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Evaluation of Phytotoxicity of Mung Bean Genotypes Against Salinity Stress

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Abstract- The purpose of present study was to evaluate the differential behaviour of mung bean genotypes under salt stress. In this experiment five mung bean genotypes (Samrat, Sonali B1, Panna, Sukumar, and Bireswar) were evaluated under five different salinity conditions including control (0, 6, 10, 16 and 20 dSm^{-1}). Mungbean (*Vigna radiata* (L.) Wilczek) varieties showed significant and distinct varietal difference during screening for salt tolerance at early seedling growth stage regarding the parameters of germination efficiency and seedling characters. More adverse effect was noticed in shoot length than that of roots. Samrat and Bireswar were found to be the most tolerant and sensitive in response to salt stress condition respectively.

Index Terms- Germination parameters, mung bean, salinity, seedling characters

I. INTRODUCTION

Vigna radiata (L.) Wilczek is a vital eco-friendly food grain leguminous crop of dry land agriculture with rich source of proteins, vitamins, and minerals (Keatinge et al., 2011). India has the credit for contributing 35.7% to the global pulse production (FAOSTAT, 2013). It is a valuable crop in sustainable agriculture production due to its ability to fix nitrogen and small life span (Somta and Srinives, 2007). Soil salinity is a global atrocious environmental problem including the developing and developed countries. Salinity stress limits agricultural production affecting about half of the irrigated lands of the world (Horney et al., 2005) and threatening the sustainability of agriculture (Dagar, 2005). The arable land is constantly being converted into saline land because of human interferences and natural salinity. As a result, up to 50% land loss is expected by 2050 (Hasanuzzaman et al., 2013). Salinity delays the germination processes and reduces the total number of seeds germinating in all plants; though the responses of the plants towards salinity are inconsistent and varied (Ungar, 2007). Salinity also can considerably decrease growth rate of plants because it prevents water uptake due to influence of ion toxicity and & high osmotic stress. (Hasanuzzaman et al., 2013)

In this study, we have selected five genotypes of mung bean which are most commonly cultivated in West Bengal, India. Present study aimed to observe the differential physiological behaviour of mung bean genotypes under salt stress and to find out the most suitable one among the selected five mung bean genotypes for salt tolerance.

II. MATERIALS AND METHODS

Mung bean seeds were collected from Pulses and Oilseeds Research Station, Berhampur, West Bengal, India. In this experiment, after surface sterilization, five varieties (Samrat, Sonali B1, Panna, Sukumar WBM 29, and Bireswar WBM 4-34-1-1) of mung bean were allowed to germinate at five different levels of saline solutions (0, 6, 10, 16 and 20 dSm^{-1}). The electrical conductivity of saline solution was measured with a conductivity meter (dSm^{-1} = deci Siemen per meter). Finally seeds were germinated. Data were recorded after seven days.

Seedlings were evaluated for the following parameters using the following formulae –

1. Plant height stress tolerance index (PHSI) = (Plant height of stressed plant / Plant height of control plants) × 100 (Ashraf et al., 2006)
2. Root length stress tolerance index (RLSI) = (Root length stressed plant / Root length of control plants) ×100 (Ashraf et al., 2006)
3. Seedling height stress tolerance index (SHSI) = (Seedling height of stressed plant/ Seedling height of control) × 100 (Ashraf et al., 2006)
4. Root phytotoxicity (%) = (Root length of Control – Root length of treatment) / Root length of control ×100 (Asmare, 2013)

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5. Shoot phytotoxicity (%) = (Shoot length of Control – Shoot length of treatment) / Shoot length of control ×100 (Asmare, 2013)

Calculation of root T_{50} and shoot T_{50} was done using empirical probit values after converting the data into arcsine values.

Statistical analysis:

Interaction and differences between different salinity concentration and their effects on mung bean genotypes were determined by two-way analysis of variance with replication (ANOVA at $P<0.01$ and $P<0.05$ level). Separation of Mean was performed by Duncan's multiple range test (DMRT at $P<0.05$). Correlation between different morphological attributes of mung bean at different salinity stage was done by using SPSS correlation matrix. Principal component analysis (PCA) of morphological parameters of mung bean at different concentration of salinity was analyzed by using XLSTAT 2015 software.

III. RESULTS AND DISCUSSION

Response of Genotypes towards salinity

The varietal growth of five mung bean genotypes was measured in terms of root and SL along with different indices at different salt stress condition as shown in the tables Table 1 and Table 2.

Table 1. Mean (± SE) values for effects of salinity on root length (RL) shoot length (SL), RL/SL ratio, Average lateral root number, PHSI, RLSI and SHSI of five genotypes of V*igna radiata*. Means with the same letter in the columns do not differ significantly (p<0.05, using DMRT).

Variety	Salinity (dSm^{-1})	Root Length (cm)	Shoot Length (cm)	RL/SL ratio	Average Lateral Root Number	PHSI	RLSI	SHSI
SAMRAT	0	10.00±0.82^{a}	14.750±0.58^{a}	0.678±0.020^{hi}	5.5±0.53^{ef}	100	100	100
	6	8.38±0.48^{b}	13.375±0.96^{bc}	0.627±0.047^{ijk}	5.75±0.21^{de}	90.677±0.78^{g}	83.8±0.48^{d}	87.89±0.48^{g}
	10	7.45±0.48^{cd}	10.300±0.87^{f}	0.723±0.047^{gh}	6.5±0.63^{c}	69.83±0.30^{k}	74.5±0.54^{h}	71.71±0.96^{l}
	16	3.13±0.92^{h}	5.675±0.54^{hi}	0.551±0.024^{lm}	3.75±0.72^{n}	38.47±0.48^{l}	31.25±1.76^{l}	35.56±1.36^{q}
	20	2.78±0.58^{hi}	2.150±0.58^{kl}	1.291±0.082^{a}	2.75±0.38^{o}	37.88±0.54^{a}	27.75±0.82^{o}	19.89±0.96^{a}
SONALI	0	9.50±0.58^{a}	13.750±1.00^{b}	0.691±0.082^{gh}	4±0.36^{kmn}	100	100	100
	6	7.95±0.82^{bc}	12.875±0.22^{bcd}	0.617±0.062^{jk}	4±0.30^{kmn}	93.64±0.82^{i}	83.68±0.^{d} 54	89.56±0.96^{i}
	10	7.20±0.82^{de}	8.300±0.77^{g}	0.867±0.033^{e}	5.25±0.13^{fg}	60.36±0.53^{m}	75.78±0.82^{g}	66.66±0.82^{m}
	16	2.75±1.36^{hi}	4.750±0.29^{ij}	0.579±0.016^{kl}	6.5±0.63^{c}	34.55±0.82^{q}	28.94±0.53^{m}	32.25±0.58^{r}
	20	1.75±0.44^{jk}	2.150±0.44^{kl}	0.814±0.059^{ef}	4.75±0.72^{hi}	15.64±0.53^{a}	18.42±0.59^{r}	16.77±0.82^{a}
SUKUMAR	0	9.70±0.96^{a}	12.000±0.58^{de}	0.808±0.082^{f}	4.5±0.63^{ijk}	100	100	100
	6	8.25±1.26^{b}	8.875±0.89^{g}	0.930±0.038^{d}	5±0.82^{gh}	73.96±0.53^{j}	85.05±1.36^{c}	78.912±0.59^{k}
	10	6.550±1.26^{e}	6.000±0.91^{h}	1.092±0.082^{c}	6±0.72^{d}	50±0.30^{n}	67.52±0.44^{i}	57.83±0.58^{p}
	16	2.75±1.78^{hi}	3.750±1.04^{j}	0.733±0.054^{g}	4.25±0.96^{iklm}	31.25±0.48^{r}	28.35±0.58^{n}	29.95±0.92^{r}
	20	1.98±0.59^{jk}	1.600±0.59^{np}	1.234±0.033^{b}	6±0.82^{d}	13.33±0.59^{a}	20.36±0.44^{q}	16.47±0.82^{a}
PANNA	0	8.45±0.53^{b}	12.625±0.29^{d}	0.669±0.015^{hij}	8±0.13^{a}	100	100	100
	6	7.00±0.82^{de}	11.125±0.96^{de}	0.566±0.047^{ijk}	4±0.49^{kmn}	98.01±0.59^{h}	82.84±0.82^{e}	91.93±0.48^{h}
	10	6.70±0.82^{e}	8.000±0.71^{h}	0.838±0.047^{ef}	4.75±0.70^{hij}	63.366±0.82^{o}	79.29±0.58^{f}	69.75±0.82^{n}
	16	2.80±1.76^{hi}	3.875±0.48^{l}	0.723±0.047^{gh}	5.25±0.43^{fg}	30.69±0.59^{r}	33.14±0.58^{k}	31.67±1.36^{t}
	20	1.300±0.54^{k}	1.650±0.54^{kl}	0.788±0.024^{nop}	7±0.63^{b}	13.06±0.82^{a}	15.38±0.58^{s}	13.99±0.58^{a}
BIRESHWAR	0	5.300±0.48^{f}	10.575±0.93^{f}	0.501±0.050^{f}	4.25±0.55^{klm}	100	100	100
	6	4.93±0.30^{fg}	8.150±0.65^{g}	0.604±0.049^{h}	4.5±0.83^{ijk}	77.068±0.59^{j}	92.92±0.58^{b}	82.36±0.92^{j}
	10	4.38±0.30^{g}	5.250±0.87^{hi}	0.833±0.047^{jk}	7.25±0.48^{b}	49.64±0.54^{p}	82.54±0.44^{e}	60.62±0.82^{o}
	16	2.28±0.78^{ij}	2.625±0.48^{k}	0.867±0.033^{m}	5.25±0.48^{fg}	24.82±0.30^{s}	42.92±1.26^{j}	30.86±0.58^{s}
	20	1.25±0.15^{k}	1.125±0.15^{l}	1.111±0.237^{p}	4.5±0.83^{ijkl}	10.64±0.48^{d}	23.58±0.59^{p}	14.96±0.96^{d}

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Table 2. Root and shoot phytotoxicity along with their T_{50} values of five genotypes of V*igna radiata*.

		Root				Shoot			
Variety	Salinity	Root Phytotoxicity	Empirical Probit	Linear Equation	T_{50} ± SEE	Shoot Phytotoxicity	Empirical Probit	Linear Equation	T_{50} ± SEE
SAMRAT	6	16.2±0.48^{s}	4.01	y = 3.218x + 1.489 R^2 = 0.986	12.33±1.000^{a}	9.32±0.44^{t}	3.68	y = 4.369x + 0.198 R^2 = 0.977	12.56±1.103^{a}
	10	25.5±0.83^{p}	4.34			30.17±0.48^{r}	4.48		
	16	68.75±0.55^{l}	5.49			61.53±0.59^{n}	5.29		
	20	72.25±0.63^{h}	5.59			85.42±0.82^{i}	6.06		
SONALI	6	16.32±0.70^{e}	4.02	y = 3.732x + 1.036 R^2 = 0.992	11.54±1.060^{ab}	6.36±0.70^{d}	3.48	y = 4.647x - 0.072 R^2 = 0.986	12.34±1.079^{ab}
	10	24.21±0.49^{s}	4.30			39.64±0.43^{t}	4.74		
	16	71.05±0.43^{p}	5.55			65.45±0.55^{s}	5.39		
	20	81.58±0.55^{m}	5.89			84.36±0.58^{l}	6.00		
SUKUMAR	6	14.95±0.43^{g}	3.96	y = 3.540x + 1.271 R^2 = 0.993	11.31±1.056^{b}	26.04±0.44^{h}	4.36	y = 3.151x + 1.864 R^2 = 0.968	9.89±1.123^{c}
	10	32.47±0.58^{b}	4.55			50.00±0.58^{c}	5.00		
	16	71.65±0.48^{s}	5.57			68.75±0.48^{t}	5.49		
	20	79.64±0.82^{q}	5.83			86.67±0.96^{o}	6.11		
PANNA	6	17.16±0.96^{k}	4.05	y = 3.841x + 0.902 R^2 = 0.969	11.67±1.129^{ab}	11.88±0.70^{j}	3.82	y = 4.309x + 0.412 R^2 = 0.991	11.61±1.064^{b}
	10	20.71±0.82^{f}	4.18			36.63±0.82^{e}	4.66		
	16	66.86±0.70^{c}	5.44			69.31±0.49^{c}	5.50		
	20	84.62±0.49^{s}				86.93±0.58^{t}	6.12		
BIRESHWAR	6	32.07±0.55^{o}	4.53	y = 2.631x + 2.421 R^2 = 0.977	9.56±1.109^{c}	27.66±0.70^{q}	4.40	y = 3.383x + 1.727 R^2 = 0.982	9.28±1.09^{c}
	10	39.66±0.43^{n}	4.74			52.72±0.55^{m}	5.07		
	16	68.62±0.48^{i}	5.45			75.18±0.48^{g}	5.69		
	20	82.76±0.58^{a}	5.94			89.36±0.70^{a}	6.25		

Under salt stress, all the genotypes of mung bean responded in similar fashion though the intensity of reduction varied with genotypes. More adverse effect was noticed in SL than the RL. A highest inhibition in SL was noticed in the salt concentration at 20 dSm^{-1}. Both RL and SL were noticed maximum in Samrat & minimum in Bireshwar. Both PHSI & SHSI were highest in Samrat in all cases except 6dS/m where Sonali showed marginally higher values than that of SAMRAT. In all salinity concentrations Bireshwar showed the least PHSI value. But Sukumar and Panna comparatively showed higher RLSI and SHSI values. In case of RLSI, Samrat showed lowest value both in 6 and 20 dS/m though in 10 and 16 dS/m Bireshwar showed the lowest value. Out of five varieties Sukumar and Samrat showed highest Root phytotoxicity. On the other hand, Bireshwar showed highest shoot phytotoxicity. However, Samrat and Sonali showed the least shoot phytotoxicity. Out of the five varieties, Samrat was established as most tolerant, whereas Bireswar was found to be most sensitive in response towards salt stress condition. The results revealed that root and SL gradually decreased with increasing salt concentrations (0 to 20 dSm^{-1}) which is in agreement with the previous reports (Elsheikh and Wood, 1990).

Correlation analysis:

Considering the present result, one attempt was made to find out a correlation between different morphological attributes of mung bean under salinity stress. From the correlation matrix (Table 3), it can be stated that root and shoot length were negatively correlates with root and shoot phytotoxicity respectively. PHSI, RLSI and SHSI were positively correlates with each others.

Table 3. Correlation of the morphological parameters & indices studied.

Variables	Root Length (cm)	Shoot Length (cm)	Average Lateral Root No.	PHSI	RLSI	SHSI	Root Phytotoxicity	Shoot Phytotoxicity
Shoot Length (cm)	**0.9346**							
Average Lateral Root No.	0.0102	-0.0273						
PHSI	**0.9096**	**0.9696**	-0.0938					
RLSI	**0.8934**	**0.8951**	0.0358	**0.9411**				
SHSI	**0.9189**	**0.9599**	-0.0081	**0.9844**	**0.9781**			
Root Phytotoxicity	**-0.8934**	**-0.8951**	-0.0358	**-0.9411**	**-1.0000**	**-0.9781**		
Shoot Phytotoxicity	**-0.9096**	**-0.9775**	0.0317	**-0.9895**	**-0.9472**	**-0.9930**	**0.9472**	
RL/SL ratio	-0.2949	**-0.5548**	-0.0487	**-0.5007**	-0.3985	**-0.5001**	0.3985	**0.5590**

Values in bold are different from 0 with a significance level alpha=0.05

Dendrogram analysis:

Dendrogram cluster analysis (Fig 1) of different genotypes of mung bean was conducted on the basis of dissimilarities among them. All five genotypes were categorized into three separate groups on dendrogram analysis. Samrat, Sukumar and Panna were placed in a group and this group shears a common ancestor of Sonali. But Bireshwar showed totally separated from rest all.

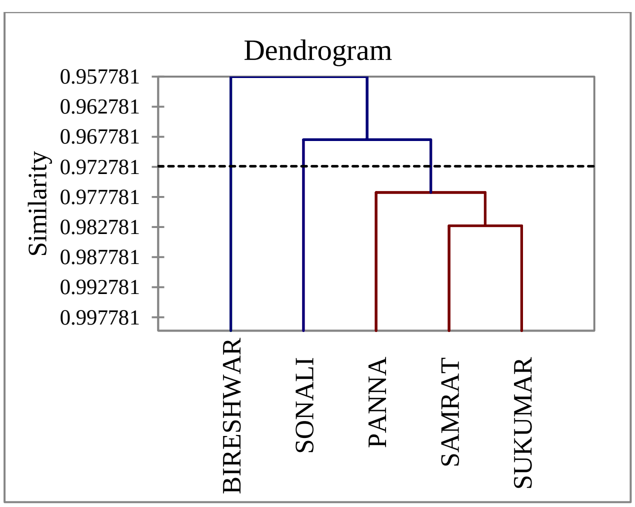

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Fig 1: Dendrogram cluster analysis of the five genotypes of Mung Bean.

Salinity assists to increase phytotoxic level of mung bean. Negative correlation between root and shoot length with their respective phytotoxicity revealed that salinity affects on root and soot development. On the basis of salinity tolerance capacity and the effects of salinity on morphological characteristic of mung bean genotypes samrat, sukumar and panna placed under a group. Though, on morphological aspect, sonali and samrat showed better stress tolerance activity among these five genotypes, but on the dendrogram analysis, sonali placed separates from samrat.

Analysis of variance (ANOVA):
In the present study, two-way ANOVA with replication was performed to find out the interaction between different concentrations of salinity with genotypes of mung bean. From ANOVA analysis (Table 3 and 4) it can be stated that the effects of both, genotypes and salinity, have a considerable impact on different morphological features of mung bean.

Table 4. Analysis of variance of five mung bean genotypes.

Source of Variation	df	F-Crit	Root Length			RL/SL Ratio			Root Phytotoxicity			Average Lateral Root Number			Shoot Phytotoxicity		
			MS	F	P-Value	MS	F	P-Value	MS	F	P-Value	MS	F	P-Value	MS	F	P-Value
Cultivars	4	2.49	42.91*	131.86	0.00*	0.21*	43.74	0.00*	999.48*	866.29	0.00*	6.19*	10.850	0.00*	442.81*	4775.24	0.00*
Salinity	4	2.49	157.86*	485.04	0.00*	0.58*	122.05	0.00*	18576.29*	16100.90	0.00*	36.06*	63.174	0.00*	26228.10*	282840.04	0.00*
Interaction	16	1.78	7.82*	24.03	0.00*	0.07*	15.63	0.00*	997.33*	864.43	0.00*	4.18*	7.319	0.00*	107.28*	1156.92	0.00*
Within	75		0.33*		0.00*	0.00*		0.00*	1.15*		0.00*	0.57*		0.00*	0.09*		0.00*

Table 5. Analysis of variance of five mung bean genotypes.

Source of Variation	df	F-Crit	Shoot Length			RLSI			PHSI			SHSI		
			MS	F	P-Value	MS	F	P-Value	MS	F	P-Value	MS	F	P-Value
Cultivars	4	2.53	40.31*	201.21	0.00*	251.25*	1678.83	0.00*	928.63*	3676.66	0.00*	176.57*	1363.514	0.00*
Salinity	3	2.76	302.86*	1511.76	0.00*	20074.03*	134132.09	0.00*	18373.32*	72744.28	0.00*	19917.34*	153808.229	0.00*
Interaction	12	1.92	3.85*	19.22	0.00*	58.57*	391.35	0.00*	142.31*	563.45	0.00*	36.51*	281.934	0.00*
Within	60		0.20*		0.00*	0.15*		0.00*	0.25*		0.00*	0.13*		0.00*

Morphological variation occurs with the variation of genotypes as well as with salinity changes. Interactions within salinity and different genotypes also were significant at $p<0.05$ level. ANOVA analysis helps to visualize the overall impacts of salinity on different mung bean genotypes.

CONCLUSION

Thus, present study revealed that mung bean genotypes vary in their vigor, tolerance indices and phytotoxicity. Significant differences were noticed in control treatment for all the measured features. In line with the sensitivity towards salt stress, the mung bean genotypes can be arranged as follows: Samrat < Sonali < Panna < Sukumar < Bireshwar. Thus, screening of the mungbean germplasm suggests that for salt tolerance out of the five selected mung bean genotypes, Samrat variety had superior vigor quality and most halo-tolerant. This mung bean genotype can be further used for genetic improvement for growing in saline soil.

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