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EFFECTS OF NaCl SALINITY ON GROWTH OF SOME COTTON VARIETIES AND THE ROOT ROT PATHOGENS

Abdul Rauf, M. Javed Zaki and D. Khan

Department of Botany, University of Karachi, Karachi-77250, Pakistan

ABSTRACT

Salinity is one of the predisposing factors to plant disease and increase the severity of the plant disease. An experiment was conducted to determine the effect the different levels of NaCl salinity on growth of *Cotton (Gossypium hirsutum L.)* varieties (CIM-598, CIM-599, CIM-602, CIM-573 and CIM-554) and its root rot pathogens. These varieties of Cotton were grown under different salinity levels @ 0, 30, 60, 90, 120 and 150mM NaCl (corresponding to 1.91, 5.72, 9.54, 13.43, 16.43, and 20.98 $dS.m^{-1}$). The salinity reduced the root and shoot growth significantly. Root weight was the most limiting growth parameter. On the basis of 50% reduction of root weight, the in hand cotton varieties were found to follow following salt tolerance order,

CIM-598 > CIM-602 > CIM-554 > CIM-573 > CIM – 599
(166.6) (142.4) (132.5) (119.1) (94.4)…mM NaCl

The results of 3-way ANOVA showed that salinity treatment ($P < 0.008$, $F = 3.21$) and fungal type ($P < 0.001$, $F = 238.47$) significantly affected the colonization of root rot fungi while all varieties of cotton behaved more or less similarly and didn't differ significantly ($p < 0.364$, $F = 1.086$) in colonization. The interactions amongst the three factors were highly significant indicating the fact that the intensity of colonization was an interactive function of salinity varietal specificity and nature of the root rot fungi. There was somewhat irregular trend of decline of colonization with salinity. However, maximum colonization was apparent in control and 30 mM NaCl treatment and minimum in 120 mM NaCl salinity. There was no significant difference in varietal response to fungal colonization (39.92- 45.91%). *Fusarium* sp. had, however, relatively higher colonization (64.98%). *M. phaseolina* had the moderate (48.18%) and *R. solani*, the least (15.38%) colonization.

Key-words: Cotton varieties, NaCl- salinity, Root rot pathogens, Colonization

INTRODUCTION

Salinity and drought are the major predisposing factors of plant to diseases (Ma *et al*. 2001; Triky-Dotano *et al*. 2005). Salinity has been found to affect pathogens, host or microbial activity in soil (Triky-Dotano *et al*. 2005). In several studies, salt stress was found to increase susceptibility of crops against root pathogens (Blaker and MacDonald, 1986; El-Abyad *et al*., 1988; Snapp *et al*., 1991; Swiecki and MacDonald, 1991). The increase in salinity is known to cause severe *Phytophthora* root rot infection on some plants. (Blaker and MacDonald, 1986). Salinity also increases the susceptibility of tomato crop against root knot nematode (Edongali and Ferris, 1982; Maggenti and Hardan, 1973). The severity of root rot disease of citrus caused by *Phytophthora parasitica* increased with increase in salinity (Blaker and MacDonald, 1986). Root colonization of *Macrophomina phaseolina* was found to increase in high salinity level (Goudarzi1 *et al*., 2011).Waller (1986) found that defense mechanism of plant is impaired as salt stress predisposes the plant to *M. phaseolina*.

Cotton is an important cash crop. Root rot of cotton is one of the important diseases that usually result in losses in its yield especially in Indo-Pakistan subcontinent (Ghaffar & Parveen, 1969). The pathogens invade the roots of cotton and affect the water transport system badly. Cotton root rot disease is mainly caused by *Rhizoctonia bataticola* (Taub) and *R. solani* Kuhn. Besides, *Fusarium* sp., *F. oxysporum, Macrophomina phaseolina* also colonize cotton roots (Ghaffar and Parveen, 1969).

Salt stress is one of the important factors for increased incidence of *M. phaseolina* rot in melon (Nischwitz *et al*. 2002) and Sunflower (El Mahjoub *et al*. 1979) and make crop more susceptible against pathogenic invasion. Disease development of *M. phaseolina* has been studied at 1400mg/kg (24mM NaCl) to 2800mg/kg (48mM) NaCl (Goudarzi *et al*., 2011) and at 40mM NaCl (You *et al*., 2011 while *F .Oxysporum* has been studied at 3.2 $dS\ m^{-1}$ (35mM NaCl) to 4.6 $dS\ m^{-1}$ (50mM NaCl) NaCl (Triky-Dotano *et al*., 2005). NaCl affects plant cell growth and survival and increases the susceptibility of plant to pathogen's invasion (Munns and Tester 2008; Zhu, 2003). The purpose of the present study is to determine the effects of different levels of NaCl on growth of some Cotton cultivars and their root rot pathogens.

MATERIAL AND METHODS

Soil used in this study was collected from PARC (Pakistan Agriculture Research Centre). Texturally, Soil was sandy loam containing sand, silt and clay in ratio of 70:20:10, respectively. PH of soil ranged between 7.5 to 8.0 and

Water Holding Capacity were 40%.Natural infestation of root rot fungi in soil were 06 sclerotia/g of *Macrophomina phaseolina* by wet sieving (Sheikh & Ghaffar, 1975), 3000 cfu /g *Fusarium* sp. by soil dilution technique (Nash & Synder, 1962) and 8 % *Rhizoctonia solani* colonization using baiting technique on sorghum seeds (Wilhelm, 1955).

Five different varieties of cotton *(Gossypium hirsutum L.)* namely CIM-598, CIM-599, CIM-602, CIM-573 and CIM-554, were used. Before sowing of seeds they were first delinted by using H_2SO_4 (100ml/kg). Delinted seeds were washed with tap water to remove acid from surface of seeds.

Plastic pots of 8cm diameter filled with sandy loam soil @ 300 g/pot were used for this experiment. After washing seeds were sown in soil. There were four replicates to each salinity treatment @ 0, 30mM, 60mM, 90mM, 120mM and 150mM NaCl (corresponding to 1.91,5.72, 9.54, 13.43, 16.43, and 20.98 $dS.m^{-1}$) against five varieties of cotton. Seeds were germinated in fresh water and pots were kept in green house during June to July at temperature ranging 30 – 38^{o}C and kept according to completely randomized block design. Each plant was provided with 50% Hoagland solution (HS) @ 37.5 mL per 300g soil in the first week of growth. And the same dose of HS was again given after 30 day of emergence. Irrigation of seedlings with 100 mL NaCl solution @ 30mM, 60mM, 90mM, 120mM or and 150mM was initiated after 10 days of emergence. The salinity treatment was provided every third day. The control plants received tap water. After 2- month, plants were carefully uprooted and growth data such as shoot length, root length, shoot weight and root weight were recorded. Foliar phenolic contents were determined (Swain and Hills, 1959). The roots of the plants were cut into 1cm long pieces and they were surface sterilized by using 1 % sodium hypochlorite. Five pieces of root of a plant were transferred on potato dextrose agar plates having antibiotics penicillin and streptomycin @ 2mg/litre. Plates were incubated at room temperature for seven days and then colonization of roots by infecting fungi was observed.

$$\text{Colonization (\%)} = \frac{\text{Number of infected root pieces}}{\text{Total number of root pieces}} \times 100$$

The data were subjected to the analysis of variance (ANOVA) along with calculation of least significant difference (LSD) were made at $p < 0.05$ (Gomez and Gomez, 1984). Simple linear regression was performed between salinity and growth parameters to determine the rate of decline of growth under salinity. The statistical analyses were performed with SPSS version - 12 and COSTAT statistical package.

RESULTS

Result from present study showed reduction in plant growth as it exposed to salinity. Both treatments ($P<0.001$, $F= 19.35$) and varieties ($P<0.001$, $F = 13.39$) showed significant effect on reduction of shoot length.CIM-554 showed **(Fig. 1a)** highest shoot length at all salinity level as compared to others varieties. CIM-554 showed shoot length value (17.78cm) at 150mM NaCl found to be highest as compared to other varieties followed by CIM-599 with value (16.99cm) at 150mM. While CIM-598 with value (17.89cm) at 30mM and (17.06cm) at150mM showed lowest shoot length. Over all salt tolerance were found to showed by CIM-554 and CIM-602 with mean value of (19.78cm and 18.92cm), While CIM-598 found to showed lowest shoot length mean at over salt level (16.06 cm).

A significant reduction in root length at NaCl salinity treatment observed. Salinity treatment ($P<0.001$, $F = 17.72$) and varieties ($P<0.001$, $F = 8.37$) significantly effect the reduction of root length. Root length **(Fig. 2a)** found to be reduced in all variety as compare to control. CIM-554 showed increase root length value (14.37cm) at 60 mM, while reduce root length in CIM-599 at 150mM found with value (8.00cm) . CIM-554 showed highest overall salt tolerance with mean value (12.41cm) and CIM-599 mean value (9.93cm) were found to be poor.

Significant reduction in shoot fresh weight (SFW) was observed in all varieties under salinity. The reduction in SFW was due to significant effect of both salinity treatment ($P<0.001$, $F = 67.8085$) and varieties ($P < 0.001$, $F = 13.39$). CIM-554 (Fig. 1b) @ 60mM showed increased shoot fresh weight with mean value (1.60 g). At 150mM, CIM-554 showed increased shoot fresh weight mean value (0.85gm). CIM-554 showed highest overall mean value over the salinity range applied (1.30g) and CIM-598 were found to be poor with lowest mean value of (0.92g).

Fresh weight of root decreased from 30mM to 150mM NaCl but result from study showed that this reduction is only due to significant effect of treatment ($P<0.001$, $F = 13.72$) but all varieties behaved more or less similarly. Increased root fresh weight (Fig. 2b) at 150mM observed in CIM-554 with mean value (0.13g). Overall salt tolerance were found to be in CIM-554 with mean value of (0.21gm). while CIM-599 showed the lowest mean value of (0.166g).

There was a great degree of variation in salinity magnitude corresponding to 50% reduction in growth performance of various varieties based on different parameters of growth (Table 1). This is in agreement with Khan and Sahito (2014) Sahito *et al.* (2013) who also reported variation in critical salinity inducing 50% reduction in

growth in *Vachellia nilotica* subsp. *indica and Acacia stenophylla*, *respecytively* on the basis of different growth parameters studied while irrigated with seawater dilutions.

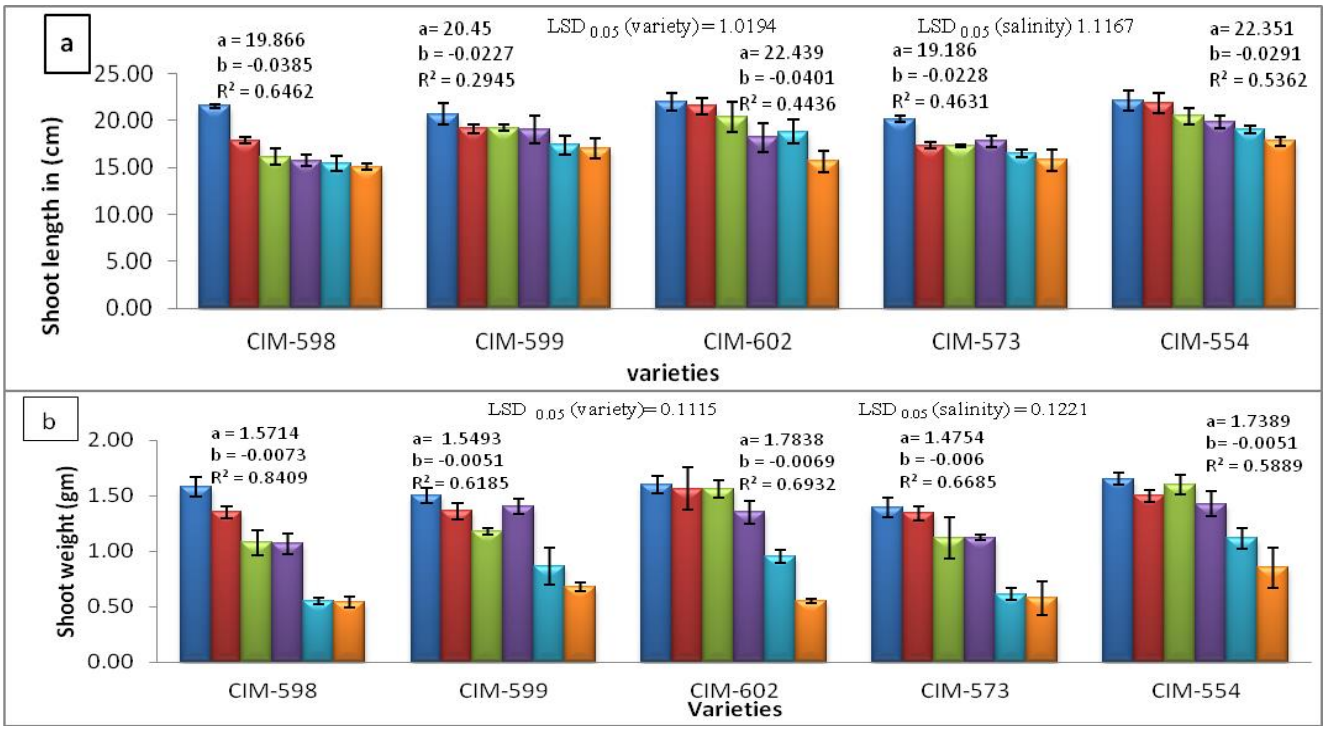

Fig. 1. Effects of NaCl salinity on Shoot growth (a) Shoot length (b) Shoot fresh weight. Figures above the bar graphs depict the regression intercept (a), slope (b) and the coeffient of determination.

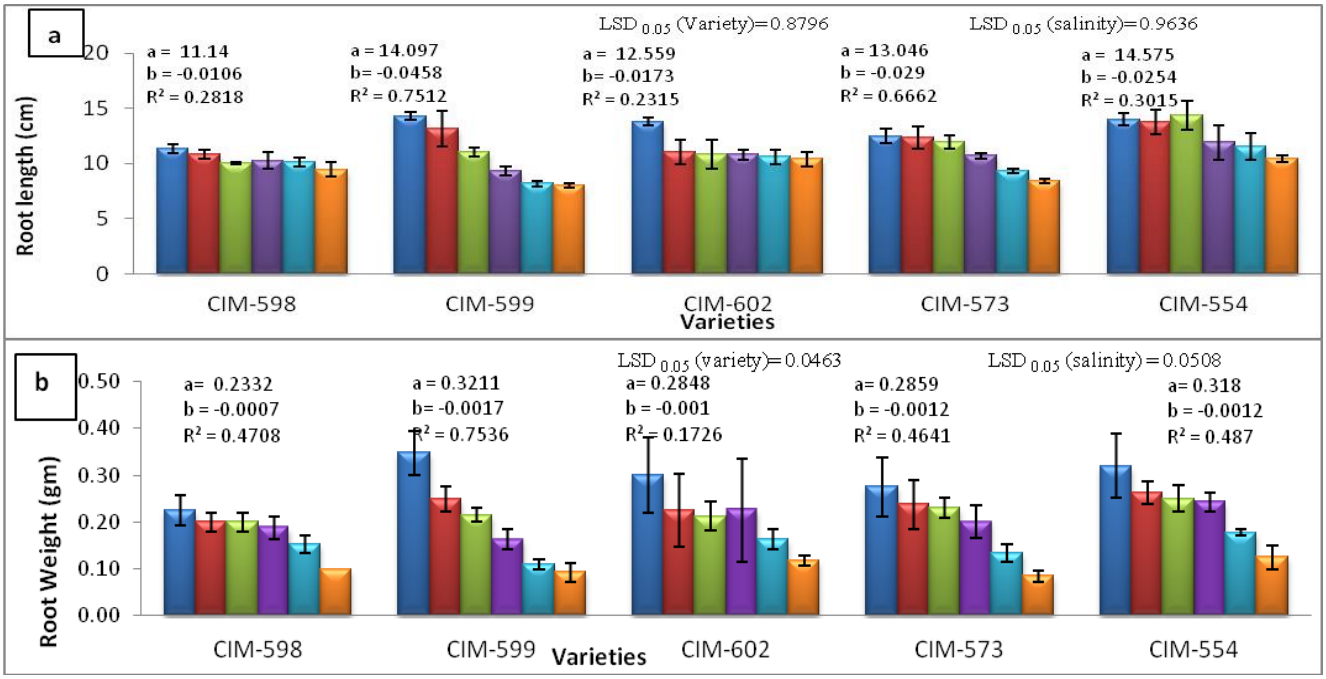

Fig. 2. Effects of NaCl salinity on Root growth (a) Root length (b) Root fresh weight. Figures above the bar graphs depict the regression intercept (a), slope (b) and the coeffient of determination.

Control	30mM	60mM	90mM	120mM	150mM

The hierarchical clustering of the varieties in hand on the basis of averaging grouping calculated through the Euclidean distances due to various growth parameters (Fig. 3) indicated that in hand varieties may be grouped into two. Group-I varieties (CIM-599, CIM- 573 and CIM-554) were more similar in their response to salinity. Group-II varieties, CIM – 598 and CIM-602 were more similar to each other and linked at significantly lower similarity level with the group I varieties. The salt tolerance of in hand varieties on the basis of root and shoot components appeared to be as follows. However, it looks to be more reasonable that the salt tolerance of in hand varieties should be evaluated on the basis of root growth because the root weight appeared to be more limiting to their growth.

Shoot length: CIM-599 > CIM- 573 > CIM- 554 > CIM- 602 > CIM- 598
Root Length: CIM-598 > CIM-602 > CIM-554 > CIM- 573 > CIM - 599
Shoot Weight: CIM-554 > CIM-599 > CIM- 602 > CIM-573 > CIM- 598
Root Weight: CIM-598 > CIM-602 > CIM-554 > CIM-573 > CIM – 599

Table 1. NaCl concentrations (mM) corresponding to the 50% reduction in growth parameters of the cotton cultivars as calculated from intercept and slope values of linear regression given in Figure 1 and 2.

Growth parameters	Cotton Cultivars				
	CIM-598	CIM-599	CIM-602	CIM-573	CIM-554
Shoot Length	253.0	450.4	279.8	420.7	384.0
Root Length	525.5	153.9	362.9	224.9	286.9
Shoot Weight	107.6	151.9	129.3	122.9	170.5
Root Weight	166.6	94.4	142.4	119.1	132.5
Mean ± SE	264.43 ± 92.35	212.66 ± 80.44	228.62 ± 56.25	221.93 ± 70.64	243.48 ± 57.22

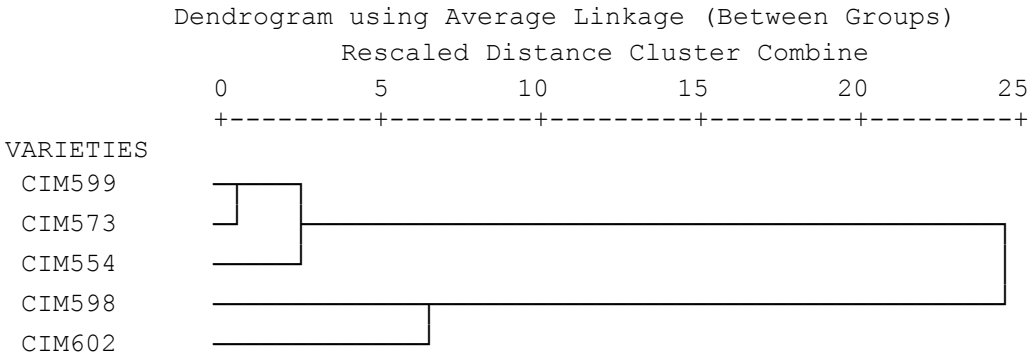

Fig. 3. Cluster dendrogram of varietal similarity on the basis of 50% reduction of various growth parameters (Table 1) under NaCl salinity. Hierarchical clustering based on Euclidean distances.

Phenolic content was found to increase significantly ($p < .0001$, $F=30.13$) in all varieties at increased salinity. Data also showed that variation in increase of phenol content was the function of salinity and not due to varieties specificity. All cultivars behaved more or less similarly and exhibited phenol increment with salinity. Maximum phenol contents were estimated at 150mM as compared to control. Highest value of phenol content (μg/g dry weight) was observed at 150mM NaCl by CIM-602 followed by CIM-573 (Fig. 4). Under overall salinity, CIM-598 showed the highest mean value of phenol content (2160.12 μg/g) while CIM-599 showed the lowest mean value (1506.19 μg/g).

The colonization of root rot fungi in roots of in hand varieties is depicted in Fig. 5. Based on the results of the Two-way ANOVAS with salinity levels and varietal types as two independent factors influencing colonization as dependent variable of three fungi separately it was evident that colonization of *Fusarium* sp. was affected significantly ($P < 0.001$, $F = 7.40$) by NaCl salinity. CIM-599, CIM-602 and CIM-573 showed (Fig. 5a) higher root colonization of *Fusarium* sp. at 120mM, 30mM and 90mM, respectively, as compared to the control. Colonization of *M. phaseolina* was significantly affected by both treatment ($P < 0.1$, $F = 2.49$) and variety ($P < 0.01$, $F = 4.35$). Greater colonization of *Macrophomina phaseolina* was observed in all varieties except CIM-573 as compared to control (Fig. 5b). Highest colonization *Fusarium* sp. and *M. phaseolina* was found in CIM-602 at low salinity of 30mM NaCl. *R. solani* colonization (Fig. 5c) was comparatively low in CIM-599. Highest colonization of *R. solani* occurred in CIM-554 under 90mM NaCl salinity. In general, variety CIM-599 appeared to be somewhat more resistant against *Fusarium* sp. *and R. solani* and variety CIM-554 against *M. phaseolina.* Variety CIM-602 was

more susceptible against *Fusarium* sp and M. *phaseolina.* Variety CIM-554 was observed to be more susceptible against *R. solani* than other species.

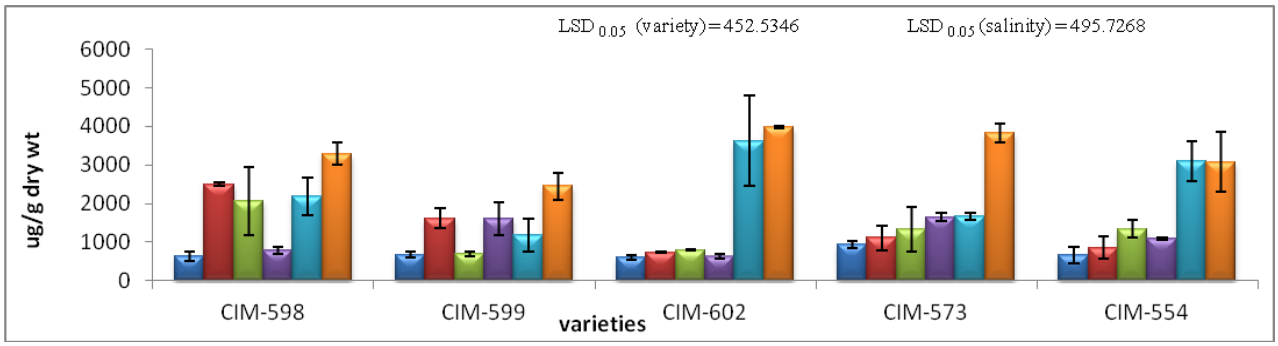

Fig 4. Foliar phenol content (µg/g dry wt.).

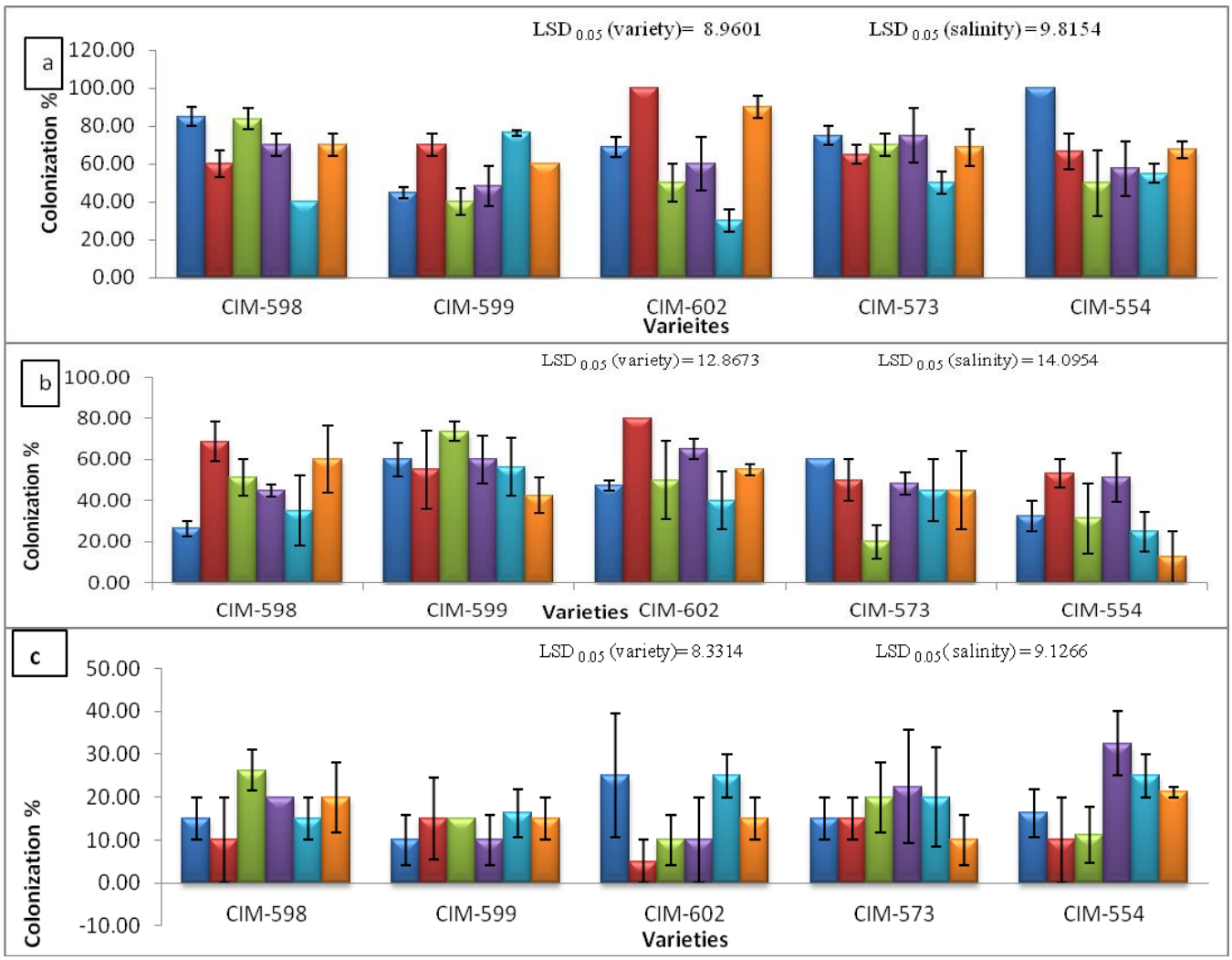

Fig 5. Effect of NaCl salinity on root rot fungi colonization - (a) *Fusarium* sp. (b) *Macrophomina phaseolina* (c) *Rhizoctonia solani*. LSDs as per Two-way ANOVA.

To investigate the overall interactive effects of the three factors (salinity levels, varieties, and root rot fungus types) in connection with the intensity of colonization, a three-way ANOVA was performed. The results of 3-way ANOVA showed that salinity treatment ($P < 0.008$, $F = 3.21$) and fungal type ($P < 0.001$, $F = 238.47$) significantly influenced the colonization intensity while all varieties of cotton behaved more or less similarly and didn't differ significantly ($p < 0.364$, $F = 1.086$) in colonization (Table 2). The interactions amongst the three factors were highly significant indicating the fact that the intensity of colonization was an interactive function of salinity and nature of variety and the fungus. There was somewhat irregular trend of decline of colonization with salinity treatment. However, maximum colonization was apparent in control and 30 mM NaCl treatment and minimum in 120 mM NaCl salinity. There was no significant difference in varietal response to fungal colonization (39.92- 45.91%). *Fusarium* sp. had, however, relatively higher colonization (64.98%). ***M. phaseolina*** had the moderate (48.18%) and *R. solani*, the least (15.38%) colonization.

Table.2. Three-way ANOVA for colonization as influenced by levels of salinity, varieties and the fungi

Source	SS	df	MS	F	P
Main Effects					
salinity	5132.255556	5	1026.451111	3.212586432	0.0078 **
variety	1388.038889	4	347.0097222	1.086070942	0 .3637 ns
fungus	152386.5389	2	76193.26944	238.4696757	0.0000 ***
Interaction					
salinity x variety	13218.99444	20	660.9497222	2.068640276	0.0054 **
salinity x fungus	11153.52778	10	1115.352778	3.490830846	0.0002 ***
variety x fungus	10444.04444	8	1305.505556	4.085970962	0.0001 ***
salinity x variety x fungus	26837.72222	40	670.9430556	2.099917408	0.0003 ***

Salinity			Variety			Fungi		
Rank	Salinity	Mean	Rank	Variety	Mean	Rank	*Fungus*	Mean
1	30 mM	48.23 a	1	CIM-602	45.91 a	1	*Fusarium sp.*	64.98 a
2	Control	45.4 ab	*2*	CIM-598	43.41 a	2	*M. phaseolina*	48.18 b
3	90 mM	43.63 abc	3	CIM-573	43.02 a	3	*R. solani*	15.38 c
4	150 mM	43.5 abc	4	CIM-599	41.84 a			
5	60 mM	39.16 bc	5	CIM-554	39.92 a			
6	120 mM	36.91 c						
$LSD_{0.05}$: 6.43			$LSD_{0.05}$: 6.5.87			$LSD_{0.05}$: 4.54		

DISCUSSION

Salinity is one of the important predisposing factors makes plant more susceptible against disease and effect plant growth in different ways like ion toxicity, nutritional disorder and water deficit (Munns *et al*., 2006, Läuchli and Epstein, 1990). Under saline condition plant undergoes different changes until maturity and number of studies has been carried showing the effect of salinity more on seedling stage as compare to germination (Wilson *et al*., 2000, Del Amor *et al*., 2001, Botia *et al*., 2005). In present study plant growth parameter like shoot length, fresh shoot weight, root length and fresh root length reduced significantly as salinity level went high. These parameters may be regarded as key contributors and selection criteria for salinity tolerance during early phase of growth. (Ashraf, 1994). All varieties of Cotton showed reduced shoot growth at increasing salinity but it differs among varieties. Maximum reduction in Shoot length was observed in CIM-598 when exposed to high salinity (150mM)as compare to control. Shoot fresh weight in CIM-554 showed lowest reduction while CIM-598 showed highest reduction as compare to control. Shoot growth data concluded that CIM-554 and CIM-598 found to be more tolerated and susceptible variety respectively under overall saline condition as compare to others varieties. Salinity reduced shoot length by means of stunted growth, reduced leaf area (Läuchli and Epstein, 1990) and leaf expansion (Jafri and Ahmad, 1995) while shrinkage in cell content and membrane damage are the some other reason of reduced growth under saline condition (Kent and Lauchli, 1985). At high saline condition decrease in permeability

of root lead to the displacement of plasmalemma cause root length to reduce (Saqib *et al*., 2002). The reduction in shoot length may also be due to toxic effects of Na^+ and Cl^- on the metabolic pathways, which in turn produce some sticky material on the cell walls, causing a decrease in cell elasticity and cell expansion. As a result, new cells created quickly and shoot remained dwarf (Ashraf, 2002; Ibrahim, 2003) accumulation of Na^+ in plant system in increased amount effect plant growth which detected by intra and extracellular sensor and activated other mechanism as counteracting (Bartels & Sunkar, 2005). Similarly reduction in shoot fresh weight occurs because of excess salt uptake by root in increase amount and less water uptake (Saqib *et al*., 2002). Previous work of Noor *et al*. (2001), Iqbal *et al*. (2013), Abbas *et al*. (2011) Akhter and Azhar (2001) on cotton, while Khan and Sahito, (2014) on *Vachellia nilotica* sub sp. *indica* (Benth.) Kyal & Boatwr clearly described the significant reduction of shoot growth at higher salinity stress. Root permeability for water uptake decreases at increased salinity and Ca^{2+} displacements from the plasmalemma takes place causing a reduction in root length (Khan *et al*., 2001; Saqib *et al*., 2002). Root length reduction was observed in all varieties reduction varied among the varieties. CIM-598 showed lowest root length at highest salinity at 150mM, while CIM-554 showed highest root length. Under overall range of salinity CIM-599 was found to be more susceptible variety. As root length has proved to be the main indicator of salt stress in plant and based on root length it has been become easier to differentiate plant growing in normal condition with plants growing in salt stress condition. Cytokinin is a growth regulator that promotes cell division and produced mainly in root. It has been reported that Cytokinin production in plant stopped when it expose to high saline condition (Bottger, 1978). Beside this, improper availability of nutrients in soil and salt toxicity reduce root growth and sometime under saline condition when photosynthetic activity is low in shoot govern reduction in root growth. Root fresh weight in all varieties reduced at increased salinity. Reduction in root length at increased salinity has also been described by Bhatti & Azhar (2002), While CIM-599 appeared to be most salt sensitive in terms of shoot and root fresh weight. Same result of reduced root growth has already been reported by Qadir and Shams, (1997) and Ashraf and Ahmad, (2000). In saline soils, water availability to plant is low because roots face decrease in osmotic potential and Na^+ and Cl^- ions concentration also obstruct the uptake of water and that result in reduction in root fresh weight (Gorham and Wyn Jones, 1993; Levitt, 1980). Besides salinity, root colonization by root rot pathogens could have also affected the water transport system.

As salinity predisposes the host plant to the infections by soil pathogens and enhance the root rot severity (Swiecki, 1984).Therefore increased salinity increase the incidence of root rot pathogens like *M. phaseolina*, *R. solani* and *Fusarium* sp colonization as compared to control but there colonization differ amongst varieties and salt treatments. Highest colonization except CIM-554 and CIM-598 remaining varieties showed increased colonization of *Fusarium* sp at salt stress as compare to control. Incidence of *Macrophomina phaseolina* recorded with increase colonization in all varieties except CIM-573 at increase salinity. While all varieties showed increase colonization of *R. solani* in saline treatment as compare to control. Increase in salinity result in effect on one or more component of biotic factor. It may be pathogen, host or microbial antagonist. Salinity also affects the physio-chemical properties of soil which in turn affect biotic component. Increased salinity cause different effect on plant physiology, morphology, and anatomy and plant metabolism. Certain changes like phytohormones balance, cell growth, division (Schoeneweiss, 1981) salt accumulation, enzymatic activity, water relation (Hasegawa *et al*. 2000), cuticle thickness, stomatal number and size, lipid metabolism (Bernstein & Kafkafi, 2002, Campbell and Pitman, 1971) are takes place when exposed to high saline condition and these changes make host plant more susceptible against plant pathogen for invasion (Rasmussen and Stanghellini 1988). Salinity also lead to decrease in mineral nutrient especially potassium inside the tissue. Potassium (K+) is one of the important nutrient help plant to survive under biotic as well as abiotic stress. Present study showed that under overall salinity CIM-599 against *Fusarium* sp. & *R .solani* and CIM-554 against *M. phaseolina* showed more resistance while CIM-602, CIM-599 and CIM-554 observed as more susceptible varieties against *Fusarium* sp., *M. phaseolina* & *R. solani* respectively. Therefore present study result is also supported by same result as for charcoal root rot of *Macrophomina phaseolina* on Sorghum (Goudarzi *et al*., 2011) and on melon (Nischwitz *et al*., 2002), Fusarium on tomato variety (Triky-Dotano *et al*., 2005) and on *cotton* (Turco *et al*., 2002).

In the present study, phenol content was found to be high in high salinity treatments. In all varieties phenol content was observed to be on higher side as compared to non-stress plant. There was a direct correlation of foliar phenol content in the varieties with their salt tolerance. The variety CIM-598 highest salt tolerant amongst the varieties studied had highest level of mean phenolic content (2160 µg per g dry weight) over the range of salinity applied and the variety CIM-599 with the lowest level of salt tolerance had the lowest mean phenolic content (1506 µg per g dry weight). In plants, salinity influences the metabolism of polyphenol and plays an important part in plant growth under stress condition by increasing phenolic content level as salinity level increase. An accumulation of polyphenol has been reported in *Bruguiera parviflora* leaf (Parida *et al.,* 2004) and increased phenol content in leaves under salt stress have been reported in *Sesbania grandiflora* (Chavan and Karadge, 1986), in maize and

cotton (Khan *et al*., 1976), in a variety of groundnut (Karadge and Chavan, 1981), in mustard (Singh and Kumari, 2006) in *Nitraria retusa* (Boughalleb and Denden, 2011), in *Acacia stenophylla* (Sahito *et al.,* 2013) and in *Vachellia nilotica* subsp. *indica* (Khan and Sahito, 2014). Phenolic substances as secondary metabolites are involved in disease resistance in plants through inhibition of fungal extracellular enzyme, by restricting mycelial growth as well as spore germination and oxidative phosphorylation (Scalbert, 1991, Mandeel and Baker, 1991) and make defense strategies against biotic stress or plant diseases and necessary for lignin biosynthesis (Mahmoud *et al*., 2006) which is one of the fundamental component of cell wall. Phenolic accumulation in leaf of Apple infected by *Venturia inaequalis* (Treutter and Feucht, 1990) and in leaf of Pear (Hua *et al*., 2014), Maize infected by *Rhizoctonia solani* (Akhter *et al*., 2011), in root of Soybean infected with *Fusarium* sp. (Lozovaya *et al*., 2004) and in flax against mildew (Ashry amd Mohammed, 2011). Benefits of increased phenolic compounds in salt tolerance and fight against diseases should be available to all the varieties in hand but particularly more to the variety CIM-598.

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