Original Article

Sodium Chloride Induced Salinity Effects On Quality Protein Maize (Zea Mays L.) Hybrids At Germination And Early Seedling Stage

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Abstract

Incubation investigation was conducted at the throughout the summerseas on of 2022 to observe the effects of diverse levels of salinity on germination and early seedling development of ten QPM hybrids. The response of QPM hybrids against four different salinity levels viz. 0, 50, 100 and 150 mM) were studied. This study was implemented as a factorial trial under Completely Randomized Design (CRD) with three replications for all salinity levels. Analysis of Variance (ANOVA) showed that there were significant differences ($P < 0.05$) among salinity stress levels, hybrids and interaction effects for all investigated traits. Additional study presented that there were significant differences ($P < 0.05$) among hybrids for germination percentage, germination time, shoot length, root length seedling biomass and seedvigor at all Salinity levels. Then, there were no significant differences originated in seedling dry weight ofthe hybrids at salinity level of 150 mM for the lengths of shoot, root and the entire seedling. Germination percentage gradually decreased with the increase of concentration of salt. Up to 50 mM concentration wasconsidered safe for QPM hybrids seed germination. Salinity affected delay in germination. Highest seedling height was found at 0 mM NaCl concentration. Highest Shoot length (2.38cm) and root length(3.4544cm) was found in 50 mM NaCl concentration. In 100 mM NaCl concentration roots were abnormal, deformed and twisted. The 0 and 50 mM NaCl concentration provided statistically similar shoot length. The 50 mM NaCl concentration was found satisfactory permissible for germination and early seedling development of maize. Results showed that hybrid VH141720was the most tolerant hybrid than new hybrids under salinity stress.

Key words: Germination indices, QPM hybrids, salinity stress and NaCl.

1. INTRODUCTION

Salinity is a common abiotic stress factor extremely affecting crop yield indiverse are as, mostly in waterless and semi-arid areas of the world. It is expected that over 800 million hectares of land in the world are affected together by salinity and sodicity(Munns, 2005).

Among the cereal species, Maize (Zea mays L.) appears to be vulnerable to salt stress. Maize is being cultivated more in India. Its farming area is increasing to areas having high possibility for addition of saltsin the soil profile, such as in India, the area under salt-affected soils is about 6.73 million ha with states ofGujarat (2.23 m ha), Uttar Pradesh

(1.37 m ha), Maharashtra (0.61 m ha), West Bengal (0.44 m ha) and Rajasthan (0.38 m ha) together accounting for almost 75% of saline and sodic soils in the country. It is, therefore, significant to develop novel maize varieties which are highly tolerant to salt stress. The first vital step in breeding innovative varieties with extraordinary salt tolerance is to require a useful and significant genetic difference in acceptance to salinity stress. Breeders seek to develop and recognize cultivars that are additional tolerant toward salinity and water stress .Sowing of seeds and its germination phase is the most critical and sensitive phases in the life cycle of the plant during which the seeds are exposed to the stressful environmental conditions of the soil which affect the seedling phase. Seed planting normally careful the first critical and most sensitive phase in the life cycle of plants and seeds are regularly exposed to disapproving environmental situations that may negotiation the establishing of seedling (Figueiredo-e-Albuquerque and Carvalho 2003; Misra and Dwivedi, 2004). Growth and seedling features are the maximum feasible benchmarks used for choosing salt tolerance in plants. Germination percentage, its rate and seedling lenght are most appropriate benchmarks for selection of cultivars. Seed reaction to salinity can be imitated by NaCl induced ionic stress in the initial growth of seeds. Ionic stress is affected by a toxic addition of NaCl in plant tissues. Germination rates decline with arise in NaCl concentration (Murillo-Amador et al., 2002).

The current study was consequently conducted mostly to estimate the affect of salinity on seed germination and seedling progress of tenQPM hybrids under salinity situations. The main objective wasto compare ten QPM hybrids with required to their tolerance towards salinity stress and to select the extreme tolerant QPM hybrid.

2. MATERIALS AND METHODS

A total of 10 QPM hybrid lines (Table.1) designed for current study were obtained from International Centre for Maize and Wheat Improvement Centre (CIMMYT), ICRISAT, Hyderabad, India .These lines were sown at Department of Botany, Andhra University Visakhapatnam, Andhra Pradesh during 15 April to 27April 2022.Impact of salt stress incited by four levels specifically 0, 50, 100 and 150 mM of NaCl ongermination and early seedling progression of QPM lines were examined. This experiment was conductedas factorial experiment under Completely Randomized Design (CRD) using three replications for each hybrid and salinity levels.

This study was done in Petri-dishes (11 cm) .The ten seeds of each QPM hybrid were taken and washed two times in sterile distilled water. Then, there spectivea mount of NaCl and H_2O solution according to the salinity was poured in Petri-dishes. Then theseeds of each QPM hybrid were placed in these Petri dishes and then kept in an incubator (50% relative humidity) at 30°C.Germination rate was observed every day and salinity solutions were supplemented when required. Comparably particular salt solution arrangements were added as and they when required.

Germinated seeds were measured after 7 daysfor respective characters. After 7 days, germination percentage was measured by ISTA (International Seed Testing Association) standard technique. By the completion of the 7th day, the germination percentage, mean germination duration, shoot length, root length, length of seedling, Seedling biomass, Seedling dry weight and seed vigor were also measured by using following formula.

Formula 1: $GP = \frac{SNG}{SN0} \times 100$

Where, GP germination rate; SNG is the quantity of sprouted seeds and SN0 number of experimental seeds with viability (Scott et al., 1984).

Formula 2: $GR = \frac{\sum N}{\sum (n \times g)}$

Where, GR is germination rate; n is the number of germinated seed on g^{th} day and g is the number of total germinated seeds (Ellis and Robert, 1981).

Formula 3: Seed energy = Germination rate × Seedling length

Analyses were done using the SAS software. Differences between means were determined by Excel tool at probability level 5%. Drawn plots using software MS-Excel spread sheet.

Table1. Details of the 10 QPM hybrids used in this study Stock ID (V-15371)

Sl.No.	Name	Pedigree
1	VH141734	CML171-BBB-1-B*10/CLQRCYQ44-B*4-1-#-B
2	VH141730	(CML161xCLQ-RCYQ31)-B-22-2-B*5/((CML150xCLG2501)-B-31-1-B-1-BBB/CML193-BB-B- 2-BB(Q)-B*4
3	VH141782	CML451Q-B*8/CML193-B*7-#-B
4	VH141950	S99TLYQ(HG-AB)-BBB-6-B*7/(CML161xCLQ-RCYQ31)-B-22-2-B*5
5	VH141775	Pop61C1QPMTEYF-39-3-1-2-B-1-BB-#((CML150Xclg2501)-B-31-1-B-1-BBB/CML193-BB)-B- 2-BB(Q)-B*4
6	VH141720	(CLQ-RCYQ46xCLQ-rcyq14=(cml164*cml161)-B-1-1-1-BBB)-B-11-1 B*5/((CML150xCLG2501)-B-31-1-B-1-BBB/CML193-BB)-B-2-BB(Q)-B*4
7	VH141732	(CML161xCLQ-RCYQ31)-B-22-2-B*5/G34QC24-BBB-16-B*8-#-B
8	VH133634	(CLQ-RCYQ31xCLQ-RCYQ49=(CML176xCL-G2501)-B-55-2-1-B)-B-10-3- B*5/(CML161X165)-F2-5-2-2-1-B-1-1-BBB-#-B
9	VH141733	CML171-BBB-1-B*10/(CML176xCLG2501)-b-55-1-2-B*4)
10	VH1411986	(CML161xCLQ-RCYQ31)-B-3-6-BB-3-B*8/(CLQ-6601xCL-02843)-b-26-1-1-BB-1 B*9

3. RESULTS AND DISCUSSIONS

Analysis of Variance showed that there were significant differences between salinity stress levels. The results of this study reveal that various concentrations of NaCl had a significant effect on the all measured traits except Seedling dry weight. For QPM hybrids, there were significant differences for all traits except Seedling dry weight and seedling biomass of drought level and hybrids. Also, Analysis of Variance presented that interaction effects were significant for all traits except seedling dry weight had non- significant at interaction effect of hybrids and level of salinity. (Table-2).

Germination percentage of all QPM hybrids ware significantly harmfully affected due to the use of different levels (0, 50, 100 and 150 mM) of NaCl salt. The differences between the average of hybridsand salinity levels were associated and are explained in (Fig.-1). It was seen that in all the hybrids there was a linear decline in germination percentage because of gradual salinity increment. However in this trial, diverse QPM hybrids exhibited several responses toward salinity stress. Among the hybrids, VH141720 had the highest germination percentage and the hybrids VH141782,VH141730 and VH141734 had the lowest germination percentage (Fig.- 2). However, maximum reduction in germination percentage was observed at the highest level of applied salts that is, 150 mM of NaCl (Fig-1).Hybrids VH141720 and VH1411986 had the highest germination rate and some hybrids like VH141732, VH133634 and VH141733 were relative lytolerant to salinity stress (Table 3). There were significant differences among hybrids in the term of their germination percentage at all levels of salinity stress (Table4).

Table 2. Analysis of Variance for measured traits in QPM hybrids under control and different levels of Salinity

Source of Variance	D. f.	Germin ation %	Germinati on time (Days)	Root lengt h (cm)	Shoot lengt h (cm)	Seedling lengt h (cm)	Seedling biomas s(g)	Seedling dry weigh t	Vigor index
Drought Levels	3	367.5**	24.053**	13.426**	66.484**	402.249**	2.640**	0.010ns	3359358.91**
Hybrids	9	220.834**	1.172**	13.426**	4.080**	25.459**	0.138**	0.033ns	264439.33**
Drough t levels× Hybrid	27	189.723**	0.168*	3.820**	1.352**	8.560**	0.038 ns	0.005ns	77805.41**
Error	80	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265

** Significant &**ns** non-significance at 5% level of significance

Table 3. Mean comparison of QPM hybrids at different salinity stress levels.

Genotype	Germination %	Germinatio nperiod (Days)	Shoot lengt h (cm)	Root lengt h (cm)	Length of seedling (cm)	Seedling biomass(g)	Seedlin gdry weight	Vigo r inde x
H1	75	3.875	2.01	1.89 3	3.90 3	0.55 2	0.2	312.82 5
H2	75	3.875	2.01	1.89 3	3.90 3	0.55 2	0.2	312.82 5
H3	74.25	3.375	1.55 5	2.37 6	3.93 1	0.56 1	0.245 7	303.21 1
H4	82.5	4	3.11	4.69	7.8	0.61 5	0.258 8	669.02 5
H5	81.25	4.575	2.06	2.76 5	4.82 5	0.58 1	0.205	408.27 5
H6	86.75	3.875	2.91	4.45	7.36	0.76 3	0.255	689.86 5
H7	83.25	4.225	1.42	2.5	3.92	0.81 2	0.321	331.75
H8	83.437	4.1687	2.37 5	3.60 2	5.97 6	0.69 3	0.259	524.72 9

H9	83.672	4.211	2.192	3.329	5.523	0.712	0.260	488.654
H10	84.277	4.119	2.224	3.471	5.694	0.745	0.274	508.749

Table 4. Supplementary analysis of interaction effects between salinity and QPM hybrids

Treatment	Germination %	Germinationperiod (Days)	Shoot length (cm)	Root length (cm)	Length of seedling (cm)	Seedling Biomass (g)	Seedlingdry weight	Vigor index
0 control	88	3.08	4.306	6.183	10.489	1.058	0.225	931.1
50 mM	85	3.7	2.38	3.454	5.834	0.764	0.267	504.13
100mM	82	4.19	1.268	1.700	2.968	0.468	0.253	242.02
150mM	80	5.2	1.05	1.48	2.53	0.416	0.263	205.08

Results of means of the assessment values showed that germination percentage and germination rate were linearly decreased by decrease in Osmotic potential of NaCl solution, while the maximum germination rate and percentage was obtained at zero level of applied salts (Fig-1 and Table.3). Outcomes also show that germination rate had the most significant effect on plants establishment under laboratory conditions. This is also in agreement with the results of Farsiani and Ghobadi (2009) and Khayatnezhad et al. (2010) in maize, Gholamin and Khayatnezhad (2010) in wheat and Mostafavi (2011) in Safflower. Some studies showed that stress can contribute to improve germination rate and seedling emergence in different plant species by increasing the expression of aquaporins (Gao et al., 1999), enhancement of ATPase activity, RNA and Acid Phosphatase Synthesis (Fu et al., 1988) and also by increase of amylases, proteases or lipases activity (Ashraf and Foolad, 2005). The decreasing tendency of germination rate due to increasing salinity was in the conformity with the reports of early researchers (Mohammed et al., 1989; Khan et al., 1997). The reduction of germination rate at high salt levels might be mainly due to osmotic stress (Heenan et al., 1988)

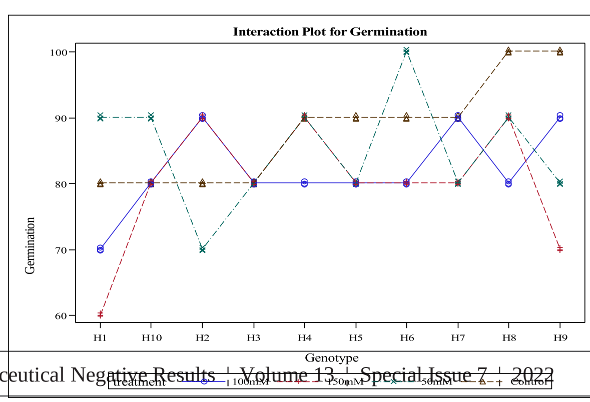

Fig.1. Interaction plot for germination percentage at different levels of salinity (0, 50mM, 100mM and 150mM)

InFig -1,out of tenmaize hybrids, VH141775and VH141733 had the highest mean germination time. The mean germination time increased with decrease in the osmotic potential in NaCl solution (Table 3). In NaCl treatments, the mean germination time was delayed by stress conditions. There were significant differences between hybrids for mean germination time at all salinity levels (Table 4). Alebrahim et al. (2008) reported that with decrease in the Osmotic potential in PEG and NaCl solutions, the mean germination time in lines of MO17 and B73 increased. Mostafavi (2011) in a study of 6 genotypes of Safflower reported that the mean germination time increased withincrease in the Osmotic potential in NaCl solution.

The length of shoot is one of the greatest important traits for salinity stress because roots are in interaction with soil and taken water from soil. For this reason, the Shoot length provides an important sign to the response of plant life to salinity stress. A noticeable reduction in the shoot length, root length and length of seedling of all hybrids of maize was seeing due to salt stress. Among the 10 QPM hybrids, hybrid VH141950 and VH141720 had the highest shoot length, root length and seedling length, hybrid VH141732 VH141734 and VH141730 had the lowest shoot length, root length and seedling length (Table3).

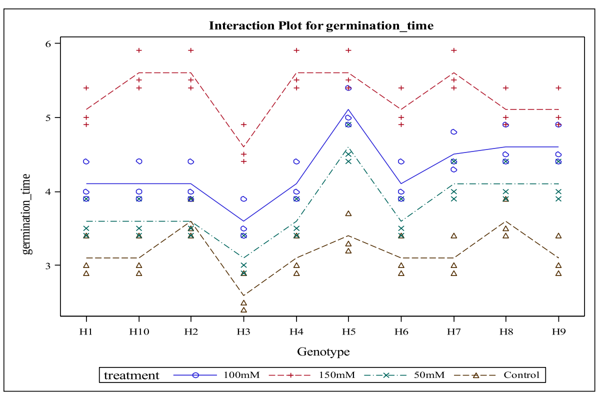

Fig.2. Interaction plot for germination period(days) at different levels of salinity (0, 50mM, 100mM and 150mM)

The results of this study show that length of Shoot, Root and Seedling decreased with increasing salinity levels in all hybrids (Table 3). Also, it was clearly determined that there were no significant differences between studied hybrids at salinity level 150 mM for the length of shoot , root and seedling (Table 4). The most effective levels in reducing these attributes were 100 mM of NaCl (Table 3).The Best level these of NaCl concentration in shoot length, root length and seedling length was control treatment. This results arein agreement with many earlier studies (Gholamin and Khayatnezhad, 2010; Farsiani and Ghobadi, 2009; Mohammadkhani and Heidari, 2008; Jajarmi, 2009; Khayatnezhad et al., 2010). Reduction of seedling height is a common phenomenon of many crop plants grown under saline conditions (Javed and Khan, 1995; Karim et al., 2010; Amin et al., 1996). Kramer (1974) reported that the first effect that is measurable due to water deficit was the growth reduction, caused by the declining in the cellularexpansion. The cellular elongation process and the carbohydrates wall synthesis are very susceptible to water deficit (Wenkert et al., 1978) and the growing decrease was a consequence of the turge scence lyingdown of those cells (Shalhevet et al., 1995).

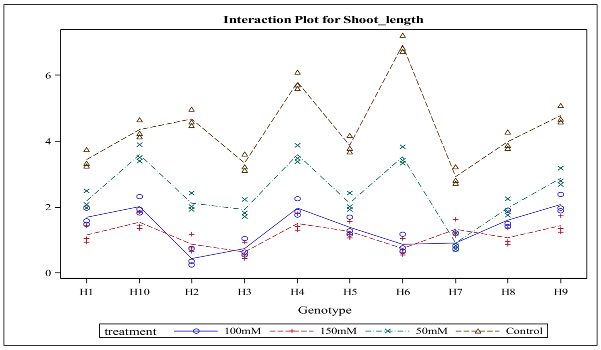

Fig.3. Shoot length at different levels of salinity (0, 50mM, 100mM and 150mM)

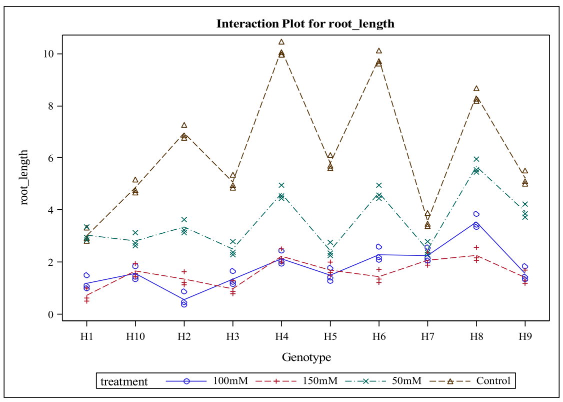

Fig.4. Rootlength at different levels of salinity (0, 50mM, 100mM and 150mM)

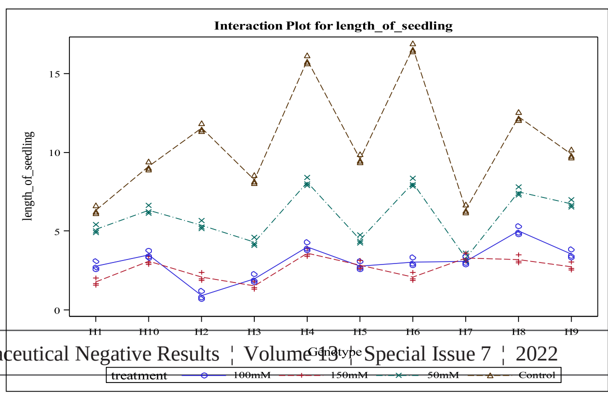

Fig.5. Length of Seedling at different levels of salinity (0, 50mM, 100mM and 150mM**)**

A clear reduction in the seedling biomass and seedling dry weight of all QPM hybrids was seen due tosalt stress. Among the 10 maize hybrids, hybrid VH141720 and VH141732 had the highest seedling biomass and seedling dry weight, hybrid VH141730and VH141734 had the lowest seedling biomass and seedling dry weight (Table 3).respectively.

Outcomes of this experiment showed that seedling biomass and seedling dry weight reduced with increasing salinity levels in all hybrids (Table 3). Also, it was clearly determined that there were no significant differences among the hybrids at salinity level 150 mM for the seedling biomass, and seedling dry weight (Table 4). The most effective levels in dropping these traits were 100 mM of NaCl (Table 3). Best level of NaCl concentration in seedling biomass and seedling dry weight was control treatment.

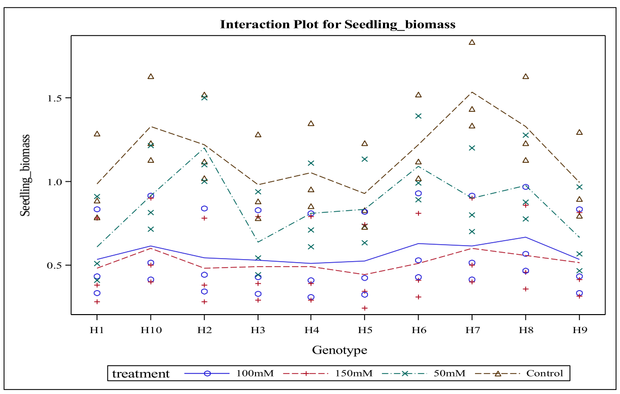

Fig.6. Seedling biomass at different levels of salinity (0, 50mM, 100mM and 150mM)

Seed vigor decreased with decrease in Osmotic potential of NaCl solution. Best level of NaCl concentration in seed vigor was the control treatment (Table 3). A significant inter-genotype variation was observed under salt stress. Out of all the hybrids, VH141950 and, VH141720 produced highest seed vigor at all salt concentrations, while VH141734 and VH141730 produced lowest seed vigor (Table 3). There were significant differences for seed vigor between hybrids in all salinity levels (Table 4). Mostafavi (2011) reported that seed vigor increased in Osmotic potential until -3 bars but decreased in -5 bars.

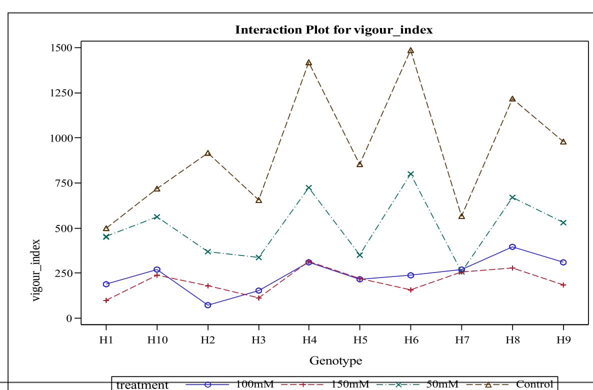

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Fig.7. Seed vigor at different level of salinity (0, 50mM, 100mM and 150mM)

4.1 Character Association

In a biological system, most of the characters are associated with each other and such correlation may be the result of some pleiotropic effects of a gene due to environmental effects. Correlation analysis helps in the figuring out the strength of relationship between the two traits. To estimate the genetic inter- relationship of two characters under study, phenotypic correlation coefficients were worked out and measured for all possible combinations of characters of 10 QPM hybrids under various saline environments. Germination percent exhibited positive and significant association with Seed vigor, Root length, Seedling length, shoot length and seedling biomass but Positive non-significant effect with seedling dry weight while there is Negative association with germination time. Germination time showed positive and weak association with seedling dry weight where asshoot length, root length seedling length seedling biomass and vigor index had strong and Negative association. Shoot length exhibited Strong with the length of seedling, seed vigor root length and seedling biomass where as very weak and Negativeseedling dry weight. Root length show positive and strong association with Seedling length (cm) flowed by Seed vigor and seedling biomass while seedling dry weight had very weak and Negative association. Seedling length exhibited highly strong and positive association with Seed vigor fallowed by seedling biomass where as seedling dry weight had very weak and negative association. Seedling biomass exhibited very strong positive association with Seed vigor whereas seedling dry weight had very weak and Negative association. Seedlings dry weight exhibit very weak and negation whereas other had no any correlation with others. The results from table-4 indicated that there was significant correlation between leaf length root length, shoot length, fresh plant weight and dry plant weight. The correlation between root length and shoot length was also found as positive and significant. The positive and significant correlation among studied traits indicated that the selection of chickpea and pea genotypes for salt stress tolerance may be helpful to improve yield under salt stress environmental conditions (Ali et al., 2013; 2016; Flowers et al., 2010; Khalil et al., 2020; Mazhar et al., 2020).

Table 5. Estimates of phenotypic correlation coefficients between Germination percentage and its related traits in 10QPM hybrids.

	Germination %	Germinationtime (Days)	Shoot length (cm)	Root length (cm)	Length of seedling (cm)	Seedling biomass (g)	Seedling dry weight	Vigor index
Germination %	1.000							
Germination time(Days)	-0.264	1.000						
Shoot length(cm)	0.391	-0.679**	1.000					
Root length(cm)	0.459**	-0.606**	0.886**	1.000				
Length of	0.444**	-0.653**	0.957**	0.983**	1.000			

seedling(cm)								
Seedling biomass(g)	0.336	-0.709**	0.745**	0.746**	0.767**	1.000		
Seedling dry weight(g)	0.265	0.173	-0.171	-0.021	-0.082	-0.004	1.000	
Vigor index	0.534**	-0.634**	0.944**	0.978**	0.992**	0.751**	-0.061	1.000

**** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

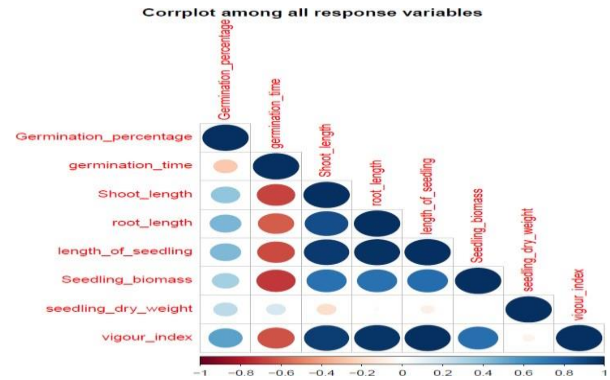

Fig-8. Character association at different concentrations of salinity (0, 50mM, 100mM and 150mM).

4. CONCLUSIONS

In the current study, Salt stress unfavorably affected the germination percentage, mean germination time, length of shoot, rootlength, seedling length, seedling biomass, seedling dry weight and seedvig or of ten QPM hybrids. A significant difference in salt tolerance was also seen between all the considered hybrids. Clearly, satisfactory growth of plants in waterless and semiarid lands which counter the effects of salinity stress is associated to the ability of seeds that best germinated under unfavorable situations, so the assessment of salinity tolerant genotypes is significant at primary growth stage. In this investigation, with consideration to the hybridsVH141950, VH141720 and VH141732had the highest Germination percentage, mean germination time ,shoot length , root length ,seedling length, seedling biomass ,seedlingdry weight and seed vigour be valued as salt stress tolerant hybrid whereas , hybridsVH141734 and VH141730is the maximum sensitive hybrid with regard to salinity stress.

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