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GENETIC ASSOCIATION AND PATH COEFFICIENT ANALYSIS FOR BIOMASS PRODUCTION IN SUNFLOWER AT DIFFERENT SALINITY LEVELS

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ABSTRACT

Four levels of salinity ($0dSm^{-1}$, $3dSm^{-1}$, $6dSm^{-1}$ and $9dSm^{-1}$) were used to evaluate twenty different sunflower (*Helianthus annuus* L.) accessions. NaCl was used to generate these salinity levels whereas control contained tap water. Triplicated completely randomized design was followed. Data of 60 days old ten seedlings from each entry was recorded and analyzed. Correlation between different morphological and physiological parameters was estimated and path analysis was worked out. DSW showed positive and significant association at all the salinity levels, FRW at $0dSm^{-1}$, $3dSm^{-1}$ and $9dSm^{-1}$, DRW at $6dSm^{-1}$ and $9dSm^{-1}$ with biomass production. Negative and significant correlation was observed by K^+/Na^+ at $0dSm^{-1}$ and none of the trait showed negative and significant affiliation with biomass at $3dSm^{-1}$, $6dSm^{-1}$and $9dSm^{-1}$. SL and DSW put forth positive and direct effects on biomass production at all the salinity levels. FRW, Na^+ and K^+/Na^+ exerted negative and direct effects on biomass at $0dSm^{-1}$ and $3dSm^{-1}$ whereas K^+ and Mort at $6dSm^{-1}$ and $9dSm^{-1}$.

Key words: Sunflower, salinity, path coefficient analysis, physio-chemical evaluation

INTRODUCTION

Salinity and sodicity affect the world's agricultural land. About 6.67 m h land is salt affected in Pakistan and 60% of which is saline sodic (Khan, 1998). Soil salinity can be diluted by management practices but due to bad quality water, poor soil structure and costly inputs reclamation is not feasible on large scale. Salinity adversely effects the germination and crop stand (Almansouri *et al*., 2001). It is considered as major factor of abiotic stress and effects crop production all over the world (Khajeh Hosseini, *et al*., 2003). Literature proved sunflower as salt tolerant and this tolerance level depends upon the growth stage of the plant (Katerji *et al*., 2000).

Edible oil production is less than requirement in Pakistan which is fulfilled by import. Total edible oil production was 0.680 million tones whereas demand was 1.749 million tones and 1.246 million tones was imported (Economic Survey of Pakistan, 2009-2010). It is need of the day to increase edible oil production either by increasing the area or per unit area production of conventional oilseed crops. Potential of sunflower crop can be exploited to bridge the gap in the demand and production of edible oil. Correlation of a particular character with other characters contributing to biomass production is of great importance in indirect selection of genotypes for higher seed yield. This necessitates developing locally well-adapted, high yielding sunflower genotypes under local agro ecological conditions. Keeping in view these facts the present work was carried out to develop selection criteria for genotypes of sunflower with high salt tolerance.

Correlation coefficients can be partitioned in to direct and indirect effects by following Path analysis to estimate the contribution of traits individually. Many researchers partitioned the correlation coefficients in to direct and indirect effects (Kaya and Atakisi, 2003; Kaya *et al*., 2008; Vidhyavathi, *et al.,* 2005; Göksoy and Turan, 2007). In the present study the genotypic correlation between different physiological and morphological traits was determined and path coefficients to know direct and indirect contribution of different traits was estimated.

MATERIALS AND METHODS

The research material was comprised of 20 sunflower accessions namely G-16, G-30, G-32, G-36, G-44, G-45, G-61, G-64, G-66, G-68, G-86, A-2, A-14, A-23, A-56, A-60, A-61, A-79, A-133 and A-185, developed by the Oilseed Research Program of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Experiment was conducted in a glasshouse following triplicated factorial complete randomized design. The sunflower seeds were planted in iron trays filled with soil and sand with 1:1. Row-to-row and plant-to-plant uniform distance of 2.5 cm each was maintained with seed at depth of 1.5 cm. The mixture of sand and soil with no salinity and sodicity signs was collected and analyzed for chemical characters. The EC of soil was 1.23 dS m^{-1} with saturation 25.7% and total soluble salt 17.7 me L^{-1}. Tap water was applied for irrigation for 15 days according to requirement. After germination, four salt (NaCl) levels of irrigation water were maintained i.e., Normal water (Tap water), 3 dsm^{-1}, 6 dsm^{-1}, 9 dsm^{-1}. The tap water comprised of EC 1.036 me L^{-1}, Na^{+} 3.83, Ca^{+} and Mg^{++} 6.53 me L^{-1} and total soluble salts 10.36 me L^{-1}. Sixty days old, ten randomly selected plants per entry were uprooted after flooding to facilitate the process of uprooting and data was recorded. Two lower leaves (from the basal node) and two upper leaves (from the top node) were collected. The soil residues were washed from samples by using tap water and then dipped instantly in distilled water for a short period. The samples were blotted dry, placed in polyethylene bags, marked with the spirit marker and stored in the deep freezer. Frozen leaf samples were thawed, after washing with distilled water the tissue sap was extracted in ependorf tubes by using metal rod and immediately stored back in the deep freezer. After thawing the tissue sap at room temperature, it was centrifuged at the 6500 rpm for five minutes. The supernatant was analyzed for chloride, sodium, and potassium ions. Chloride ions in the tissue sap were determined using Sherwood chloride analyzer 926. Sodium and potassium ions were determined by diluting tissue sap with distilled water using Sherwood flame photometer 410. Data was analyzed by using CRD with factorial classification (Steel *et al*., 1997) using MSTATC software. Treatment means were compared by LSD test.

The data recorded were subjected to correlation analysis to estimate the correlation between different traits at phenotypic and genotypic levels following statistical techniques developed by Kown and Torrie (1964). Correlation coefficients were partitioned following Dewey and Lu (1957) to study direct and indirect effects of different morphological traits under study on the seed yield. This method has been extensively used by the sunflower researchers (Lakshimanrao *et al.,* 1985; Marinkovic, 1992).

RESULTS AND DISCUSSION

Results depicted in table.1 exhibited genetic correlation between parameters under study.

SL showed positive and significant correlation with FSW at all the treatment levels, FRW at $0dSm^{-1}$, and DSW, K^{+}/Na^{+}, biomass, and K^{+} at $3dSm^{-1}$. Negative and significant affiliation was observed with Chlo at $odSm^{-1}$, K^{+}/Na^{+} at $6dSm^{-1}$, and Na+ at $9dSm^{-1}$ by SL. RL was positively and significantly associated with FRW at all the treatment levels except $6dSm^{-1}$, with K^{+} at $0dSm^{-1}$, Cl^{-1} and Chlo at $3dSm^{-1}$, and DRW and K^{+}/Na^{+} at $9dSm^{-1}$. Negative and significant association was observed with K+ and K^{+}/Na^{+} at $3dSm^{-1}$. FSW showed positive and significant affiliation with DSW, Biomass and Chlo at $3dSm^{-1}$ and with SL at both $6dSm^{-1}$, and $9dSm^{-1}$, whereas negative and significant correlation with R/S at $3dSm^{-1}$. FRW expressed affiliation with RL at $0dSm^{-1}$, $3dSm^{-1}$ and $9dSm^{-1}$, with biomass at $0dSm^{-1}$ and $3dSm^{-1}$, and with Chlo and Cl^{-1} at $3dSm^{-1}$. Negative and significant correlation was observed with Na^{+} at $3dSm^{-1}$. DSW was positively and significantly associated with biomass at $0dSm^{-1}$ and $3dSm^{-1}$ and with FSW and FRW at $6dSm^{-1}$ and $9dSm^{-1}$ respectively but negative and significant correlation with K^{+}/Na^{+} and at $0dSm^{-1}$ and with R/S at $6dSm^{-1}$. DRW showed positive and significant correlation with R/S at $0dSm^{-1}$and $3dSm^{-1}$ but Chlo at $0dSm^{-1}$. Positive and significant affiliation was exhibited with DSW at $6dSm^{-1}$ and $9dSm^{-1}$ whereas FRW and R/L at $9dSm^{-1}$. Positive and significant association was exhibited by Na^{+} with biomass at $0dSm^{-1}$. Na^{+} showed negative and significant correlation with K^{+}/Na^{+} at $0dSm^{-1}$ and at $3dSm^{-1}$, whereas with FSW and SL at $9dSm^{-1}$. Positive and significant association was observed between K^{+} and K^{+}/Na^{+} at both $0dSm^{-1}$ and $3dSm^{-1}$. Cl^{-1} did not show positive or negative and significant affiliation with any trait at $0dSm^{-1}$. Positive and significant relation was observed with Chlo at $3dSm^{-1}$, with DRW at $3dSm^{-1}$ and with DSW and DRW at $9dSm^{-1}$. Chlo exhibited positive and significant association with R/S at $0dSm^{-1}$, with Cl^{-1} at $6dSm^{-1}$ and with K^{+} at $9dSm^{-1}$. Mortality exhibited positive and significant association with Cl^{-1} and DRW at $6dSm^{-1}$. None of the significant association was observed at $9dSm^{-1}$. K^{+}/Na^{+} exhibited positive and significant association with K^{+} and negative and significant correlation with Na^{+} at $6dSm^{-1}$and $9dSm^{-1}$ but positive and significant with RL at $9dSm^{-1}$. Moreover, negative and significant correlation with biomass at $0dSm^{-1}$ and with SL and Mort at $6dSm^{-1}$. R/S exhibited positive and significant affiliation with DRW at $6dSm^{-1}$and $9dSm^{-1}$, whereas with Cl^{-1} at $6dSm^{-1}$ and with FSW at $9dSm^{-1}$. Biomass showed positive and significant association with DSW and DRW at $6dSm^{-1}$ and $9dSm^{-1}$ but with FSW at $6dSm^{-1}$ and with Cl^{-1} and FRW at $9dSm^{-1}$.

Results presented in table's no. 2 and 3 depicted that SL, DSW put forth the positive and direct effects on biomass at all the levels of salinity. RL and K^{+} exerted positive and direct effects on biomass at $0dSm^{-1}$ and $3dSm^{-1}$. FRW and Na^{+} put forth negative and direct effects on biomass at all the salinity levels except $9dSm^{-1}$. DRW and Cl^{-1} put forth positive and direct effects on biomass at all the salinity levels except $6dSm^{-1}$. FSW put forth positive and direct effects on biomass at $3dSm^{-1}$ and $6dSm^{-1}$. Chlo exerted positive and direct effects at $3dSm^{-1}$ and $6dSm^{-1}$ whereas negative and direct effect at $0dSm^{-1}$ and $9dSm^{-1}$. Mort put forth negative and direct effects at all the salinity levels except $3dSm^{-1}$. Na^{+}/K^{+} exerted positive and direct effects at $6dSm^{-1}$ and $9dSm^{-1}$. R/S put forth positive and direct effects at $0dSm^{-1}$ and $6dSm^{-1}$.

FRW exerted positive and indirect effects through K^{+}, through FRW and DSW by Cl^{-1}, through RL and FSW by Chlo, through DSW by FSW, by Na^{+} through R/S, by R/S through K^{+} and through Mort by K^{+}, and by DSW through SL, RL, and FRW at all the salinity levels. Whereas negative and indirect effects were exerted through FRW by SL, by FSW through R/S, through RL by Mort and through Na^+/K^+ by Chlo at all the levels of salinity.

FSW exerted positive and indirect effects through Cl^{-1}, through FSW by DSW, through Na^+/K^+ by Na^+, through Na^+ by K^+, by RL through Na^+ and Mort, by FSW through K^+, Chlo, and Na^+/K^+ at all the salinity levels except $9dSm^{-1}$. But FRW exerted negative and indirect effects through RL, FSW, DSW, through DRW by FRW, through Na^+ by DRW, by FSW through Na^+, through R/S by DSW, through DSW and Chlo by Mort, by Na^+/K^+ through SL, through Mort by DRW and through DSW by K^+ at all the salinity levels except $9dSm^{-1}$.

SL exerted positive and indirect effect through Cl^{-1} and DSW, by FSW through DSW, through Chlo by FRW, by FSW through Mort, through FSW and FRW by Na^+/K^+, by FRW through Na^+/K^+, by DRW through K^+ and through SL and Na^+/K^+ by Cl^{-1} at all salinity levels except $3dSm^{-1}$. SL exerted negative and indirect effect through R/L, through SL by R/S, through R/S by SL, by Cl^{-1} through Na^+ and R/S and by FSW through RL at all the levels except $3dSm^{-1}$.

Positive and indirect effect through Mort was exerted by SL, by K^+ through RL, by Mort through SL, through DSW by Na^+/K^+, through DRW and Chlo by R/S and through FRW, DSW, Cl^{-1} by RL at $0dSm^{-1}$and $6dSm^{-1}$, whereas negative and indirect at $3dSm^{-1}$ and $9dSm^{-1}$.

FRW exerted negative and indirect effect through Mort, by DSW through Na^+, by Na^+ through Mort, by Mort through FSW, DRW and R/S, by RL through FSW and through Chlo by K^+ at all levels of salinity except at $0dSm^{-1}$. Whereas FSW put forth positive and indirect effects through DSW, through DRW by DSW, through K^+ by Mort, by Na^+/K^+ through RL and through R/S by FRW at all salinity levels except at $0dSm^{-1}$.

Positive and indirect by DSW through Cl^{-1}, through FRW, Chlo and R/S by DRW, by Na^+ through DRW, by Cl^{-1} through RL, through FRW and Na^+ by Mort, by R/S through Na^+/K^+ and Chlo except at $6dSm^{-1}$. RL put forth negative and indirect affect through R/S, through DRW by RL, by Chlo through Na^+ and K^+, through Na^+/K^+, by R/S through RL, through DRW by Na^+/K^+, through Na^+ by Na^+/K^+, through FSW and FRW by R/S, by K^+ through FRW and Cl^{-1} and by FSW through DRW at all the salinity levels except $6dSm^{-1}$.

RL put forth positive and indirect effects through K^+ and Na^+/K^+, through Na^+/K^+ by DRW, through Cl^{-1} by Na^+, through Mort by Cl^{-1}, by Chlo through FRW and by K^+ through Na^+/K^+ at $0dSm^{-1}$ and $3dSm^{-1}$, whereas negative and indirect effects at $6dSm^{-1}$ and $9dSm^{-1}$.

Positive and indirect effects were put forth through Chlo by RL, through Cl^{-1} by FRW, by Na^+ and Cl^{-1} through K^+, through Mort by Chlo, through Cl^{-1} by R/S, through K^+ by Na^+/K^+ and through Mort and Na^+/K^+ by DSW at $6dSm^{-1}$ and $9dSm^{-1}$ but negative and indirect at $0dSm^{-1}$ and $3dSm^{-1}$. Positive and indirect effects were through FSW and Na^+ by SL, by FSW through SL and FRW, through SL by RL, by Na^+ through SL, RL, FSW, FRW and DSW, by FRW through Na^+, through K, SL by FSW, by Na^+ through SL, RL, FSW, FRW, and DSW and through Na^+ by FRW, by R/S through Mort and Na^+, through R/S by Na^+/K^+ , by Chlo through DRW, Cl^{-1} and R/S and through Chlo by DSW at $3dSm^{-1}$ and $6dSm^{-1}$, but negative and indirect at $0dSm^{-1}$ and $9dSm^{-1}$.

DRW exerted positive and indirect effect through FSW, by K^+ through DRW, through SL by Chlo and R/S at $0dSm^{-1}$ and $9dSm^{-1}$ whereas negative and indirect effects were exerted at $3dSm^{-1}$ and $6dSm^{-1}$. Positive and indirect effects were exerted through RL, SL, $Cl^{-1,}$ and DSW by DRW, through DRW by Cl^{-1}, by R/S through DSW, through Mort, Chlo and Cl^{-1} by Na^+/K^+, through Cl^{-1} by Mort, through SL and FSW by K^+ and by Na^+ through Chlo at $3dSm^{-1}$ and $9dSm^{-1}$ but negative and indirect effects at $0dSm^{-1}$ and $6dSm^{-1}$.

Significant reduction in the studied growth parameter as well as in macro and micro nutrients was reported. This reduction in growth and development might be due to occurring defects in metabolism. High level of Na^+ inhibits the K^+ concentration and ultimately alters K^+/Na^+ ratio. This may cause disturbance in the ion balance in plant by increase in Na^+ uptake. High level of Cl^- ion accumulation in shoot tissue is the result of increase uptake through media. Root and shoot growth retardation might be the result of high level of Na^+ and Cl^- ions in the media (Mehmat, 2009). Decrease in root growth may be due to excessive accumulation of salts in the zone which ultimately reduce cell division and enlargement (Ahmed, 2010). Reduction in shoot area might be due to adverse effects of salinity on phytohormones biosynthesis and action (Cuartero *et al*., 2006) and leaf primordial initiation (Mauromicale and Cavallaro, 1997). Growth inhibition at seedling level may be due to increase in MET and reduction in dry weight (Ahmed, 2010). High level of correlation between different physiological parameters indicates that these traits depend on each other. Salinity effects nutrient availability, competitive uptake, transport or partitioning within plants and these traits depend very much on each other. In the light of findings of this study it could be said that sunflower is moderately tolerant of saline conditions, therefore can be grown on most agricultural lands and further study by using new techniques should be carried out to reach more realistic results for the remediation of salt stress effects in the soils.

Table.1. Genotypic correlation coefficients (r_g) among different seedling traits of sunflower under Salt stress 0 dsm^{-1} & 3 dsm^{-1} (bold) and 6 dsm^{-1} & 9dsm^{-1}.

	Levels (dsm^{-1})	SL	RL	FSW	FRW	DSW	DRW	Na^+	K^+	Cl^-	Chlo	Mort	K/Na	R/S	Biomass	Levels (dsm^{-1})	
SL	6	**1.00**	**-0.006**	**0.977***	**0.419***	**0.289**	**-0.007**	**0.117**	**-0.321**	**0.062**	**-0.496***	**-0.138**	**-0.280**	**-0.050**	**0.351**	0	**SL**
	9	**1.00**	**-0.286**	**0.637***	**0.255**	**0.666***	**0.076**	**-0.374**	**0.527***	**-0.283**	**-0.093**	**-0.353**	**0.660***	**-0.391**	**0.590***	3	
RL	6	-0.006	**1.000**	**0.050**	**0.353***	**0.032**	**0.015**	**0.268**	**0.321***	**0.120**	**-0.017**	**0.020**	**0.149**	**-0.010**	**0.084**	0	**RL**
	9	0.259	**1.000**	**0.109**	**0.309***	**0.186**	**0.217**	**-0.111**	**-0.455****	**0.495****	**0.466****	**-0.109**	**-0.309***	**0.051**	**0.242**	3	
FSW	6	0.700*	-0.186	**1.000**	**0.477**	**0.265**	**0.162**	**0.020**	**-0.238**	**-0.093**	**-0.374**	**-0.294**	**-0.214**	**0.104**	**0.385**	0	**FSW**
	9	0.689*	0.400	**1.000**	**0.291**	**0.628***	**-0.204**	**-0.196**	**0.221**	**0.162**	**0.477***	**-0.202**	**0.331**	**-0.630***	**0.570***	3	
FRW	6	0.336	0.150	0.020	**1.000**	**0.413**	**0.333**	**0.129**	**-0.315**	**0.200**	**-0.264**	**-0.317**	**-0.293**	**0.221**	**0.543***	0	**FRW**
	9	-0.008	0.642*	0.218	**1.000**	**0.309**	**0.331**	**-0.540***	**-0.109**	**0.525***	**0.681***	**0.141**	**0.188**	**-0.005**	**0.447***	3	
DSW	6	0.159	0.280	0.505*	0.158	**1.000**	**-0.231**	**0.176**	**-0.455***	**0.293**	**-0.098**	**-0.176**	**-0.732***	**-0.384**	**0.979***	0	**DSW**
	9	0.159	0.203	-0.151	0.593*	**1.000**	**0.381**	**-0.109**	**-0.001**	**0.131**	**0.235**	**-0.204**	**0.240**	**-0.540***	**0.952***	3	
DRW	6	0.149	0.290	0.051	0.039	0.429*	**1.000**	**-0.131**	**0.093**	**-0.321**	**0.532***	**-0.180**	**0.170**	**0.922***	**0.331**	0	**DRW**
	9	0.378	0.587*	0.390	0.740*	0.524*	**1.000**	**-0.194**	**-0.185**	**0.209**	**0.384**	**-0.232**	**0.009**	**0.675***	**0.370**	3	
Na^+	6	-0.250	0.000	-0.155	-0.261	-0.040	0.177	**1.000**	**0.148**	**-0.250**	**0.267**	**-0.224**	**-0.489***	**-0.187**	**0.463***	0	**Na^+**
	9	-0.410*	-0.311	-0.435*	-0.195	-0.006	0.197	**1.000**	**0.072**	**-0.001**	**-0.180**	**0.327**	**-0.464***	**-0.010**	**-0.325**	3	
K^+	6	0.251	-0.189	0.436	-0.249	0.299	0.360	-0.073	**1.000**	**-0.164**	**0.394**	**0.065**	**0.764***	**0.143**	**-0.359**	0	**K^+**
	9	-0.315	0.051	-0.238	0.248	-0.106	-0.082	0.380	**1.000**	**-0.148**	**-0.374**	**0.037**	**0.830***	**-0.203**	**-0.057**	3	
Cl^-	6	-0.097	0.194	0.027	-0.089	-0.057	0.415*	0.320	-0.040	**1.000**	**0.067**	**0.337**	**0.058**	**-0.356**	**0.126**	0	**Cl^-**
	9	0.133	0.007	0.023	0.394	0.665*	0.397*	-0.063	0.146	**1.000**	**0.586***	**0.035**	**-0.086**	**0.049**	**0.190**	3	
Chlo	6	-0.011	0.002	0.243	-0.230	0.351	0.381	0.211	0.262	0.445*	**1.000**	**0.302**	**0.148**	**0.495***	**0.122**	0	**Chlo**
	9	-0.232	-0.065	-0.276	0.351	-0.058	0.145	0.292	0.617*	0.279	**1.000**	**-0.166**	**-0.208**	**0.171**	**0.287**	3	
Mort	6	-0.054	0.106	0.107	-0.230	0.178	0.471*	0.376	-0.119	0.565*	0.318	**1.000**	**0.208**	**-0.149**	**-0.204**	0	**Mort**
	9	0.227	0.134	0.234	-0.209	-0.019	0.127	-0.012	-0.015	-0.019	-0.356	**1.000**	**-0.184**	**-0.043**	**-0.208**	3	
K/Na	6	-0.985*	-0.113	0.283	-0.018	0.220	0.054	-0.765*	0.675*	-0.352	-0.043	-0.44*	**1.000**	**0.247**	**-0.600***	0	**K/Na**
	9	0.099	0.424*	0.299	0.335	-0.187	-0.226	-0.537*	0.526*	0.040	0.216	0.151	**1.000**	**-0.166**	**0.194**	3	
R/S	6	-0.035	0.081	-0.290	-0.017	-0.292	0.904*	0.222	0.177	0.451*	0.096	0.362	-0.063	**1.000**	**0.213**	0	**R/S**
	9	0.214	0.409	0.441*	0.260	-0.400	0.558*	0.291	-0.010	-0.149	0.188	0.186	-0.102	**1.000**	**-0.415**	3	
Biomass	6	0.223	0.286	0.508*	0.146	0.945*	0.612*	-0.092	0.332	-0.017	0.399	0.200	0.217	-0.142	**1.00**	0	**Biomass**
	9	0.240	0.268	-0.028	0.616*	0.998*	0.572*	-0.030	-0.097	0.653*	-0.057	0.024	-0.166	-0.254	**1.00**	3	

= *Significant ($P \leq 0.05$), ** = Highly significant ($P \leq 0.01$)

Abbreviations: SL=Shoot length, RL=Root length, FSW=Fresh shoot weight, FRW= Fresh root weight, DSW=Dry shoot weight, DRW=Dry root weight, Chlo=Chlorophyll, Mort=Mortality, K/Na=K^+/Na^+ ratio, R/S= Root/shoot ratio

Table.2. Direct (bold) and indirect path effects at Salt stress 0 dsm^{-1} & 3 dsm^{-1}.

	SL		RL		FSW		FRW		DSW		DRW		Na+		K+		Cl^-		Chlo.		Mort.		K^+/Na^+		R/S	
Levels (dsm^{-1})	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**
SL	**4.72**	**0.10**	-0.00	0.02	-4.92	0.07	-0.64	-0.07	0.30	0.15	-0.02	0.08	-0.11	0.30	-0.99	0.40	0.07	-0.06	1.02	-0.00	0.03	-0.06	0.94	-0.69	-0.03	0.35
RL	-0.03	-0.03	**0.65**	**-0.08**	-0.33	0.013	-0.58	-0.10	0.04	0.04	-0.01	0.33	-0.26	0.09	1.01	-0.37	0.14	0.11	0.03	0.01	-0.00	-0.03	-0.54	0.35	-0.02	-0.08
FSW	4.61	0.07	0.04	-0.01	**-5.04**	**0.17**	-0.73	-0.08	0.27	0.14	0.47	-0.2	-0.02	0.16	-0.74	0.17	-0.1	0.03	0.77	0.01	0.06	-0.03	0.72	-0.35	0.06	0.56
FRW	1.98	0.03	0.25	-0.03	-2.40	0.03	**-1.53**	**-0.29**	0.43	0.07	0.98	0.33	-0.13	0.43	-0.97	-0.08	0.22	0.11	0.54	0.02	0.06	0.02	0.99	-0.20	0.14	0.01
DSW	1.37	0.07	0.03	-0.02	-1.34	0.07	-0.63	-0.09	**1.03**	**0.22**	-0.68	0.38	-0.17	0.09	-1.41	-0.00	0.33	0.03	0.20	0.01	0.04	-0.03	2.46	-0.25	-0.24	0.48
DRW	-0.03	0.01	-0.0	-0.03	-0.81	-0.02	-0.51	-0.10	-0.3	0.08	**2.93**	**1.00**	0.13	0.16	0.29	-0.14	-0.4	0.04	-1.1	0.01	0.04	-0.04	-0.57	-0.01	0.56	-0.60
Na^+	0.55	-0.04	0.17	0.01	-0.10	-0.02	-0.20	0.16	0.18	-0.0	-0.38	-0.2	**-0.97**	**-0.8**	0.46	0.05	-0.3	0.000	-0.6	-0.00	0.05	0.05	1.64	0.48	-0.11	0.01
K^+	-1.52	0.06	0.21	0.04	1.20	0.02	0.48	0.03	-0.5	0.00	0.27	-0.2	-0.14	-0.1	**3.09**	**0.76**	-0.2	-0.03	-0.8	-0.01	-0.01	0.01	-2.57	-0.87	0.09	0.18
Cl^-	0.29	-0.03	0.08	-0.04	0.47	0.02	-0.31	-0.15	0.30	0.03	-0.94	0.21	0.24	0.00	-0.51	-0.11	**1.11**	**0.20**	-0.2	0.02	-0.07	0.01	-0.19	0.09	-0.22	-0.04
Chlo.	-2.35	-0.01	-0.01	-0.04	1.88	0.05	0.40	-0.20	-0.1	0.05	1.56	0.39	-0.26	0.15	1.22	-0.28	0.08	0.12	**-2.1**	**0.03**	-0.06	-0.03	-0.50	0.22	0.30	-0.15
Mort.	-0.65	-0.04	0.01	0.01	1.48	-0.02	0.49	-0.04	-0.2	-0.1	-0.53	-0.2	0.22	-0.3	0.20	0.03	0.38	0.01	-0.6	-0.01	**-0.20**	**0.16**	-0.70	0.19	-0.09	0.04
Na^+/K^+	-1.32	0.07	0.10	0.03	1.08	0.04	0.45	-0.05	-0.8	0.05	0.50	0.01	0.47	0.37	2.36	0.63	0.07	-0.02	-0.3	-0.01	-0.04	-0.03	**-3.36**	**-1.04**	0.15	0.15
R/S	-0.24	-0.04	-0.02	-0.01	-0.52	-0.07	-0.34	0.00	-0.4	-0.1	2.71	0.68	0.18	0.01	0.44	-0.15	-0.4	0.01	-1.0	0.01	0.03	-0.01	-0.83	0.17	**0.61**	**-0.90**

Table.3. Direct (bold) and indirect path effects at Salt stress 6 dsm^{-1} & 9 dsm^{-1}.

	SL		RL		FSW		FRW		DSW		DRW		Na+		K+		Cl^-		Chlo.		Mort.		K^+/Na^+		R/S	
Levels (dsm^{-1})	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**	**6**	**9**
SL	**0.05**	**0.27**	0.00	-0.11	0.06	-0.40	-0.02	-0.00	0.17	0.06	-0.02	0.29	0.02	-0.18	-0.02	0.15	0.01	0.02	-0.0	0.11	0.00	-0.04	-0.00	0.09	-0.0	-0.02
RL	0.00	0.07	**0.05**	**-0.44**	-0.020	-0.23	-0.01	0.13	0.31	0.08	-0.04	0.45	0.00	-0.14	0.02	-0.03	-0.02	0.00	0.00	0.03	-0.00	-0.03	0.00	0.40	0.03	-0.04
FSW	0.03	0.18	-0.01	-0.18	**0.08**	**-0.58**	-0.00	0.04	0.52	-0.06	-0.01	0.30	0.02	-0.19	-0.04	0.11	-0.00	0.00	0.03	0.13	-0.00	-0.04	0.00	0.28	-0.10	-0.04
FRW	0.02	-0.00	0.01	-0.28	0.00	-0.13	**-0.06**	**0.20**	0.16	0.23	-0.01	0.57	0.02	-0.09	0.02	-0.12	0.01	0.07	-0.02	-0.17	-0.00	0.04	0.00	0.32	-0.01	-0.02
DSW	0.01	0.04	0.01	-0.09	0.04	0.09	-0.01	0.12	**1.04**	**0.39**	-0.05	0.40	0.01	-0.00	-0.03	0.05	0.01	0.11	0.04	0.03	-0.01	0.00	0.00	-0.2	-0.11	0.03
DRW	0.01	0.10	0.02	-0.26	0.00	-0.23	-0.00	0.15	0.44	0.21	**-0.12**	**0.76**	-0.0	0.09	-0.03	0.04	-0.04	0.07	0.04	-0.07	-0.01	-0.02	0.00	-0.2	0.32	-0.05
Na^+	-0.0	-0.11	0.00	0.14	-0.01	0.25	0.02	-0.04	-0.1	-0.00	-0.02	0.15	**-0.1**	**0.44**	0.01	-0.18	-0.03	-0.0	0.02	-0.14	-0.01	0.00	-0.00	-0.5	0.08	-0.03
K^+	0.01	-0.08	-0.01	-0.02	0.04	0.14	0.02	0.05	0.31	-0.04	-0.04	-0.1	0.01	0.17	**-0.09**	**-0.47**	0.00	0.03	0.03	-0.30	0.00	0.00	0.00	0.50	0.06	0.00
Cl^-	-0.0	0.04	0.01	-0.00	0.00	-0.01	0.01	0.08	-0.1	0.26	-0.05	0.30	-0.0	-0.03	0.01	-0.07	**-0.09**	**0.17**	0.05	-0.14	-0.02	0.00	-0.00	0.04	0.16	0.01
Chlo.	-0.0	-0.06	0.00	0.03	0.02	0.16	0.02	0.07	0.36	-0.02	-0.04	0.11	-0.0	0.13	-0.02	-0.29	-0.04	0.05	**0.10**	**-0.48**	-0.01	0.07	0.00	0.20	0.03	-0.02
Mort.	-0.0	0.06	0.01	-0.06	0.01	-0.14	-0.00	-0.04	0.18	-0.01	-0.06	0.10	-0.0	-0.01	0.01	0.01	-0.05	-0.0	0.03	0.17	**-0.03**	**-0.19**	-0.00	0.14	0.13	-0.02
Na^+/K^+	-0.1	0.03	-0.01	-0.19	0.02	-0.17	0.00	0.07	0.23	-0.07	-0.01	-0.2	0.07	-0.24	-0.06	-0.25	0.03	0.01	-0.01	-0.11	0.01	-0.03	**0.00**	**0.94**	-0.02	0.01
R/S	-0.0	0.06	0.00	-0.18	-0.02	-0.25	0.00	0.05	-0.3	-0.16	-0.11	0.43	-0.0	0.13	-0.02	0.01	-0.04	-0.0	0.01	-0.09	-0.01	-0.04	0.00	-0.1	**0.36**	**-0.08**

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