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Evaluation of sulphate and chloride dominant salt tolerance of groundnut genotypes based on physiological traits

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ABSTRACT

Six genotypes of groundnut were germinated at 28 ± 2^{0}C temperature in seed germinator and irrigated with sulphate and chloride dominant saline solution. Both type of salinity affected the normal growth of groundnut seedlings. Germination per cent, root and shoot length, fresh and dry weight of seedlings, vigour index, and relative water content (RWC) at 4 and 8 days after sowing (DAS) were recorded relatively higher in chloride dominated salinity compared to sulphate dominated salinity. It indicated that the sulphate dominant salinity was more detrimental to germination and seedling growth than chloride dominant salinity. Germination percentage was decreased significantly in all groundnut genotypes with increasing concentration of 0, 20, 40 and 80 m eq/L salts. Higher germination percentage was found in JL-24 in sulphate dominant salinity and GG-2 genotype in chloride dominant salinity. The higher root and shoot length were found in JL-24 and GG-2 genotypes while fresh and dry weight of seedlings were recorded higher in JL-24, GG-2 and GAUG-10 genotypes in response to salt stress. Jl-24 genotype exhibited superior in vigour index at 4 and 8 DAS. Among the genotypes tested, less reduction of RWC in GAUG-10 indicated greater tolerance capacity to both the salt stress. Thus, JL-24 was found relatively more salt tolerant genotype followed by GG-2 and GAUG-10 while GG-7, GG-13 and GG-20 were evaluated as salt susceptible genotypes against sulphate and chloride dominant salinity.

Key words : Groundnut, Salinity, Germination, Vigour index, Relative water content, Salt tolerance

INTRODUCTION

Among oilseed crops grown in India, groundnut occupies a predominant position. It has now not remained only as an important edible oilseed, but also gained prominence as an important cash crop and foreign exchange earner for India. Therefore, groundnut is rightly eulogized as 'King of oilseeds' in India as it contributes 40 per cent of the total area and 30 per cent of total production of oilseed crops. India ranks first in area (5 million hectares) and second in production (4.625 million tones) in the world, though the productivity level is less than half of the major groundnut growing countries and around one-third of the rest of world levels (Singhal, 2003).

The multiple uses of the groundnut make it an excellent cash crop for domestic markets as well as foreign trade. The total area under groundnut cultivation in India is 8.0 million hectares, which accounts for the total production of 7.5 metric tones with the productivity of 937.5 kg ha^{-1}. (FAO, 2004). Among the major groundnut growing states, Gujarat is the most important one accounting for 32 per cent of the total area. The total area under groundnut cultivation in Gujarat is 2 million hectares accounting for 4.4 metric tones production and the productivity is 2235 kg ha^{-1} (Anonymous, 2004).

The productivity of groundnut in India is lower because this crop is grown mainly on marginal lands in rain fed areas, inland saline and coastal saline soils with low inputs. A salt affected soil in India varies from 8.56 M ha to 10.9 M ha. In Gujarat, the salt affected area is 1.34 M ha. which work out to 6.5 % of cultivated area (Goyal *et al.,* 2004). Saurashtra region of Gujarat, which is popularly known as groundnut bowl of India, is affected by soil and water salinity. Due to non availability of good quality water, farmers have no option but to use saline water for groundnut cultivation. The management of saline water and soil salinity under agro climatic conditions for increasing groundnut production is one of the important areas of the research (Girdhar *et al.,* 2004).

Salinity is the accumulation of dissolved salts in the soil water to an extent that inhibits plant growth (Gorham, 1992). Salinity is a major constraint to food production because it limits crop yield and restricts use of land previously uncultivated. Salinity can affect growth, dry matter accumulation and yield. It is well known that dry mass of plant is reduced in proportion to the increase in salinity. The reduction in growth of salinized plants may be related to salt induced disturbance of the plant water balance, and growth reduction under salinity stress include ionic imbalances, changes in nutrient and phytohormonal status, physiological processes, biochemical reactions, or a combination of such factors (Kumar, 2000).

Among several strategies advised to overcome the problem of salinity stress, the selection of crop species or cultivars with salt tolerance traits has been considered an economical and efficient strategy. Hence, present study aimed to screen the salt tolerance genotypes of groundnut based on physiological traits which give better

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response under salt stress.

MATERIALS AND METHODS

Six genotypes (V_1 - JL-24, V_2 – GG-2, V_3 – GG-7, V_4 – GAUG-10, V_5 – GG-13 and V_6 – GG-20) of Groundnut (*Arachis hypogaea* L.) were germinated 28 ± 2 ^{O}C in seed germinator. Prior to that, seeds were sterilized with 0.1 % $HgCl_2$ solution and washed with distilled water. Fifty seeds each was kept in filter paper lined Petridishes and irrigated with salt solution. Two types of saline solution namely Sulphate and Chloride dominants were created by mixture of different salts (Table 1). The concentration of saline solutions- 20, 40 and 80 m eq /L were used for Salt stress. Total eight treatments were arranged as – (A) Sulphate based salinity - T_1 - 00 m eq /L (*i.e.* Distilled water, Control), T_2 - 20 m eq /L, T_3 -40 m eq /L, T_4 -80 m eq /L; (B) Chloride based salinity - T_5 - 00 m eq /L (*i.e.* Distilled water, Control), T_6 -20 m eq / L, T_7 -40 m eq /L, T_8 -80 m eq /L. Seedling of 4 and 8 days after sowing (DAS) were taken out, washed with distilled water and placed between filter paper for removing external moisture. Entire seedling including cotyledon was used for determination of various physiological parameters. Experiment was conducted in three replications of Completely Randomized Design with two factors to interpret the data (Snedecor and Cochran, 1967).

Seeds of six groundnut genotypes were allowed to germinate as described previously and germination per cent was calculated (ISTA, 1976). Shoot and root length of the seedlings were recorded at 4 and 8 DAS for each genotype. Fresh and dry weight of entire seedlings were also measured at both the stages. Vigour index was calculated as germination per cent multiplied with shoot length (ISTA, 1976). For determination of relative water content (RWC), One gram of groundnut leaf sample was transferred in a petridish. To this, 10 ml distilled water was added and kept for one hour. Then the leaves were taken out, dried by blotting paper and weighed (turgid weight). After that, the leaf was kept in oven at 80^{0} C for 5 hours and weighted until constant dry weight was obtained. RWC was calculated as per following formula (Weatherley, 1962).

$$\text{RWC (\%)} = \frac{\text{Fresh weight (g.)} - \text{Dry weight (g.)}}{\text{Turgid weight (g.)} - \text{Dry weight (g.)}} \times 100$$

RESULTS AND DISCUSSION

The results obtained from the present study as well as relevant discussion have been presented under following heads:

Germination:

Higher germination per cent was observed on control treatment (T_1) and it was significantly reduced with increasing salt concentration of sulphate dominant salinity (Table 2A). Mean significant highest germination per cent was recorded in JL-24 (85.3%), followed by genotypes GG-2 (81.8%), GG-20 (79.7%), GAUG-10 (77.5 %), GG-7 (76.7 %) and GG-13 (75.7 %). The interaction effect between genotypes and treatments indicated that germination per cent was higher in JL-24, followed by GG-2, GG-20, GAUG-10, GG-13 and GG-7 in T_1 and it was significantly declined in salt treatments like T_2, T_3, and T_4. Drastic reduction in germination per cent was observed in salt susceptible genotypes - GG-13, GG-20, GG-7 at higher salt concentration treatments (T_3 and T_4) compared to salt tolerant genotypes – Jl-24, GG-2, GAUG-10. Similar trend of decreasing germination per cent was observed against chloride dominant salinity (Table 2B) as found in sulphate dominant salinity, but the germination per cent was found higher in all genotypes at higher salt treatments (T_3 and T_4) compared to sulphate dominant salinity. It indicated that chloride dominant salinity was

Table 1 : Preparation of sulphate and chloride dominant solution by mixture of different salts

Conc. of salt (m eq/L)	1 N Solution					Conc. of Ions (m eq/L)	
	NaCl (ml/L)	Na_2SO_4 (ml/L)	$MgCl_2$. $6H_2O$ (ml/L)	Mg SO_4 .$7H_2O$ (ml/L)	$CaCl_2$. $2H_2O$ (ml/L)	SO_4^{-2}	Cl^{-1}
(A) Sulphate Dominant Salinity							
20	3.66	9.34	0.5	4.0	2.5	13.3	6.7
40	7.33	18.68	1.0	8.0	5.0	26.7	13.3
80	14.66	37.36	2.0	16.0	10.0	53.3	26.7
(B) Chloride Dominant Salinity							
20	7.33	4.67	1.0	2.0	5.0	6.7	13.3
40	14.66	9.34	2.0	4.0	10.0	13.3	26.7
80	29.32	18.68	4.0	8.0	20.05	26.7	53.3

less harmful to germinate groundnut genotypes compared to sulphate dominant salinity. The highest germination was found in genotype JL-24 in sulphate dominant salinity and genotype GG-2 in chloride dominant salinity at T_4 treatment (80 m eq/L). Patel *et al.* (1992) found significantly highest final mean germination percentage of 72.5 in Jl-24 against salinity over rest of genotypes which support our results.

Considerable higher germination per cent in control treatment and increasing the levels of salt concentration resulted to decrease germination per cent. The similar results were also in different groundnut genotypes against increasing salinity (0.20, 9.0 12.0 m mho /cm) was reported by Nautiyal *et al.* (1989). Present results revealed that salinity stress reduced germination. Delayed germination was also observed in rice (Mondal *et al*., 1988). Inhibition of germination under chloride salinity was observed in wheat (Begum *et al*., 1992), barley (Kumar *et al*., 1988) and finger millet (Onkware *et al*., 1993). This salinity induced inhibition of germination may be due to accumulation of excess amount of ions (salts) which are toxic to plants (Begum *et al*., 1992).

Seedling growth:

The root length was not affected by lower salt concentration (T_2, T_3 and T_6, T_7) in tolerant genotypes-JL-24, GG-2 and GAUG-10 against both types of salinity (Table 3). However, root length was significantly reduced in all genotypes at higher salt concentration (T_4 and T_8 - 80 m eq/L), but rate of reduction was less in salt tolerant genotypes compared to salt susceptible genotypes (GG-13, GG-7, GG-20). Root length was increased at higher rate in salt tolerant genotypes during 4 to 8 DAS at all salt concentration compared to susceptible genotypes. Similar trend for shoot length was also observed for both types of salinity (Table 4). The shoot length significantly decreased with higher sulphate and chloride dominant salt concentration (T_4 and T_8 - 80 m eq/L) in groundnut genotypes. Among the genotypes, GG-7, GG-13 and GG-20 showed maximum decrease in shoot length as compared to control for sulphate dominant salinity on 4 DAS and also exhibited less root length of these genotypes at 8 DAS. However, JL-24 showed minimum decreased in shoot length over rest of genotypes against chloride dominant salinity on 4 and 8 DAS. The fact that

Table 2 : Effect of salt stress on germination (%) of groundnut seeds

(A) Sulphate dominant salinity

Genotypes of groundnut	Salt treatment (m eq/L)				
	T_1 (0)	T_2 (20)	T_3 (40)	T_4 (80)	Gx
JL-24	95.3	88.7	80.7	76.3	85.3
GG-2	93.4	84.3	76.7	72.6	81.8
GG-7	90.2	79.2	70.7	66.6	76.7
GAUG-10	91.4	80.4	71.6	66.7	77.5
GG-13	90.3	79.7	68.4	64.5	75.7
GG-20	93.3	83.7	73.2	68.4	79.7
Tx	92.3	82.7	73.6	69.2	
	S.E. ±		C.D. (P=0.05)		CV %
G	0.23		0.65		
T	0.19		0.53		0.99
G x T	0.46		1.30		

(B) Chloride dominant salinity

Genotypes of groundnut	Salt treatment (m eq/L)				
	T_5 (0)	T_6 (20)	T_7 (40)	T_8 (80)	Gx
JL-24	94.6	89.3	82.8	75.4	85.5
GG-2	93.7	90.5	85.5	78.4	87.0
GG-7	90.4	78.5	72.9	64.8	76.6
GAUG-10	90.2	83.8	78.3	68.9	80.3
GG-13	90.4	77.4	69.5	64.2	75.4
GG-20	93.2	80.5	75.9	68.4	79.5
Tx	92.1	83.3	77.5	70.0	
	S.E. ±		C.D. (P=0.05)		CV %
G	0.26		0.73		
T	0.21		0.60		1.1
G x T	0.51		1.46		

Table 3: Effect on root length (cm) of groundnut seedlings in response to salt stress

(A) Sulphate dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_1	T_2	T_3	T_4	Gx	T_1	T_2	T_3	T_4	Gx
JL-24	4.0	3.3	3.0	3.0	3.3	9.8	8.1	7.3	7.2	8.1
GG-2	4.2	4.3	3.2	2.5	3.6	10.8	11.0	8.1	6.3	9.0
GG-7	3.9	3.4	2.5	2.3	3.0	8.3	7.4	5.3	4.9	6.5
GAUG-10	3.7	3.4	3.0	2.6	3.2	8.6	8.0	7.0	6.1	7.4
GG-13	3.0	2.4	2.4	2.2	2.5	6.6	5.3	5.3	4.9	5.6
GG-20	3.0	2.9	2.5	2.3	2.7	6.7	6.5	5.6	5.1	6.0
Tx	3.6	3.3	2.8	2.5		8.5	7.7	6.4	5.7	
	S.E.±		C.D. (P=0.05)		CV %	S.E.±		C.D. (P=0.05)		CV %
G	0.03		0.08			0.01		0.04		
T	0.02		0.07		3.29	0.01		0.03		0.72
G X T	0.06		0.16			0.03		0.08		

(B) Chloride dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_5	T_6	T_7	T_8	Gx	T_5	T_6	T_7	T_8	Gx
JL-24	4.1	3.3	3.2	2.7	3.3	10.2	8.3	8.0	6.9	8.4
GG-2	4.3	4.2	3.8	3.0	3.8	11.2	10.9	9.9	8.0	10.0
GG-7	3.9	3.6	3.2	3.1	3.4	8.8	8.0	7.1	6.9	7.7
GAUG-10	3.7	3.7	3.4	3.1	3.5	9.1	8.9	8.2	7.7	8.5
GG-13	3.0	2.7	2.5	2.2	2.6	7.1	6.3	5.8	5.1	6.1
GG-20	3.1	2.9	2.7	2.5	2.8	7.2	6.7	6.3	5.8	6.5
Tx	3.7	3.4	3.1	2.8		8.9	8.2	7.5	6.7	
	S.E.±		C.D. (P=0.05)		CV %	S.E.±		C.D. (P=0.05)		CV %
G	0.04		0.12			0.24		0.69		
T	0.03		0.10		4.53	0.20		0.56		10.64
G X T	0.08		0.24			0.48		NS		

NS-Non significant

Table 4 : Effect on shoot length (cm) of groundnut seedlings in response to salt stress

(A) Sulphate dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_1	T_2	T_3	T_4	Gx	T_1	T_2	T_3	T_4	Gx
JL-24	1.3	1.3	0.9	0.8	1.1	4.8	4.8	3.2	3.2	4.0
GG-2	1.2	1.3	0.9	0.7	1.0	4.4	4.8	3.3	2.7	3.8
GG-7	0.8	0.8	0.5	0.6	0.7	2.7	2.7	2.5	2.5	2.6
GAUG-10	0.8	0.8	0.7	0.7	0.7	3.5	3.5	3.0	3.0	3.3
GG-13	0.9	0.9	0.8	0.6	0.8	3.3	3.2	2.9	2.0	2.9
GG-20	0.8	0.8	0.7	0.6	0.7	2.8	2.8	2.7	2.2	2.7
Tx	1.0	1.0	0.7	0.7		3.6	3.7	3.0	2.6	
	S.E.±		C.D. (P=0.05)		CV %	S.E.±		C.D. (P=0.05)		CV %
G	0.02		0.05			0.01		0.04		
T	0.01		0.04		7.0	0.01		0.03		1.56
G X T	0.03		0.09			0.03		0.08		

(B) Chloride dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_5	T_6	T_7	T_8	Gx	T_5	T_6	T_7	T_8	Gx
JL-24	1.3	1.4	1.2	0.9	1.2	5.1	5.7	4.7	3.6	4.8
GG-2	1.2	1.1	0.7	0.6	0.9	4.7	4.3	3.0	2.3	3.6
GG-7	0.6	0.6	0.6	0.6	0.6	3.0	2.9	2.8	2.8	2.9
GAUG-10	0.8	0.8	0.7	0.6	0.7	3.8	3.8	3.4	3.0	3.5
GG-13	0.9	0.8	0.7	0.7	0.8	3.6	3.4	2.8	2.8	3.1
GG-20	0.8	0.7	0.7	0.6	0.7	3.3	3.0	2.7	2.4	2.9
Gx	0.9	0.9	0.8	0.6		3.9	3.8	3.2	2.8	
	S.E.±		C.D. (P=0.05)		CV %	S.E.±		C.D. (P=0.05)		CV %
G	0.02		0.04			0.14		0.39		
T	0.01		0.04		6.6	0.11		0.32		13.6
V X T	0.03		0.09			0.27		0.77		

lower sulphate and chloride dominant salinity did not affect growth in all genotypes of groundnut on 4 and 8 DAS but higher both types of salinity reduced the length of root and shoot during 4 to 8 DAS. The reduction was found higher in sulphate dominant salinity than chloride dominant salinity in salt susceptible genotypes compared to salt tolerant genotypes. Mondal *et al.* (1988) observed plumule and radicle length of rice gradually decreased with increasing salinity. Higher salinity also decreased the seedling growth of barley (Kumar *et al.*, 1988). The excessive accumulation of both Na and Cl ions and increase in Na/K ion ratio under higher salinity are responsible for poor growth of seedlings (Matsushita and Matoh, 1991).

Fresh and Dry weight of seedlings (g/ 10 seedlings) significantly decreased with the increase in sulphate and chloride dominant salinity from 0 to 80 m eq/L for all groundnut genotypes at 4 and 8 DAS (Table 5 and 6). The highest mean fresh and dry weight of seedlings was obtained in GAUG-10 for both type of salinity at 4 and 8 DAS. Rate of increase in fresh and dry weight during 4 to 8 DAS was also found higher in GAUG-10 compared to rest of genotypes. The seedling dry weight of all genotypes decreased with the increase in salinity level. Similar decrease in shoot and root dry weight also observed in barley (Kumar *et al*., 1988), rice (Mondal *et al*., 1988) and guar (Khan *et al*., 1989).

Seedling vigour:

The highest vigour index was recorded in JL-24 followed by GG-2 and GG-13. However, genotype GAUG-10 was at par with GG-20 and again significantly decreased by GG-7 at 4 DAS in sulphate dominant salinity (Table 7A). While the significantly highest vigour index

Table 5 : Effect on fresh weight (g/10 seedlings) of groundnut seedlings in response to salt stress

(A) Sulphate dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_1	T_2	T_3	T_4	Gx	T_1	T_2	T_3	T_4	Gx
JL-24	27.1	21.4	15.2	10.8	18.7	41.5	32.9	23.6	17.0	28.7
GG-2	26.2	23.8	18.8	14.2	20.8	40.1	36.5	29.0	22.1	31.9
GG-7	22.1	20.4	18.1	10.8	17.9	32.0	29.4	26.0	15.0	25.6
GAUG-10	32.1	29.1	24.4	12.2	24.5	47.0	42.5	35.4	17.1	35.5
GG-13	23.4	20.4	16.0	13.2	18.3	33.9	29.1	22.5	18.3	26.0
GG-20	22.2	21.4	17.7	17.3	19.7	31.8	32.0	26.5	25.9	29.0
Tx	25.6	22.8	18.4	13.1		37.7	33.7	27.2	19.2	

	S.E.±	C.D. (P=0.05)	CV %	S.E.±	C.D. (P=0.05)	CV %
G	0.12	0.33		0.14	0.41	
T	0.10	0.27	2.02	0.12	0.34	1.70
G X T	0.23	0.66		0.29	0.82	

(B) Chloride dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_5	T_6	T_7	T_8	Gx	T_5	T_6	T_7	T_8	Gx
JL-24	28.0	24.3	21.3	18.0	22.9	42.0	36.5	32.0	27.0	34.4
GG-2	27.1	23.3	20.2	15.3	21.5	40.7	35.0	30.3	23.0	32.2
GG-7	23.0	20.7	14.7	13.3	18.0	32.5	29.1	20.1	18.0	24.9
GAUG-10	33.0	29.1	23.4	18.5	26.0	47.5	41.7	33.1	25.8	37.0
GG-13	24.3	22.3	15.3	14.2	19.1	34.2	31.2	20.7	19.0	26.3
GG-20	23.1	21.7	18.0	14.5	19.4	33.8	31.7	26.1	20.9	28.1
Tx	26.5	23.6	18.9	15.7		38.5	34.2	27.1	22.3	

	S.E.±	C.D. (P=0.05)	CV %	S.E.±	C.D. (P=0.05)	CV %
G	0.49	1.38		0.32	0.91	
T	0.40	1.13	7.96	0.26	0.75	3.64
G X T	0.97	NS		0.64	1.83	

NS-Non significant

Table 6 : Effect on dry weight (g/10 seedlings) of groundnut seedlings in response to salt stress

(A) Sulphate dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_1	T_2	T_3	T_4	Gx	T_1	T_2	T_3	T_4	Gx
JL-24	7.9	5.7	3.7	3.3	5.1	11.5	8.2	5.2	4.6	7.4
GG-2	7.0	4.6	4.2	2.7	4.6	10.2	6.6	6.0	3.7	6.6
GG-7	4.6	4.3	3.6	2.5	3.7	6.6	6.1	5.1	3.4	5.3
GAUG-10	10.8	8.3	4.7	2.7	6.6	15.9	12.1	6.7	3.7	9.6
GG-13	5.3	4.2	3.1	2.4	3.7	7.6	6.0	4.3	3.3	5.3
GG-20	4.8	4.3	3.6	3.1	3.9	6.9	6.1	5.1	4.3	5.6
Tx	6.7	5.2	3.8	2.8		9.8	7.5	5.4	3.9	

	S.E.±	C.D. (P=0.05)	CV %	S.E.±	C.D. (P=0.05)	CV %
G	0.10	0.29		0.08	0.22	
T	0.08	0.24	7.62	0.06	0.18	4.0
G X T	0.20	0.58		0.15	0.44	

(B) Chloride dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_5	T_6	T_7	T_8	Gx	T_5	T_6	T_7	T_8	Gx
JL-24	7.9	5.2	4.4	2.9	5.1	12.0	8.0	6.8	4.5	7.8
GG-2	6.9	4.3	3.9	3.0	4.5	10.5	6.6	6.0	4.7	6.9
GG-7	4.5	3.9	3.0	2.7	3.5	6.9	6.0	4.7	4.2	5.4
GAUG-10	10.7	7.6	4.9	3.6	6.7	16.2	11.6	7.5	5.6	10.2
GG-13	5.2	4.0	2.7	2.3	3.5	8.0	6.2	4.2	3.6	5.5
GG-20	4.7	4.0	3.4	3.1	3.8	7.2	6.2	5.3	4.8	5.9
Tx	6.6	4.8	3.7	2.9		10.1	7.4	5.7	4.6	

	S.E.±	C.D. (P=0.05)	CV %	S.E.±	C.D. (P=0.05)	CV %
G	0.11	0.31		0.19	0.53	
T	0.09	0.26	8.53	0.15	0.43	9.25
G X T	0.22	0.63		0.37	1.06	

was recorded in JL-24 followed by GG-2, GAUG-10, GG-13, GG-20 and GG-7 at 8 DAS. The interaction effect between genotypes and treatments was found to be significant at 4 and 8 DAS. The higher vigour index was found in chloride based salinity in all respects (Table 7B) as compare to sulphate based salinity. However, the pattern of fall in vigour index was similar for both sulphate and chloride dominant salinity.

Vigour index showed a gradual decrease under sulphate and chloride dominant salinity ranging from 0 to 80 m eq/L at 4 and 8 DAS (Table 7). The maximum seedling vigour was observed in JL-24 at all salinity level and during entire growth period (4 and 8 DAS). At 80 m eq/L (T_4 and T_8) concentration of both type of salinity, the seedling vigour was decreased maximum as compared to control at both the stages 4 and 8 DAS. Genotypes GG-7, GG-13 and GG-20 showed minimum seedling vigour compared to control at higher salt concentration (T_3, T_4 and T_7, T_8) during 4 to 8 DAS. JL-24 exhibited superior in vigor index on all days after germination.

Relative water content (RWC):

The mean value for genotypes showed significantly highest RWC in GAUG-10 (73.6 %) followed by the genotypes GG-2, GG-20, GG-13, GG-7 and JL-24 at 4 DAS (Table 8A). RWC increased significantly in all genotypes during 4 to 8 DAS under sulphate dominant salinity. Control (T_1) had significantly higher value of 75.9 and 82.6 % RWC compared to salt stress treatments - 20, 40 and 80 m eq / L at 4 and 8 DAS, respectively. Combined effect of genotypes and treatments indicated higher RWC with T_1 in GAUG-10, while it was lowest in JL-24 at higher salt stress *viz*., T_3, and T_4 treatments under sulphate dominant salinity.

Significantly highest mean RWC was recorded in GAUG-10 (75.4 %) under chloride based salinity at 4 DAS followed by the cv. JL-24, GG-2, GG-20, GG-13 and GG-7 (Table 8B). Similar pattern of decreased in RWC was found under chloride dominant salinity as observed in sulphate dominant salinity. The highest RWC was found in chloride dominant salinity as compare to sulphate dominant salinity under 0, 20, 40 and 80 m eq / L treatments at both 4 and 8 DAS. Among the genotypes,

Table 8 : Effect on relative water content (RWC) of groundnut seedlings in response to salt stress

(A) Sulphate dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_1	T_2	T_3	T_4	Gx	T_1	T_2	T_3	T_4	Gx
JL-24	76.4	72.6	65.9	55.8	67.7	83.0	79.9	74.5	65.5	75.7
GG-2	76.4	76.4	71.1	65.9	72.4	83.0	80.7	78.7	74.5	79.2
GG-7	74.7	73.1	70.9	58.2	69.2	81.6	80.3	78.5	66.7	76.8
GAUG-10	78.2	77.8	76.9	61.5	73.6	84.4	82.1	83.4	70.6	80.1
GG-13	75.3	73.2	68.5	64.5	70.4	82.1	80.4	76.6	73.2	78.1
GG-20	74.6	74.2	70.4	70.5	72.4	81.5	81.3	77.3	78.2	79.6
Tx	75.9	74.5	70.6	62.7		82.6	80.8	78.2	71.4	

	S.E.±	C.D. (P=0.05)	CV %	S.E.±	C.D. (P=0.05)	CV %
G	0.08	0.22		0.06	0.16	
T	0.06	0.18	0.37	0.05	0.13	0.26
G X T	0.15	0.43		0.12	0.33	

(B) Chloride dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_5	T_6	T_7	T_8	Gx	T_5	T_6	T_7	T_8	Gx
JL-24	76.6	75.6	73.1	70.6	74.0	83.7	83.0	81.0	78.9	81.6
GG-2	76.7	75.5	72.3	65.8	72.6	83.8	82.8	80.3	74.9	80.5
GG-7	75.0	73.0	64.6	62.0	68.6	82.1	80.8	73.8	71.6	77.1
GAUG-10	78.5	77.9	75.0	70.3	75.4	85.0	84.7	82.4	79.1	82.8
GG-13	75.6	74.7	66.4	65.0	70.4	83.0	82.3	75.4	74.1	78.7
GG-20	74.9	74.1	69.9	63.9	70.7	82.3	81.7	78.6	73.2	79.0
Tx	76.2	75.1	70.2	66.3		83.3	82.6	78.6	75.3	

	S.E.±	C.D. (P=0.05)	CV %	S.E.±	C.D. (P=0.05)	CV %
G	0.22	0.64		0.42	1.19	
T	0.18	0.52	1.08	0.34	0.97	1.81
G X T	0.45	1.27		0.83	2.37	

Table 7: Effect on vigor index of groundnut seedlings in response to salt stress

(A) Sulphate dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_1	T_2	T_3	T_4	Gx	T_1	T_2	T_3	T_4	Gx
JL-24	108.3	100.3	61.7	54.9	81.3	430.7	398.7	244.0	215.7	322.2
GG-2	95.7	84.3	55.0	40.5	68.9	380.0	334.7	212.0	154.7	270.3
GG-7	47.1	40.9	37.0	35.8	40.2	232.7	198.0	182.0	176.2	197.2
GAUG-10	62.2	58.7	46.3	40.3	51.9	307.8	290.3	228.7	198.7	256.4
GG-13	74.1	69.6	57.9	35.3	59.3	286.7	276.0	222.7	138.7	231.0
GG-20	65.6	56.3	49.5	35.3	51.7	260.0	222.7	189.3	134.5	201.6
Tx	75.5	68.4	51.2	40.4		316.3	286.7	213.1	169.7	

	4 DAS S.E.±	4 DAS C.D. (P=0.05)	4 DAS CV %	8 DAS S.E.±	8 DAS C.D. (P=0.05)	8 DAS CV %
G	0.09	0.25		0.44	1.26	
T	0.07	0.20	0.52	0.36	1.02	0.62
G X T	0.18	0.50		0.88	2.51	

(B) Chloride dominant salinity

Genotypes of groundnut	4 DAS					8 DAS				
	T_5	T_6	T_7	T_8	Gx	T_5	T_6	T_7	T_8	Gx
JL-24	108.9	108.1	87.1	60.4	91.1	431.4	423.4	344.0	235.9	358.7
GG-2	96.2	70.6	46.0	30.9	60.9	380.7	278.0	174.4	119.5	238.2
GG-7	47.7	41.6	38.8	36.7	41.2	233.4	203.0	185.2	178.5	200.0
GAUG-10	62.7	59.1	47.1	37.4	51.6	308.5	286.4	226.7	182.1	250.9
GG-13	74.7	68.2	50.7	44.6	59.5	287.4	261.4	196.9	172.7	229.6
GG-20	70.9	55.1	45.6	35.7	51.8	279.4	214.5	175.4	137.3	201.6
Tx	76.9	67.1	52.6	41.0		320.1	277.8	217.1	171.0	

	4 DAS S.E.±	4 DAS C.D. (P=0.05)	4 DAS CV %	8 DAS S.E.±	8 DAS C.D. (P=0.05)	8 DAS CV %
G	0.36	1.02		0.61	1.74	
T	0.29	0.83	2.09	0.50	1.42	0.86
G X T	0.72	2.04		1.23	3.49	

the less reduction of RWC in GAUG-10 indicated greater tolerance capacity to salt stress. The earlier findings of Ravindra *et al*. (1990) in groundnut supported the present study, where the significant reduction in RWC was observed with stress conditions.

Considering physiological traits - germination percentage, seedling vigour and RWC, it may be concluded that sulphate dominant salinity was more detrimental to seedling growth of all groundnut genotypes compared to chloride based salinity. Among the genotypes, Jl-24 was found relatively more salt tolerant towards simulated salinity stress condition while GG-2 and GAUG-10 was observed moderately salt tolerant. However, GG-7, GG-13 and GG-20 were considered as salt susceptible genotypes.

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