were not affected more. W-hereas beyond 4.0 EC level the germination percentage, radicle and plumule length were drastically affected (Table 6). Similar results were reported

Table 3: Mean plumule length of greengram genotypes at different levels of salt concentration.

Genotype	0 EC dsm^{-1}	4 EC dsm^{-1}	8 EC dsm^{-1}	12 EC dsm^{-1}	16 EC dsm^{-1}
AKM1801	11.6de	5.5 fgh	4.2fgh	2.3de	1.0d
COGG1912	14.3c	10.4bc	6.5bcde	3.4 cde	2.3cd
DGGV80	6.6jk	3.9h	2.7h	1.7 e	0.9d
IGKM 05-18-2	12.2d	10.bcd	7.9b	4.3bc	2.3cd
IPM2-14	7.5ijk	6.2fg	4.9defg	2.9cde	1.4 cd
IPMD 14-10	18.9a	12.7a	9.9a	8.0a	3.3a
JLPM504-20-27	7.9hijk	5.5fgh	3.8fgh	2.3de	1.5cd
LGG609	8.9ghi	6.4fg	5.1defg	3.5cde	2.4cd
MGG389	16.9b	9.2cd	7.4bc	5.9 b	3.2bc
MH1703	10.8def	6.2 fg	4.9defg	3.8cd	2.1cd
ML2482	7.8hijk	6.4efg	4.5fgh	2.7cde	1.5cd
NDMK17-10	9.8efg	8.3de	6.7bcd	3.9cd	2.4cd
OBGG104	14.8c	11.3ab	5.7cdef	3.7cd	1.4cd
PM1618	16.2bc	12.8a	9.8a	8.1a	3.8ab
PM1623	7.0jk	5.0gh	3.7gh	2.6cde	1.3cd
PUSA-BM5	11.6de	9.1cd	4.8efg	2.9cde	1.3cd
PUSA-M1971	8.3ghij	6.5efg	4.7efg	3.4cde	1.5cd
VBN 4	6.1k	6.9efg	3.8gh	1.7e	1.2d
VGG17-038	9.7fgh	7.1ef	4.3fgh	3.2cde	2.7cd
VGG17-043	7.4ijk	5.8fg	4.2fgh	3.5cde	2.6cd

Values with the same letter are not significantly different. Data represent means of five independent plants.

Table 4: Mean radicle length of greengram genotypes at different levels of salt concentration.

Genotype	0 EC dsm^{-1}	4 EC dsm^{-1}	8 EC dsm^{-1}	12 EC dsm^{-1}	16 EC dsm^{-1}
AKM1801	7.3defgh	6.2ghijk	4.3e	3.1cdefg	1.2 cd
COGG1912	6.8efghi	5.8 ijkl	3.9e	2.2g	2.0abcd
DGGV80	7.4defgh	6.5efghij	3.5e	2.2 fg	0.8d
IGKM 05-18-2	7.8defg	7.9de	5.8cd	3.6 bcdef	2.3abc
IPM2-14	7.5defgh	6.0hijkl	4.8de	2.9cdefg	1.0cd
IPMD 14-10	15.9a	17.4 a	9.6a	8.1a	2.7ab
JLPM504-20-27	8.5cd	7.4efgh	5.9cd	2.6defg	0.8d
LGG609	8.3d	7.7def	6.1cd	3.7bcde	1.7bcd
MGG389	10.4b	8.8cd	6.9bc	4.8b	2.7ab
MH1703	5.5i	7.4efgh	6.8bc	3.7bcde	2.0abcd
ML2482	6.9efghi	5.1 jkl	3.8e	2.4efg	1.1cd
NDMK17-10	6.0hi	5.3ijkl	4.7de	2.8cdefg	0.8d
OBGG104	6.3hi	4.9kl	3.5e	2.6defg	0.9cd
PM1618	9.9bc	11.4 b	10.0 a	4.2bc	2.7ab
PM1623	6.5ghi	5.7ijkl	4.3e	3.1cdefg	1.0cd
PUSA-BM5	7.5defgh	6.4fghijk	4.2e	2.2 fg	1.0cd
PUSA-M1971	8.2de	7.6defg	4.3e	1.9g	1.1cd
VBN 4	6.6fghi	4.6l	3.6e	2.2fg	1.00cd
VGG17-038	8.6cd	9.9c	7.7b	3.9bcd	2.1abcd
VGG17-043	7.9def	6.6efghi	4.9de	2.2fg	1.9abcd

Values with the same letter are not significantly different. Data represent means of five independent plants.

Table 5: Mean dry weight of greengram genotypes at different levels of salt concentration.

Genotype	0 EC dsm^{-1}	4 EC dsm^{-1}	8 EC dsm^{-1}	12 EC dsm^{-1}	16 EC dsm^{-1}
AKM1801	23.74i	28.7j	33.5h	37.1 f	44.7jk
COGG1912	18.0l	26.3lm	30.0 jk	37.4j	42.9 n
DGGV80	39.2b	44.4b	22.6 m	51.3ab	68.6 m
IGKM 05-18-2	26.3gh	28.9 j	30.9ij	39.7e	40.0hi
IPM2-14	27.3g	21.1 o	42.3 e	49.6 i	52.1gh
IPMD 14-10	21.1j	24.6 n	29.1k	35.5 j	39.2o
JLPM504-20-27	19.9 k	27.4k	29.3k	30.1i	38.8m
LGG609	26.7g	29.2j	31.2i	34.7k	35.2fg
MGG389	29.0f	30.0e	37.9ij	39.2f	42.3d
MH1703	34.5d	35.30g	35.1g	35.0 g	42.0d
ML2482	31.3e	33.4h	36.5f	36.9h	38.8ij
NDMK17-10	25.3h	35.7fg	38.3l	40.8f	41.5l
OBGG104	30.8e	31.4 i	37.1f	46.2c	49.3f
PM1618	25.6h	25.7m	32.4h	30.7i	38.0e
PM1623	34.9a	35.9a	39.1b	45.4b	50.0c
PUSA-BM5	31.8e	43.0c	47.2c	51.7a	62.5a
PUSA-M1971	23.6d	27.4kl	28.9k	39.3e	42.2kl
VBN 4	31.4e	41.7d	50.9a	52.0a	62.2a
VGG17-038	29.5f	31.4 i	37.2 f	38.5j	40.9e
VGG17-043	37.7c	36.7ef	44.9d	43.1d	44.2b

Values with the same letter are not significantly different. Data represent means of five independent plants.

Table 6: Simple correlation analysis for the growth characters at different salinity level for the greengram genotypes.

Characters	Correlation analysis				
	Treatments	Plumule length	Radicle length	P-R ratio	Dry weight
Germination %	0EC	0.28*	0.43**	-0.10	0.12
	4EC	0.36**	0.38**	0.01	-0.03
	8EC	0.37**	0.30*	0.11	-0.13
	12EC	0.15	0.18	0.13	0.20
	16EC	-0.21	-0.21*	0.06	-0.14
Plumule length	0EC		0.74**	0.42**	-0.48**
	4EC		0.64**	0.47**	-0.45**
	8EC		0.71**	0.36**	-0.36*
	12EC		0.73**	0.48**	-0.40**
	16EC		0.86**	0.22*	-0.25*
Radicle length	0EC			-0.26*	-0.28*
	4EC			-0.35**	-0.32*
	8EC			-0.36**	-0.25*
	12EC			-0.18	-0.41**
	16EC			-0.24*	-0.09
P-R ratio	0EC				-0.32**
	4EC				-0.1
	8EC				-0.10
	12EC				-0.
	16EC				-0.23*

*Significant at 5% level; **significant at 1% level.

by Shanthi *et al*. (2021a). Hence the radicle and plumule length can be taken as criteria for selection to identify the salt tolerant genotypes. Whereas the dry matter weight is concerned it has recorded negative and significant correlation with plumule length it clearly showed that the increasing salinity concentration reduced the plumule length and reduces the dry matter weight.

CONCLUSION

Identification of salinity tolerant greengram genotype is highly essential due to the gradual increase in salinity affected area day by day due to global warming and application of more inorganic fertilizers for cultivation. Among the 20 genotypes evaluated, based on the parameters IPMD 14-10 and VGG 17-038 are identified as most tolerant genotypes and DGGV 80, PUSA-BM5 and VBN 4 are more sensitive genotypes.

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