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RESEARCH ARTICLE

Effect of Salt Stress on the Morphological Attributes of Common Bean

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ABSTRACT

Environmental conditions such as salinity can have a negative impact on a plant's ability to grow and produce yield. The present research work was conducted at Botanical Garden and Herbarium Department of Botany, University of Malakand, Khyber Pakhtunkhwa Pakistan. To evaluate the responses of different maize at morphological level under different salt stress treatment as compare to control environment. A total of two varieties were evaluated for morphological study. After the germination different concentration (0, 25, 50, 100 and 200 mM of NaCl) were applied at appropriate stages. Salt stress caused a significant reduction in growth of all the common bean varieties. plant height incase control and with salt treated mean value was 19.0466, with standard error 0.7360, coefficient of variance was 25.877, range from Minimum 17.366cm and maximum 21.266cm, leaf length incase control and with salt treated mean value was 4.88, with standard error 0.1439, coefficient of variance was 33.891, range from Minimum 4.366cm and maximum 5.2cm, leaf width incase control and with salt treated mean value was 4.0266, with standard error 0.2682, coefficient of variance was 15.013, range from Minimum 3.066cm and maximum 4.7 respectively. Under different salt stresses when all varieties were compared to control condition.

Key words: Salt stress, stress indices, legume crops

INTRODUCTION

Common bean (*Phaseolus vulgaris L.*) having chromosomes number (2n=2x=22) is one of the world's most important food legumes. It is an important source of dietary protein, especially in developing countries (Graham et al., 2003) Common bean contributes to the national economy as a food as well as an export product, both as a source of income and as a source of employment for a large supply chain (Wondatir & Mekasha, 2014) The crop provides vital nutrients as a food, including vitamins, proteins and minerals, and the stems are also used as animal feed, particularly after the main crop season in the dry spell (Broughton et al., 2003). Local bean plants, as a legume, often contribute to soil fertility by fixing atmospheric nitrogen (Monyo & Gowda, 2014). Approximately 60% of the bean output occurs in agricultural land that is vulnerable to water deficits, without irrigation systems, where dry periods lead to losses that can reduce yields by up to 80% (Rosales et al., 2012).

Conditions of environmental stress, salinity and drought have adverse effects on plant growth and development (Shahbaz et al., 2013; Zafar et al., 2023). Salinity decreases seed germination, plant growth and flowering, which eventually reduce the productivity of plants (Kanwal et al., 2013; Zafar et al., 2024). This decrease in plant growth could be due to disrupted photosynthetic processes and biosynthesis of carbohydrates, decreased stomatal conductivity, deceased water quality and nutritional deficiency (Parihar et al., 2015, Chokshi et al., 2017; Zafar et al., 2022). Saline stress is one of the main factors in arid and semi-arid regions that limit the productivity of legumes (Lluch et al., 2007). Salinity is one of the most important factors that restrict plant growth and delay seed germination as well as the percentage of final germination (Rahman et al., 2000). Drought stress is currently the leading threat to the world's food supply, both as a natural occurrence and as part of climate change (Budak et al., 2013). This stress is more extreme than other abiotic stresses in common beans, making it the biggest obstacle for bean farmers to survive in poor, unfavorable environments. Most common bean production in developing countries occurs under conditions where there is a high risk of drought (Beebe et al., 2013).

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A significant production constraint of common bean crops is water deficit, which affects up to 60% of bean producing regions (Beebe et al., 2012). Due to increased drought in development areas, climate change has an adverse effect on food production (Dai 2011). In response to the water deficit, plants have adverse effects on production, development and yield (Lobell & Gourdji, 2012). A physiological approach may help to increase the knowledge available about the actions of growing bean genotypes toward climate change (Polania et al., 2016).

Studies on salinity and drought tolerance mechanisms have been reported in model plants such as Arabidopsis and very little work has been recorded in agricultural crops such as common bean. The objective of this research is therefore to screen resistant and prone varieties and to verify the impact on their morpho-physiological characteristics of different concentration salt solutions and drought.

MATERIALS AND METHODS

Plant Materials

The present study was carried out in the Glasshouse, at the Botanical Garden Herberium, University of Malakand. Common bean improved varieties were collected from the Plant Genetic Resources Institute (PGRI) Islamabad. To evaluate resistant and susceptible varieties the collected genotypes was sown in the pots by applying the drought and salt stress under the controlled environmental condition.

Selection of Salt Tolerance Variety

Salt tolerance capacity was tested in the four-week-old seedlings of the common been varieties cultivated in the glasshouse. All the lines were treated with 200 mM NaCl for 21 days. Control pots were irrigated with the same amount of water. Survival rates was examined after the treatment and images was captured to reveal visible phenotypes.

Morphological Characterization

Various morphological characteristics of the selected genotype were recorded. For example, Fresh Weight, Dry Weight, Length of Plant and Fresh weights (FW) of shoots and roots determination. For dry weight (DW) determination, samples were oven dried at 65±2 °C for 72 h and then will weight independently. FW and DW were expressed in grams per plant. Length of the plant was measured by using a metric scale and expressed in cm the experiments was repeated twice and each sampling will take 5 common bean seedlings from each treatment. Experimental findings of three replicate measurements were provided as a means ± standard error (SE). A statistical product and service solutions (SPSS) program will perform variance analysis and the Duncan multi-range test.

RESULTS

The experiment was conducted at the Botanical Garden & Herbarium Glass house of University of Malakand to perform the responses of selected genotype under the induced stress of different concentration of salt Sodium Chloride (NaCl), two varieties were collected from Market. The experimented was conducted in pots having three replicates. Five seeds were sown in each pot. After the complete seedling of plant uniform plants were select for the further investigation, while the rest was removed. The present research was investigating the effect salt Sodium Chloride (NaCl) on both morphological characteristics of common bean under the stress. One set of triplicate lines was controlled while the other was for different concentration of salt stress at early seedling and germination stage. At each series of germination shoot length, root length, total plant length and biomass were measured and counted. After that the following morphological parameter were studied.

Plant Height

The plant height is a major trait in plant against salt stress for the purposes the salt were applied in different concentration (0, 25mM, 50mM, 100mM, 200mM) with value local genotype (18.6, 17.3, 20.2, 17.8, 21.2cm), and tajaki with (18.06, 18.20, 19.10, 23.10, 19.4).

The descriptive statistical for plant height was in case of control mean value 19.04, standard error 0.736, and standard deviation 1.645, coefficient variance 25.87 range from 17. 366 to 21.26. while in treated plants the value is 18.33, slandered error 0.266, standard deviation 0.377, coefficient variance 68.75 range from 18.066 to 18.6 shown Table 3.1 and Fig. 3.1.

Leaf Length

The leaf length under salt stress for the salt were applied in different concentration (0, 25mM, 50mM, 100mM, 200mM) with value local genotype (5.066,4.966,5.2,4.8,4.366cm), and tajaki with (6.2,6.9,6.133,6.033,4.3cm).

The descriptive statistical for leaf length was in case of control mean value 4.88, standard error 0.143, and standard deviation 0.321, coefficient variance 33.89 range from 4.366 to 5.2 while in treated plant the value 5.633, standard error 0.566, standard deviation 0.801, coefficient variance 9.941, range from 5.066 to 6.2 shown Table 3.2 and Fig. 3.2.

Leaf Width

The leaf width under salt stress for the salt were applied in different concentration (0, 25mM, 50mM, 100mM, 200mM) with value local genotype (3.966,4.2,4.7,4.2,3.066cm), and tajaki with (5.7,7.366,6.266,5.1,4.366cm).

Table 3.1: Descriptive statistics for quantitative traits of two common bean varieties under induced salt stress.

	Descriptive statistics for 9 quantitative traits of control plants					
	Mean	Standard Error	Standard Deviation	Minimum	Maximum	CV%
PH	19.04667	0.736025	1.645803	17.36667	21.26667	25.87773
LL	4.88	0.143991	0.321973	4.366667	5.2	33.89107
LW	4.026667	0.268204	0.599722	3.066667	4.7	15.01345
PeL	9.317778	0.218768	0.489179	8.844444	10.03333	42.59213
NO. L	8.133333	0.847218	1.894436	5.333333	10.66667	9.600052
IL	5.066667	0.564899	1.263153	3.266667	6.466667	8.969152
RL	29.85333	0.762569	1.705156	27.46667	32	39.14838
PFW	1.916667	0.139296	0.311475	1.423333	2.163333	13.75968
PDW	0.1738	0.01143	0.025558	0.146	0.2	15.20588
	Descriptive statistical for 9 quantitative traits of treated plants					
	Mean	Standard Error	Standard Deviation	Minimum	Maximum	CV%
PH	18.3333	0.26667	0.37712	18.0667	18.6	68.75
LL	5.63333	0.56667	0.80139	5.06667	6.2	9.94118
LW	4.83333	0.86667	1.22565	3.96667	5.7	5.57692
PeL	3.23333	0.8	1.13137	2.43333	4.03333	4.04167
NO. L	6.58333	1.75	2.47487	4.83333	8.33333	3.7619
IL	5.83333	1.5	2.12132	4.33333	7.33333	3.88889
RL	28.35	0.71667	1.01352	27.6333	29.0667	39.5581
PFW	2.56333	0.49667	0.70239	2.06667	3.06	5.16107
PDW	0.253	0.103	0.14566	0.15	0.356	2.45631

Table 3.2: Correlation for quantitative traits of common bean under different concentration.

	PH	LL	LW	PeL	NO. L	IL	RL	PFW	PDW
PH	1								
LL	-0.4245	1							
LW	-0.46481	0.903991	1						
PeL	0.83839	0.112755	0.085721	1					
NO. L	-0.81502	0.725005	0.710009	-0.4648	1				
IL	-0.69829	0.551866	0.817704	-0.32787	0.661662	1			
RL	0.645837	0.15118	0.081925	0.790936	-0.08874	-0.34305	1		
PFW	-0.96177	0.602994	0.621139	-0.69247	0.806402	0.755726	-0.62102	1	
PDW	-0.07857	-0.71658	-0.58348	-0.48378	-0.06127	-0.18224	-0.10639	-0.19471	1

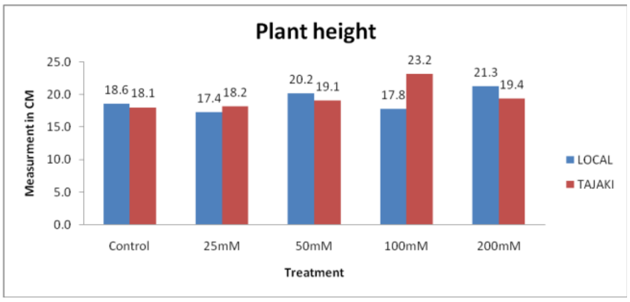

Fig. 3.1: Graphical representation of plant height under different concentration of salt

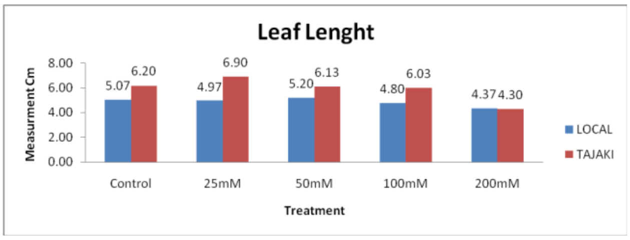

Fig. 3.2: Graphical representation of Leaf length under different concentration of salt

The descriptive statistical for leaf width was in case of control mean value 4.0266, standard error 0.268, standard deviation 0.599, and coefficient variance 15.013 range from 3.066 to 4.7 while treated value of mean is 4.833, standard error 0.866, standard deviation 1.225, coefficient variance 5.5766 range from 3.966 to 5.7 shown Table 3.1 and Fig. 3.3.

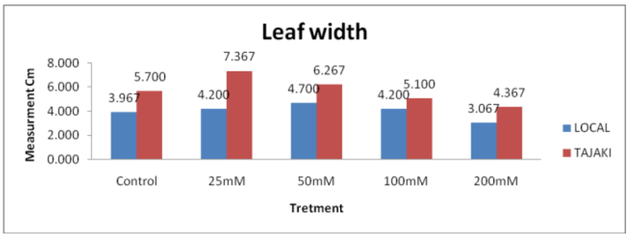

Fig. 3.3: Graphical representation of Leaf width under different concentration of salt

Petiole Length

The petiole length under salt stress for the salt were applied in different concentration (0, 25mM, 50mM, 100mM, 200mM) with value local genotype (9.211,8.844,10.033,8.933,9.566cm), and tajaki with (4.033, 3.4, 4.966, 4, 3.066cm).

The descriptive statistical for petiole length was in case of control mean value 9.317, standard error 0.218, standard deviation 0.489, coefficient variance 42.59 range from 8.844 to 10.033 while treated value of mean is 3.233, standard error 0.8, standard deviation 1.131, coefficient variance 4.041 range from 2.433 to 4.033 shown Table 3.1 and Fig. 3.4.

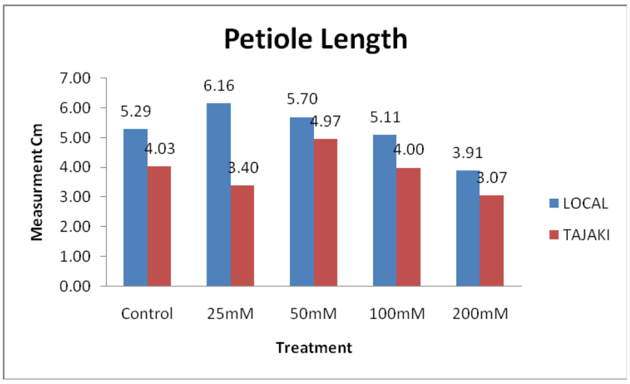

Fig. 3.4: Graphical representation of Petiole length under different concentration of salt

Internode Length

The internode length under salt stress for the salt were applied in different concentration (0, 25mM, 50mM, 100mM, 200mM) with value local genotype (4.333,5.666,5.6,6.466,3.266cm), and tajaki with (7.333,10.33,8,7.666,5cm).

The descriptive statistica for internode length was in case of control mean value 5.066, standard error 0.564, standard deviation 1.263, and coefficient variance 8.969 range from 3.266 to 6.466 while treated value of mean is 5.833, standard error 1.5, standard deviation 2.121, coefficient variance 3.888 range from 4.333 to 7.333 shown Table 3.1 and Fig. 3.5.

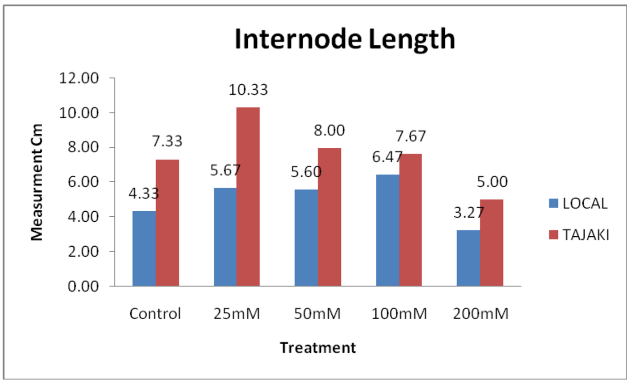

Fig. 3.5: Graphical representation of Internode length under different concentration of salt

Root Length

The root length under salt stress for the salt were applied in different concentration (0, 25mM, 50mM, 100mM, 200mM) with value local genotype (29.06,30.06,32,27.46,30.66cm), and tajaki with (27.63,22.5,27.03,25.13,312.23cm).

The descriptive statistical for root length was in case of control mean value 29.85, standard error 0.762, standard deviation 1.705, and coefficient variance 39.14 range from 27.46 to 32 while treated value of mean is 28.35, standard error 0.716, standard deviation 1.013, coefficient variance 39.55 range from 27.63 to 29.06 shown Table 3.1 and Fig. 3.6.

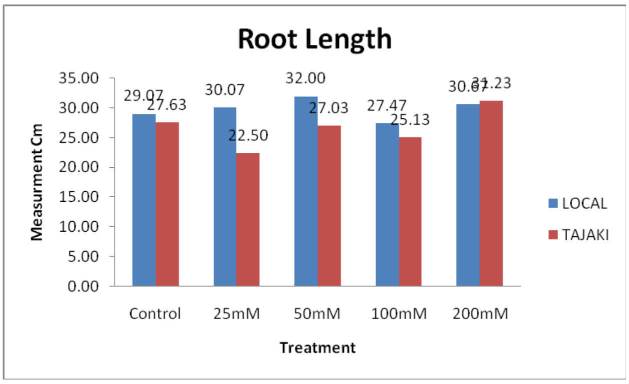

Fig. 3.6: Graphical representation of Root length under different concentration of salt

Plant Fresh Weight

The total plant fresh weight under salt stress for the salt were applied in different concentration (0, 25mM, 50mM, 100mM, 200mM) with value local genotype (2.066,2.133,1.796,2.163,1.423cm), and tajaki with (3.433,2.576,3.013,2.673cm).

The descriptive statistical for total plant fresh weight was in case of control mean value 1.916, standard error 0.139, standard deviation 0.311, coefficient variance 13.75 range from 1.423 to 2.163 while treated value of mean is 2.563, standard error 0.496, standard deviation 0.702, coefficient variance 5.161 range from 2.066 to 3.06 shown Table 3.1 and Fig. 3.7.

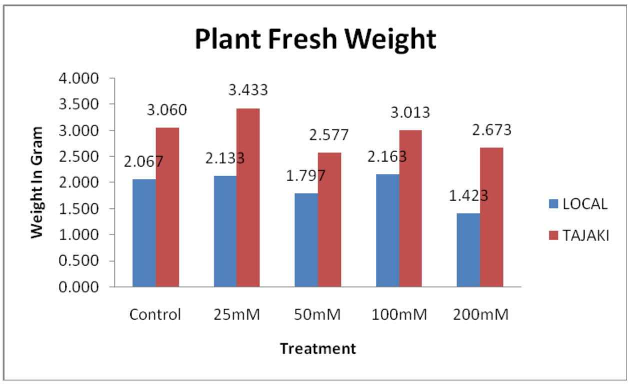

Fig. 3.7: Graphical representation of Plant fresh weight under different concentration of salt

Plant Dry Weight

The total plant dry weight under salt stress for the salt were applied in different concentration (0, 25mM, 50mM, 100mM, 200mM) with value local genotype (0.15,0.2,0.146,0.175,0.198cm), and tajaki with (0.356,0.487,0.214,0.352,0.337cm).

The descriptive statistical for total plant dry weight was in case of control mean value 0.173, standard error 0.011, standard deviation 0.025, coefficient variance 15.20 range from 0.146 to 0.2 while treated value of mean is 0.253, standard error 0.103, standard deviation 0.145, coefficient variance 2.456 range from 0.15 to 0.356 shown Table 3.1 and Fig. 3.8.

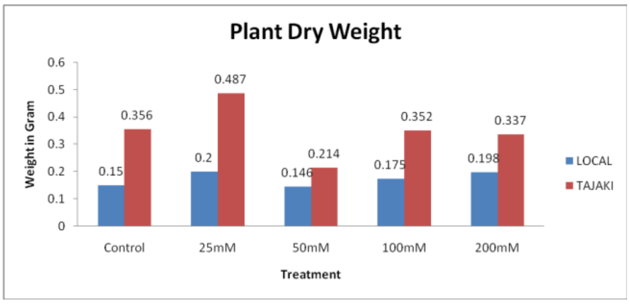

Fig. 3.8: Graphical representation of Plant dry weight under different concentration of salt

Correlation

Plant height have negative correlation with leaf length (-0.4245), plant height have negative correlation with leaf width (-0.46481), plant height have positive correlation with petiole(0.83839), plant height negative correlation with no of leaves(-0.81502), plant height have negative correlation with internode length (-0.69829), plant height have positive correlation with root length(0.645837),plant height have negative correlation with plant fresh weight (-0.96177), plant height have strongly correlation with plant dry weight(-0.07857). leaf length has positive correlation with plant height. leaf width has positive effect on plant height (0.903991), leaf width has positive effect on petiole (0.112755), leaf width has positive effect on No of leaves (0.725005), leaf width has positive effect on internode length (0.551866), leaf width has positive effect on root length (0.15118), leaf width has positive effect on plant fresh weight (0.602994), leaf width has negative effect on plant dry weight (-0.71658). petiole have positive correlation with plant height (0.085721), petiole have positive correlation with no of leaf (0.710009), petiole have positive correlation with inter node length (0.817704), petiole have positive correlation with root length (0.081925), petiole have positive correlation with plant fresh weight (0.621139), petiole have negative correlation with plant dry weight (-0.58348). Number of leaves have negative correlation with plant height (-0.4648),). No. of leaf have negative correlation with internode length (-0.32787),). No. of leaf have positive correlation with root length (0.790936), No. of leaf have negative correlation with plant fresh weight (-0.69247), No. of leaf have negative correlation with dry weight (-0.48378). internode length has positive correlation with plant height (0.661662). internode length has negative correlation with root length (-0.08874). Internode length have positive correlation with plant fresh weight (0.806402), internode length has negative correlation with dry weight (-0.06127). root length has negative correlation with plant height (-0.34305), root length has positive correlation with plant fresh weight (0.755726), root length has negative correlation with plant dry weight (-0.18224). plant fresh weight has positive correlation with plant height (0.62102),). plant fresh weight has positive correlation with plant dry weight (0.10639).). plant dry weight has positive correlation with plant height (0.19471).

DISCUSSION

Plants are faced with a variety of environmental stresses that can limit and decline the production of plants around the world. There are two kinds of stresses facing by plants that are abiotic (drought, elevated temperature, low temperature and salinity) and biotic stress (bacteria, viruses, fungus, protozoan) (Gull et al., 2019). But abiotic stress was the more constrain that can affects plants productive all over the world. Among these abiotic stresses salinity stress is one of the critical environmental stresses that can inhibits and decline plant growth, development, productivity and its negative consequences are posing a serious threat to our most valuable crops and urban greenbelts (Breś et al., 2016). Salt stress existed long before humans and agriculture; nevertheless, agricultural methods such as irrigation have contributed to the problem (Zhu, 2016). The current experiment was carried out to determine the effects of salt stress on common bean genotypes to screening salt tolerance variety under different salt treatment, because common bean is a major grain legume crop, which is third in importance after soybeans and peanuts (Sofi et al., 2018). Beans, which contain about 25% protein, are the most important source of protein. It's also high in dietary fibres and minerals particularly iron and zinc (Manjeru et al., 1995). During the present study the effect of salt stress were tested in Common bean genotype. The different morphological parameters of the selected genotypes were documented i.e. dry weight, Fresh weight, total biomass, root length, number of secondary roots, shoot length and plant length, these traits were effect by salt Similarly, salinity stress affects development processes such as seed germination, seedling growth and vigor, vegetative growth, flowering and fruit set. in present experimental work the variation was observed in dry weight of present study between control and salt stress treated plant, according to (Parihar et al., 2015) Salinity affect plant growth, and multiple pigments such as photosynthetic pigments, affecting photosynthesis, water relationship, nutrient balance and yield. Although the plant life cycle suffered severely due to salt stress, which processed the most affected still needs to be explored (Vadez et al., 2012). Root system topology, geographical distribution of primary and lateral roots, and length and quantity of secondary roots make up the architecture of the root system. The morphological plasticity of roots is influenced by the physical properties of the soil (Kole et al., 2015). Roots are now the only route to get under trace elements; hence they play a big part in excessive accumulating according to (Gama et al., 2007) the consequences increase in the root to shoot growth it showed that the association with increase salinity tolerance in the species. Descriptive statistical analyses of the current experiment regarding root length similarly under salt stressed condition the highest in previous studies, it has been revealed that plant having longer roots were more suitable to stress compared to plants having short root length (Gowda et al., 2011). It can be modified by many environmental factors, including nutrient, water availability, photoperiod and temperature (Van der Putten et al., 2010). During present study shoot length, among the treated plants, the highest mean value in the present experiment salt stress reduces the stem plant height respectively. Total plant length significant difference was present between control and salt stress treated plant. Reported plant height values of respectively, in their study the total plant height was affected by salt but in case which show resistant toward salinity. Increase total biomass of plant justifying growth promotion and consider in important parameter for habitat adaptation. Plant biomass is an environment dependent parameter (Libra et al., 2011), during present investigation the total biomass of the plant as an important parameter for adaptation to stress responses, plant biomass is an environment dependent parameter. In the present study Plant biomass Significant difference was present between control and salt stress treated plant.

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