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Effect of salinity on germination and seedling growth in Mungbean (*Vigna radiata* L. Wilczek) genotypes

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Abstract
The present investigation was carried out to find out the effect of salinity on germination and seedling growth of mungbean. Ten genotypes of greengram were evaluated at three levels of salinity *viz.* 0.0%, 0.2% and 0.4% NaCl. Salinity induced by supplementing 0.0 g, 2 g and 4 g NaCl, respectively to 1000 ml of double distilled water. Seven seeds of each genotype were sown in plastic trays filled with sterilized soil. 500 ml of test solution was applied to each plastic tray on alternate day. The temperature was 32.3 ^{0}C in laboratory room with 53% relative humidity. The experimental observations were taken on 17th day of sowing. The observations were recorded on germination percentage, shoot length, root length, seedling length, shoot fresh weight, root fresh weight, seedling fresh weight, shoot dry weight, root dry weight, seedling dry weight, root length/ shoot length ratio and seedling vigour index. The genotypes, salinity levels and genotype x salinity level interaction exhibited significant differences for most of the characters. Analysis of variance indicated significant differences among genotypes. The mean performance of all the characters decreased with increased salinity level. The genotype RMG-1099 was found more salt tolerant at seedling stage followed by RMG-1101 and MVM-2.

Keywords: Greengram, salinity, germination percentage, seedling characters

Introduction
Mungbean is a cheap source of protein and important nutritious dietary component of vegetarians in Asian countries especially in South- East Asia (Keatinge *et al.*, 2011) [15]. It is an excellent source of protein (24.5%) with high quality of lysine (460 mg/g) and tryptophan (60 mg/g), fat (0.6%), fiber (0.9%) and ash (3.7%) [Potter and Hotchkiss, 1998] [19]. Besides being a rich source of protein, it maintains soil fertility through biological nitrogen fixation in soil and thus plays a vital role in sustainable agriculture (Kannaiyan, 1999) [14]. When sprouted it also have a remarkable quantity of ascorbic acid and contains riboflavin (0.21 mg/g) and minerals (3.84 g/100g) [Gopalan *et al.*, 1995] [8]. Salinity stress is a main constraint in the production of mungbean where 50 mM NaCl can cause yield losses up to 70% (Saha *et al.*, 2010). The increased salinity of arable land is expected to have devastating global effects, resulting in up to 50% land loss by the middle of the twenty-first century (Mahajan and Tuteja, 2005; Hasanuzzaman *et al*., 2013) [16, 11]. Literature reported that higher accumulation of salt decreased the osmotic potential of soil solution causing water stress in plants and further interactions of the salts with mineral nutrition caused nutrient imbalance and deficiencies, oxidative stress ultimately lead to plant death as a consequence of growth arrest and metabolic damage (Zhu, 2001; Tavakkoli *et al.*, 2010; Hasanuzzaman *et al*., 2012) [30, 28, 10]. Study on the variability of the available material is the pre requisite for the initiation of breeding programme.

Material and Method
The experiment was carried out at the laboratory of Department of Plant Breeding and Genetics, Sri Karan Narendra College of Agriculture, Jobner (Rajasthan). Three plastic trays of 40cm×25cm in size were washed with washing powder followed by rinsing three times with tap water. After drying, these trays were filled with soil and used for sowing the seeds of different genotypes.
Seeds of 10 genotypes of mungbean *viz*: RMG-1095, RMG-1078, RMG-975, MSJ-118, RMG-976, RMG-1101, MVM-2, RMG-1079, RMG-1099 and RMG-492 were surface sterilised by using 0.1% mercuric chloride followed by three times rinsing with tap water. The three salinity levels namely 0.0% (control), 0.2% and 0.4% NaCl were created by supplementing 0, 2 and 4 g NaCI to 1000 ml of double distilled water, respectively. The experiment was carried out in completely randomized design (CRD) with three replications.

Seven seeds of each genotype were sown in plastic trays. Test solution applied in alternate day and 500 ml of test solution was applied uniformally to each plastic tray. The temperature was 32.3 ^{0}C in laboratory room with 53% relative humidity. The plastic trays were maintained in dark for the first two days followed by exposure to light achieved by tube lights and incandescent bulbs. The experimental observations were taken on 17th day of sowing. The methods used for observation are described below:

Germination percentage: The number of germinated seeds was recorded on 7th day after sowing and the final germination percentage was determined by using the following formula (Aniat *et al.*, 2012):

$$\text{Germination Percentage} = \frac{\text{Number of seed germinated}}{\text{Total number of seed sown}} \times 100$$

Root length, shoot length and seedling length (RL, SL & SLL): Seedlings were divided into two parts i.e. root and shoot by cutting with scissor and measured in centimeter by using a measuring scale. Seedling length was mentioned as total of root length and shoot length.

Root fresh weight, shoot fresh weight and seedling fresh weight (RFW, SFW & SLFW): The fresh weights of root and shoot were measured by using sensitive electronic balance in milligram. Seedling fresh weight was mentioned as total of root fresh weight and shoot fresh weight.

Root dry weight, shoot dry weight and seedling dry weight (RDW, SDW & SLDW): The roots and shoots kept into paper bags for drying in hot air oven at 65^0 C for 48 hours and dried till constant weight. After drying, the dried roots and shoots were weighed by sensitive electronic balance and mentioned in milligram.

Root length/shoot length: The root length/ shoot length ratio of seedling was calculated by the following formula.

$$\text{Root length/Shoot length Ratio} = \frac{\text{Root length}}{\text{Shoot length}}$$

Seedling vigour index (SVI): The seedling vigour index was determined by the following formula (Iqbal and Rahmati, 1992):

Seedling Vigour Index (SVI) = (RL+SL) x (GP)

Statistical analysis
The data obtained from this study were subjected to analysis of variance following standard statistical methods (Panse and Sukhatme, 1985) [18] and significant differences among the mean values were compared by least significant difference (LSD) test (P<0.05).

Result and Discussion
Analysis of variance
According to table (1) the pooled analysis of variance indicated that the mean sum of squares due to genotypes, salinity levels and genotype x salinity (G×S) interaction were significant for most of the characters. It indicated that there was significant difference among genotypes, salinity levels and significant effect of salinity on genotypes. According to Allard and Bradshaw (1964) [1] genotype × environment interaction is present in crop plant species. Azene *et al.*, (2014) [5] reported same results in lentil. Significant genotype × environment interaction, reflecting that all the genotypes respond differentially to salinity levels (Gogile *et al.*, 2013) [7]. Analysis of variance for each salinity level exhibited significant differences in genotypes which indicated that there was sufficient variability in the genotypes used for this investigation.

Effect of salinity on mean performance of genotypes
Perusal of tables indicated that germination percentage, root length, shoot length, seedling length, root dry weight, shoot dry weight, seedling dry weight and seedling vigour index decreased with increasing salinity levels, while root length/shoot length ratio was observed to be almost same. Difference was highest for shoot dry weight. Similar findings were also reported by Promila and Kumar (2000) [20]. Lowest difference was observed for root length/shoot length ratio.

Salinity considerably reduced the germination percentage with increasing salt stress. Similar findings were reported by Kandil *et al*., (2012) [13], Sehrawat *et al*., (2014) [25] and Kamrul *et al.*, (2018) [12] in mungbean. Germination percentage and seedling characteristics (root length, shoot length, seedling length, shoot fresh weight, root fresh weight, seedling fresh weight, root dry weight, shoot dry weight, seedling dry weight and seedling vigour index) were decreased with increasing salinity level and widely reported in mung bean (Swarnakar, 2016) [27], in lentil, chickpea and faba bean (Arslan *et al.*, 2016) [3], in cowpea (Haleem, 2015) [9], in *Pisum sativum* var. *abyssinicum* and *Lathyrus sativus* (Tsegay and Gebreslassie, 2014) [29], in moth bean and mung bean (Saroj and Soumana, 2014) [24]. The mean values of all the characters adversely affected by salinity levels. The effect of salinity was much higher at 0.4% (S_3) salinity level than at 0.2% (S_2) as compared to control (S_1). Seedling survival on saline soils may depend on tolerance to low osmotic potential (Roundy, 1983) [22]. Both radical and shoot length are closely related to early growth, which could be used to evaluate the early growth potential (Shen *et al*., 1991; Pujol *et al*., 2000) [26, 21]. In addition to toxic effect of certain ions, higher concentration of salt reduce the water potential in the medium which hinder the water absorption by germinating seed and thus reduce germination. Salinity suppressed the uptake of essential nutrients like P and K (Nasim *et al*., 2008) [17], which could adversely affect seedling growth and vigour. Salt induced changes in plant growth and morphology, photosynthetic capacity, cell membrane integrity, cellular enzyme protection system and many physiological and biochemical activities (Chen *et al*., 2007 [6] According to overall rank (Table 3) the genotypes RMG-1099, RMG-1101 and MVM-2 exhibited more tolerance to salinity level.

Table 1: Pooled ANOVA showing mean sum of squares of various characters in mungbean

		Characters											
Source	**df**	**GP(%)**	**SL**	**Rl**	**SLL**	**RFW**	**SFW**	**SLFW**	**RDW**	**SDW**	**SLDW**	**RL/SL**	**SVI**
Genotypes (S)	9	160.85**	10.27**	5.88**	23.69**	3375.05**	109708.62**	132712.53**	100.83**	184.52**	485.50**	0.01**	279579.44**
Salinity levels (S)	2	6584.92**	1266.19**	235.41**	2590.11**	539233.25**	7810807.85**	12454031.49**	1006.35**	101640.69**	122863.93**	0.00	38731214.71**
G X S	18	108.95**	3.19**	2.09**	7.81**	912.32**	45330.83**	41854.77**	32.03**	64.57**	86.69**	0.00**	148872.80**
Pooled Error	60	43.21	1.29	0.48	1.50	214.95	10235.28	11243.43	3.51	24.47	24.24	0.00	59899.00

** significant at 1% significance * significant at 5% significant

Table 2: Effect of salinity on mean performance of various characters at different salinity level in set-II

S. No.	Characters		Mean of genotypes									
			RMG-1095	**RMG-1078**	**RMG-975**	**MSJ-118**	**RMG-976**	**RMG-1101**	**MVM-2**	**RMG-1079**	**RMG-1099**	**RMG-492**
1	Germination Percentage	S_1	100	95.24	100	100	85.71	95.24	100	95.24	90.24	90.47
		S2	71.42	80.95	76.18	85.71	76.18	85.71	80.95	76.18	71.42	76.18
		S3	57.14	57.14	66.66	85.71	66.66	61.9	57.14	66.66	66.66	71.42
2	Shoot Length	S_1	26.37	25.3	26.98	26.98	29.83	25.02	26.43	27.15	26.02	27.26
		S2	22.96	24.75	25.79	25.53	27.38	24.67	26.1	25.79	25.16	26.31
		S3	12.85	13.32	14.25	15.76	14.95	13.68	16.38	13.55	17.21	16.59
3	Root Length	S_1	12.12	9.27	11.15	12.59	12.59	10.83	13.43	11.75	11.45	11.67
		S2	9.29	10.46	10.21	11.69	10.31	9.81	13.33	10.56	10.94	10.59
		S3	6.43	5.53	5.95	5.83	5.29	6.63	7.46	6.27	8.23	6.62
4	Seedling Length	S_1	38.49	34.57	38.13	38.94	42.42	35.85	39.87	38.9	37.47	38.93
		S2	29.77	31.65	33.1	35.25	35.57	31.08	35.92	32.69	32.27	33.81
		S3	19.28	18.85	20.2	21.58	20.24	20.31	23.84	19.82	25.44	23.21
5	Root Fresh Weight	S_1	231.97	281.77	262.5	288.5	296.13	254.07	351.4	250.53	261.93	281.97
		S2	229.47	246.8	243.67	258.43	250.17	248.47	326.37	247.17	257.6	254.47
		S3	31.03	31.57	33.1	32.43	29.47	35.1	41.27	35.1	45.03	36.17
6	Shoot Fresh Weight	S_1	2049.33	1915.13	2094	2161.33	2437.33	1909.8	2031.67	2100.33	2009	2100
		S2	1755.43	1914.43	2037.77	2003.53	2240	1907.07	1996	2026.08	1963.37	2078.33
		S3	1031.67	1033.33	1130.33	1258.77	1210	1064.33	1485	1077.67	1347.667	922
7	Seedling fresh Weight	S_1	2281.3	2196.9	2356.5	2449.83	2733.46	2163.81	2383.07	2350.87	2270.93	2381.97
		S2	1994.9	2161.23	2281.43	2261.97	2490.17	2155.53	2322.37	2273.97	2220.97	2332.8
		S3	1062.7	1064.9	1163.43	1291.47	1239.47	1099.43	1526.27	1112.77	1392.7	958.17
8	Root Dry Weight	S_1	20.83	34.63	30.87	38.47	37.73	29.37	41.37	31.03	34.47	33.27
		S2	26.43	27.97	27.53	28.77	28.1	25.67	38.77	28.83	33.77	25.33
		S3	2013	19.77	21.07	20.33	19.3	21.9	24.3	21.6	26.47	22.87
9	Shoot Dry Weight	S_1	147.37	148.03	149.77	159.37	164.2	141.7	159.27	155.33	153.37	154.47
		S2	106.73	113.07	118.1	116.2	123.53	112.43	114.87	117.3	115.07	120.07
		S3	32.57	41.17	39.37	42.6	42.93	36.7	47.4	36.3	45.1	26.7
10	Seedling Dry Weight	S_1	168.2	182.67	180.63	197.83	201.93	171.07	200.63	186.37	187.83	187.73
		S2	133.17	141.03	145.63	144.97	151.63	138.1	153.63	146.13	148.83	145.4
		S3	52.7	60.93	60.43	62.93	62.23	58.6	71.7	57.9	71.57	49.57
11	Root Length/Shoot Length Ratio	S_1	0.46	0.37	0.41	0.48	0.42	0.43	0.51	0.43	0.44	0.43
		S2	0.4	0.42	0.4	0.46	0.38	0.4	0.51	0.41	0.44	0.4
		S3	0.5	0.42	0.42	0.37	0.36	0.49	0.46	0.46	0.48	0.4
12	Seedling Vigour Index	S_1	3848.67	3283.19	3813.33	3894	3634.2	3411.66	3986.67	3695.27	3389.24	3524.56
		S2	2303.06	2853.9	2745.7	3189.55	2866.4	2954.71	3194.35	2774.12	2578.26	2803.64
		S3	1101.66	1077.28	1344.44	1849.91	1355.1	1260.28	1362.22	1316.25	1699.07	1657.42

Table 3: The overall rank of different genotypes of mungbean based on rank of % reduction in S_m as compared to control (S_1)

Variety	GP	SL	RL	SLL	RFW	SFW	SLFW	RDW	SDW	SLDW	RL/SL	SVI	Total	Rank
RMG- 1095	10	10	9	10	1	10	10	1	10	6	6	10	93	9
RMG- 1078	7	6	1	3	9	4	4	8	4	5	1	5	57	4
RMG- 975	8	7	6	7	5	5	5	5	2	3	5	9	67	5
MSJ- 118	1	4	8	6	8	6	6	9	7	9	10	1	75	7
RMG- 976	2	9	10	9	10	9	9	10	6	8	9	6	97	10
RMG- 1101	4	5	4	5	4	3	3	4	1	2	3	4	42	2
MVM- 2	9	2	3	2	6	1	1	6	5	4	7	7	53	3
RMG- 1079	6	8	7	8	3	7	7	3	8	7	4	8	76	8
RMG- 1099	5	1	2	1	2	2	2	2	3	1	2	3	26	1
RMG- 492	3	3	5	4	7	8	8	7	9	10	8	2	74	6

Where S_m is the mean of two salinity levels, GP= germination percentage, SL=shoot length, RL=root length,SLL=seedling length, RFW=root fresh weight, SFW=shoot fresh weight, SLFW=seedling fresh weight, RDW=root dry weight, SDW=shoot dry weight, SLDW=seedling dry weight, RL/SL=root length/shoot length ratio, SVI=seedling vigour index

Conclusion and Recommendation

First essential requirement of successful breeding programme is collection and evaluation of germplasms having adequate variability for economically important characters. The response to salinity is a complex phenomenon and according to age of the plant the response of genotypes to stress varied. The germination and seedling establishment are most sensitive to salinity (Awasthi *et al*., 2016).

With reference to the effect of salinity on seedling traits at higher salinity level (0.4%) the means performance of various traits reduced in comparison to 0.0% and 0.2% NaCl salinity. However, variation existed; the genotypes RMG- 1099, RMG-1101 and MVM-2 were found to be the best suited for salinity. Direct or indirect exploitation of these genotypes through hybridization is recommended for breeding of genotypes suitable for salinity.

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Conflict of Interest

Authors would hereby like to declare that there is no conflict of interest that could possibly arise.

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