Effect of arginine on growth, nutrient composition, yield and nutritional value of mung bean plants grown under salinity stress

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Abstract: Salinity is a major limitation to legume production in many areas of the world. The salinity sensitivity of mung bean was studied to determine the effect of salinity on vegetative growth (plant dry weight and plant height), yield components (plant height, pods number, pods weight, seeds number/pod, seeds weight/plant and biological yield/plant), nutritional value of produced seeds (N, P, K, Ca, Mg, Na, Cl, soluble carbohydrate, polysaccharides, total carbohydrate, proline, total amino acids and protein contents) and mineral contents in green shoot at harvest (N, P, K, and Na). Also, the role of arginine in alleviating the effect of salinity stress was studied. Mung bean seeds were planted in soils of different salinity levels. The concentration of the irrigation water used in this experiment were (0, 15000, 3000, 4500 and 6000 ppm). All growth parameters were significantly reduced with high salinity levels (4500 and 6000 ppm) while 1500 and 3000 ppm induced slight increase. Salinity stress also, induced significant increases in Na, Cl, Ca and Mg and decreased significantly N, P, and K contents. Salinity stress reduced most yield components and nutritional value of produced seeds. However, spraying plants with arginine could alleviate the harmful effect of salinity at all studied parameters. [Nature and Science 2010;8(7):30-42]. (ISSN: 1545-0740).

Key words: Mung bean, Salinity, Arginine, growth, Yield, Mineral compositions

1. Introduction

Salinity is a common a biotic stress factor seriously affecting crop production in different regions, particularly in arid and semi – arid regions. It is estimated that over 800 million hectare of land in the world are affected by both salinity and sodicity (Munns, 2005). There are various detrimental effects of salt stress in crop plants, responsible for severe decrease in the growth and yield of plants. Osmotic stress (drought problem), ion imbalance, particularly with Ca, K, and the direct toxic effects of ions on the metabolic process are the most important and widely studied physiological impairments caused by salt stress (Zhu, 2001; Munns, 2002; Munns et al., 2006 and Eker et al., 2006). Salt stress, like many a biotic stress factors, reduces the ability of plants to take up water, leading to growth reduction as well as metabolic changes similar to those caused by the water stress (Munns, 2002). High salt concentration in root affects the growth and yield of many important crops (Alam et al., 2004; Taffouo et al., 2004). The salinity may reduce the crop yield by upsetting water and nutritional balance of plant (Khan et al., 2007 and Taffouo, 2009).

Agricultural soils have many types of salt ions. However, NaCl is usually the damaging and predominant salt (Turan et al., 2007a). Although, adaptation of plants to salinity is associated with osmotic adjustment (Turan et al., 2007b), they widely differ from the exerted to which they accumulate inorganic ions (Munns, 1993). Osmotic regulators in plants include K, soluble sugar, proline and betaine (Le Rudulier, 2005). These molecules are important physiological indicator for evaluating osmotic adjustment ability (Zhu, 2002).

Mung bean (*Vigna radiate* L.Wilczek) is a summer pulse crop with short duration (70 – 90 days) and high nutritive value. It has many effective uses, green pods in cooking as peas, sprout rich in vitamins and amino acids. This crop can be used for both seeds and forage since it can produce a large amount of biomass and then recover after grazing to yield abundant seeds (Lawn and Ahn, 1985) and can be used in broilers diets as a non – traditional feed stuff (El-Karamany et al., 2003).

Arginine is one of the essential amino acids (considered the main precursor of polyamines which produced by decarboxylation of arginine via arginine decarboxylase to form putrescine (Evans and Malmberg, 1989; Bocherueu, 1999). Polyamines and their precursor arginine have been implicated as vital modulators in a variety of growth, physiological and developmental processes in higher plants (Glastone and Kaur-sawhny, 1990). Polyamines are involved in the control of cell cycle, cell division, morphogenesis in phytochrome and plant hormone mediated process and the control of plant senescence, as well as in plant response to various stress factors (Walters, 2000 and Abdel Monem, 2007). The application of arginine significantly promoted the growth and increased the fresh and dry weights, certain endogenous plant growth regulators, chlorophylls a and b and carotenoids in bean (Nassar et al., 2003); in wheat

Abd ElMonem, 2007) and El-Bassiouny et al., 2008). Moreover Hassanein et al., (2008) and Khalil et al., (2009) recorded the positive role of arginine in alleviating the inhibition occurs as the result of exposing plants to stress.

The objective of the present study was to evaluate the response of mung bean to grown under saline irrigation and to study the role of arginine in alleviating the harmful effects of salinity stress.

2. Material and Methods

The experimental plant used in this investigation was mung bean (*Vigna radiata* var. kawmy-1). The chemical used in the present work was arginine (one of the essential amino acids); it was supplied from SIGMA – ALDRICH.

A pot experiment was carried out in the screen greenhouse of National Research Centre, Dokki, Giza, Egypt. This experiment was carried out to study the effect of spraying mung bean plants with different concentrations of arginine (0.0, 1.25, 2.50 and 5.00 mM) on growth, yield and chemical composition of yielded seeds of mung bean under different salinity levels (1500, 3000, 4500 and 6000 ppm). The salt components of salt mixture are shown in Table 1.

Table (1): The component of salt mixture used for chloride Stalinization expressed as % of total salt content as described by Stroganov (1962):

$MgSO_4$	$CaSO_4$	NaCl	$MgCl_2$	$CaCO_3$
10	1	78	2	9

The components of specific anions and cations in chloride mixture expressed as percentage of total mill equivalent

Table (2): The components of specific anions and cations in chloride mixture expressed as percentage of total mill equivalent

Na^+	Mg^{+2}	Ca^{+2}	SO_4^{-2}	Cl^-	CO_3^{-2}
38	6	6	5	40	5

A homogenous lots of mung bean seeds variety kawmy-1 was sown in pots (50 cm in diameter) containing equal amounts of mixture sandy and clay soil (2:1). The pots were divided into five groups according to irrigation with different levels of saline solutions by using Stroganov nutrient solutions. Each group was divided into four sub-groups according to the concentration of arginine (0.0, 1.25, 2.5 and 5.00 mM). Each sub-group sprayed with one concentration at 21 days after sowing and the spraying was repeated after one week from the first spray. Every treatment consisted of 5 replicates distributed in a completely randomized design. The pots were irrigated with equal volumes of the various salinity levels, after 21 from sowing. Irrigation was run as follow 3 times with saline solutions and one with tap water. Fertilization was done with the recommended dose i.e. (phosphorous / pot as triple phosphate, nitrogen / pot as urea and potassium / pot as potassium sulphate) during preparation of pots and after sowing. After 15 days from sowing thinning was carried out, so as five uniform seedlings were left in each pot for studying the effect of different treatments on the yield of mung bean cultivar.

Five mung bean plants from each pot were cut from ground surface at 75 days after sowing. Plant height and dry weight of mung bean of shoot were determined. Dry weight was determined after drying in a forced oven at 70˚C till constant weight. Measurement of yield and its components was recorded at harvest.

Chemical composition of seeds and green shoots at harvest:

The dried seeds were finally ground. A total soluble carbohydrate was determined using modifications of the procedures of Yemm and Willis, (1954) and Handel (1968). Total carbohydrate content was determined calorimetrically according to Dubois et al., (1956). Polysaccharides were calculated by the difference between total carbohydrates and total soluble carbohydrates. Total free amino acids and proline contents were determined calorimetrically according to Hassanein, (1977) for extraction (Muting & Kaiser, 1963) and Bates et al. (1973). Total N and protein contents were determined by the Kjeldahl method of Pirie (1955). The nutrient elements K, Na, Mg, Ca, Cl and P were determined according to the method described by Chapman and Pratt (1978) in seeds and green leaves. Also, the protein electrophoratic pattern of yielded grains was recorded according to Reuveni et al., (1992) with some modifications.

Statistical analysis:

The data recorded were subjected to the statistical analysis by M-STAT-C statistical analysis program (MSTAT, 1988). Least significant difference test was applied at 0.05 probability level to compare mean treatments.

3. Result Analysis

Mung bean growth:

Data in Table 3 clear that, the irrigation of mung bean with saline water (1500 and 3000 ppm) increased significantly plant height and dry weight /plant as compared with control plant. While the higher levels of salinity (4500 and 6000 ppm) decreased significantly these parameters as compared with untreated plant. The reduction in vegetative growth due to high salinity effect is in harmony with previous investigators (Taffouo et al., (2004) on some legumes plants Mohamedin et al. (2006) on sunflower and Touffouo et al. (2009) on cowpea plants.

The inhibition effects of salinity on growth parameters of mung bean plants might be due to salinity which inhibits the growth through reduced water absorption, reduced metabolic activities due to Na^+ and Cl^- toxicity and nutrient deficiency caused by ionic interference (Ghoulam et al., 2002 and DeLacerda et al., 2003).

The results in same table also showed that, spraying mungbean with arginine (1.25, 2.5 and 5 mM) reduced significantly plant height of mung bean plants as compared with control plant. Increasing arginine concentration reduced gradually plant height of mung bean plant. Plant dry weight increased significantly over the control plant. These results are in good harmony with those obtained by Abd El-Monem (2007) and El-Bassiouny et al., (2008) on wheat plants.

The results also showed that, spraying mung bean plants with different concentrations of arginine could alleviate the harmful effect of salinity on plant height and plant dry weight). The highest value of plant dry weight was recorded at 2.5 mM arginine. These results are in agreement with those obtained by Abd El-Monem (2007) who found that, arginine at 2.5 mM was the optimum concentration in the alleviation the harmful effects of stress. Also, Xu et al. (2001) and Nassar et al. (2003) concluded that exogenous application of polyamine (end product of arginine) to several plant species have been shown to promote cell division, cell differentiation and general growth promotion. They can also help to stabilize membrane and wall properties (Velikov et al., 2000) and protect plant against environmental stress (Mo and Pua, 2002).

Mung bean yield and its components:

Data in (Table 4) showed the plant height at harvest, number and weight pods per plant, pods weight per plant, seeds number /pod, seeds and biological yield per plant affected by salinity irrigation and spraying plants with arginine concentrations. All these criteria decreased under different salinity irrigation. The plant height, pods number/plant and seeds number /pod were significantly decreased under all salinity levels. Increasing salinity levels induced gradual reduction as compared with untreated plant. While, pods and seeds weights/plant increased significantly under lower levels of salinity (1500 and 3000 mg/l) and decreased under the higher concentrations (4500 and 6000 mg/l). Biological yield was increased significantly under 1500 mg/l and gradually reduced under all other salinity levels. For instance the reduction in the plant height, pods number /plant and seeds number/pod reached to 63.84%, 59.66% and 12.2% at 6000 mg/l respectively. The lowest level of salinity (1500 mg/l) increased the weight of pods and seeds /plant and the biological yield of mung bean by 24.52%, 27.16% and 14.99% respectively. The highest level of salinity reduced the parameters by 58.65%, 43.21% and 37.10 % respectively. These results agree with those obtained by Mass and Grieve (1990) on both durum and bread wheat; Sharma and Gill (1994) on mustard yield; Abd El-Halim et al. (1995) on wheat; El-Bassioumy et al. (1999) on sunflower; El-Bassiouny and Bekheta (2001) on wheat and Zadeh and Naeini (2007) on canola. The depressive effect of salinity on yield may be attributed to the inhibitory effect of salinity on vegetative growth (Table 3). In this connection Abd El-Halim et al. (1995) concluded that, the reduction of wheat grain yield per plant due to salinization might be due to the harmful effect of salt stress on growth, the disturbance in mineral uptake and/or enhancement of plant respiration. Moreover, Taffouo et al. (2009) reported that, the significant decrease of yield components observed under salt stress in cowpea would be partly related to a significant reduction of foliar chlorophyll contents (more than 50%) and K^+ concentration in saline medium.

Results in same table also show that, exogenous application of arginine under salinity level caused increase in all parameters of yield components as compared to the corresponding salinity level. Krishnamurthy (1991) reported that, when putrescine (arginine forming substance) was exogenously supplied on the salt stressed plant, the grain yield of rice increased. This increment could be due to antisenescence effect of putrescine. El-Bassiouny and Bekheta (2001) proved that, putrescine is intimately involved in salt treated wheat plant thereby regulating growth, development and grain yield. Nassar et al. (2003) concluded that, arginine induce early flowering and fruiting of bean plants respectively.

Chemical analysis of yielded seeds:

The obtained results in Table (5) show that irrigation of mungbean with different salinity levels decrease total soluble carbohydrates, polysaccharides, total carbohydrates, total amino acid contents and protein percentage of mung bean seeds as compared to plants irrigated with non saline water (control). The magnitude of reduction was increased with increasing salinity level. The reduction in total soluble carbohydrates, polysaccharides and total carbohydrates in mung bean seeds could be attributed to the nutritional imbalance and specific toxic effect of salinity as recorded by Nou et al. (1995); hyperosmotic stress and reduced photosynthesis Abd El-Wahab (2006).

Moreover, total amino acid content in mung bean seeds found to be adversely affected due to salinity effect. The same result was obtained by Sarwat and Sherif (2007) who stated that, amino acid appeared to be decreased with salinity depending on the concerned amino acid response on barley.

The reduction in protein percentage in seeds of mung bean plants irrigated with salinity may be attributed to the reduction in the total nitrogen (Table 6) content as salinity increased. This result was in line with El-Hindi and El-Ghamry (2005) on cherry gold plants and Abd El- Wahab (2006) on Foeniculum vulgare.

The results in same table clear that Proline content of mung bean seeds increased gradually with increasing salinity levels as compared with those plants grown on non saline water. This result demonstrate that, the physiological function of proline accumulated in mung bean under salinity stress may not be just behave as an osmolyte and protectant but may also have other roles related to stress. The result of proline in mung bean seeds is in good agreement with those obtained by Nuran and Cakirlar (2002) on maize; Abd El-Hamid et al. (2003) on *Pancratium maritimum*; Shi and Sheng (2005) and Mohamedin et al. (2006) on sunflower.

Table 5 also shows the role of arginine in ameliorate the adverse effect of salinity on all chemical composition of mung bean seeds. Arginine treatment of mung bean plants increased significantly total soluble carbohydrate, poly saccharides, total carbohydrates, proline, total amino acid and protein contents of mung bean seeds under saline and non saline irrigation. The magnitude of increment was much pronounced by using 2.5 mM arginine under all salinity levels. These results could be supported by the results obtained by Abd El-Monem (2007); El-Bassiouny et al. (2008) and Hassanein et al. (2008) who indicated that arginine was the most effective compound in increasing soluble carbohydrate, poly saccharides, total carbohydrates, proline, total amino acid and protein contents of wheat plants and grains under normal or stressed condition.

Macro elements in mungbean leaves and seeds at harvest:

N, P and K concentrations in mung bean green seeds (Table 6) and leaves (Table 7) were significantly decreased under different saline irrigation compared with control plants. Data also in Table (7) show that, Na content of green leaves and Na, Ca, Mg and Cl concentrations of seeds (Table6) increased significantly in response to irrigation with all salinity levels as compared to leaves or seeds irrigated with tap water. Confirm these results Pessarakli (1991) and Al-Rawahy et al. (1992) who stated that, salinity can reduce N accumulation in plants. Many scientists attributed the reduction of N concentration to Cl antagonism of NO_3^- uptake Lea-Cox and Syverten (1993). This may be attributed to increase in Cl uptake which accompanied by a decrease in NO_3 concentration (Bar et al., 1997). Phosphate availability is reduced in saline soils not only because of ionic strength effect that reduce the activity of phosphate but also because phosphate concentration in soil solution is tightly controlled by sorption processes and by the low solubility of Ca and P minerals. Therefore, it is understandable that phosphate concentration in field grown agronomic crops decreased as salinity increased (Mohamedin et al., 2006).

In response to K results Grattan and Grieve (1999) reported that under saline conditions, high level of external Na not only interfere with K^+ acquisition by roots but also may disturb the integrity of root membranes and alter selectivity.

The obtained results of Na and Cl concentrations in mung bean seeds are in good harmony with those obtained by Francois (1996); Barrett-Lennard (2003) and Shi & Sheng (2005) on sunflower. Salinity has an antagonistic effect on the uptake of Ca and Mg which caused by displacing Ca in membranes of root cells (Yermiyahu et al., 1997); and (Asik et al., 2009) on wheat.

External application of arginine reduced significantly Na and Cl concentrations, in leaves and seeds of mung bean, while increased the uptake of N, P K in leaves and N, K, Ca, Mg and P in mung bean seeds and furthermore the K/Na ratio increased under all salinity levels compared to corresponding control. The magnitude of reduction was increased with increasing arginine concentration. These results are in good harmony with those obtained by Sharma et al. (1997) they reported that foliar application of putrescine (one product of arginine) enhance the uptake of K, Ca and Mg but decreased Na and Cl uptake in chick pea plant. Santa-Cruzet al. (1997); Mansour and Al-Mutawa (1999) and El-Bassiouny and Bekheta (2001) suggested that the main role of all arginine products (putrescine, spermidine and spermine) in salt treated plants in the long term is to maintain a cation-anion balance in plant tissues by stabilizing membrane at high external salinity.

Protein electrophoratic pattern:

Results in Table (8) show that, the changes in protein electrophoretic pattern of mung bean seeds sprayed with arginine (1.25, 2.5 and 5 mM) and irrigated with different levels of salinity (1500, 3000, 4500 and 6000 ppm).

In the control mung bean seeds sowing without treatment, the separation of 8 protein bands were apparent, their molecular weights ranged between 117 KDa and 8 KDa. Irrigation of wheat plants with different salinity levels (2000, 4000, 6000 and 8000 ppm) showed an increase in the number of protein bands to 17, 17, 17 and 18 bands, respectively. The result also showed the disappearance of protein bands at molecular weights 36 and 14.5 KDa at all salinity levels. These results indicate that the seeds of plant irrigated with different salinity levels characterized by disappearance of certain bands and the appearance of new ones as compared with that of the untreated grains, Table (8). In this respect Kermode (1997) and Bekheta and El-Bassiouny (2005) concluded that one of the important mechanism involved in the cell protection against salinity stress is the induction of de novo synthesis of a set of new protein. Therefore, in the present study, salinity stress in general induced synthesis of a new set of protein bands (3 bands) at molecular weights 100, 70 and 44 KDa at all salinity levels, and at molecular mass 36 KDa at 8000 ppm only.

In this respect, HSP 70 a group of HSPs accumulated in response to drought stress (Pareek et al., 1995). Such proteins are referred to as associated proteins. Moreover, Close (1996) and Han et al (1997) concluded the presence of some protein band at different molecular weight have a protective role in under water loss due to their function as an trap ion in dehydrating cells and sequestering ions as they become concentrated.

Irrigation of mung bean with different concentrations of arginine induced the appearance of protein band at molecular weight 80 KDa. In this respect, Kuznetsov and Shevyakova (1997) stated that putrescence (the final product of arginine decarboxylation) could change the stability and substrate specificity of protein kinase/phosphayase systems to modify the properties of polypeptides and acting as substrates for phosphorylation and dephosphorylative enzymes and affect the stability of protein molecules in plants. It is worthy to mention that, arginine treatments induced the appearance of new protein bands at molecular weight 131.00 KDa. This band disappeared when plants irrigated with different salinity levels.

Moreover, there are a protein bands appeared at molecular weights 92, 90, 71.5, 60, 32.5, 16.5 and 8 KDa are appeared in plants sprayed with all arginine concentrations and irrigated with all salinity levels. Arginine also showed disappears of protein band at molecular weight 19 KDa under all salinity levels, and at molecular weights 117 and 104 KDa under control, 4500 and 6000 ppm. These results are in good harmony with those obtained by (Abd El-Monem, 2007, El-Bassiouny *et al.*, 2008 and Khalil *et al.*, 2009) who indicated that, arginine treatments induced the appearance of new protein bands at molecular weights 222.0, 214.6, 131.8, 93.1, 78.7, 50.7, 34.6 and 14.1 KDa in wheat plants. Also Bekheta and El-Bassiouny concluded that the plant treated with putrescine and irrigated with different salinity levels showed that the improving salt tolerance by adding putrescine increased the intensity of salt responsive proteins at molecular weights 91, 70, 36, 21, 17 and 15 KDa).

Table (3): Effect of different concentrations of arginie on plant height and dry weight of mungbean at 75 DAS grown under salinity stress.

Treatment		Shoot length (cm)	Dry weight/plant (g)
Salinity (ppm)	**Arginine (mM)**		
Zero	**Zero**	32.67	4.29
	1.25	39.00	5.42
	2.50	38.00	4.48
	5.00	37.00	4.03
1500	**Zero**	45.00	3.89
	1.25	46.00	5.54
	2.50	30.67	3.18
	5.00	29.00	2.14
3000	**Zero**	35.33	3.11
	1.25	42.00	5.09

	2.50	28.67	3.20
	5.00	26.00	2.00
4500	**Zero**	33.00	2.97
	1.25	39.00	3.43
	2.50	25.00	2.41
	5.00	22.00	1.74
6000	**Zero**	20.67	1.85
	1.25	23.67	2.11
	2.50	21.33	1.65
	5.00	19.33	1.63
LSD at 5%			**0.12**
Mean of main effects:			
Salinity (ppm)	**Control**	36.67	4.55
	1500	37.67	3.69
	3000	33.00	3.35
	4500	29.75	2.64
	6000	21.25	1.81
LSD at 5%		**1.31**	**0.04**
Arginine (mM)	**Zero**	33.33	3.22
	1.25	37.93	4.32
	2.50	28.73	2.99
	5.00	26.67	2.31
LSD at 5%		**1.14**	**0.05**

Table (4): Effect of different concentrations of arginine on mungbean yield and its components grown under salinity stress.

Character Treatment		**Plant ht. at harvest (cm)**	**Pods no/ plant**	**Pods wt. (g/plant)**	**Seeds no/pod**	**Yields/plant (g)**			**HI %**
Salinity (ppm)	**Arginine (mM)**					**Seed**	**Straw**	**Bio.**	
Zero	**Zero**	59.00	6.00	2.08	4.07	1.62	8.38	10.00	16.20
	1.25	43.67	6.58	2.46	4.37	1.88	8.90	10.78	17.44
	2.50	42.00	8.67	2.91	4.89	2.03	9.86	11.89	17.07
	5.00	43.33	5.08	1.81	2.80	1.26	8.74	10.00	12.60
1500	**Zero**	50.67	5.67	2.59	4.95	2.06	7.16	9.22	22.34
	1.25	41.33	7.33	2.82	5.42	2.36	8.09	10.45	22.58
	2.50	40.00	7.33	3.09	4.68	2.55	8.12	10.67	23.90
	5.00	40.00	3.92	2.20	3.34	2.01	7.10	9.11	22.06
3000	**Zero**	47.33	4.83	2.36	3.90	1.88	7.23	9.11	20.64
	1.25	41.33	6.50	2.58	4.63	2.22	8.11	10.33	21.49
	2.50	34.33	6.75	2.75	3.49	2.52	7.03	9.55	26.39

	5.00	24.00	3.17	1.84	2.95	1.20	8.13	9.33	12.86
4500	**Zero**	39.67	3.58	1.59	2.80	1.07	8.04	9.11	11.75
	1.25	40.00	3.92	1.96	3.52	1.34	8.44	9.78	13.70
	2.50	30.67	5.00	2.12	2.86	1.56	7.44	9.00	17.33
	5.00	31.33	2.33	1.33	2.17	0.87	7.02	7.89	11.03
6000	**Zero**	21.33	2.42	0.86	2.56	0.92	7.86	8.78	10.48
	1.25	34.00	3.08	0.99	3.09	1.06	8.27	9.33	11.36
	2.50	28.67	3.42	1.11	2.62	1.27	7.95	9.22	13.77
	5.00	28.00	1.33	0.64	1.34	0.55	6.89	7.44	7.39
LSD at 5%		**2.14**	**0.42**	**0.12**	**0.54**	**0.19**	**0.22**	**0.12**	**5.72**
Mean of main effects:									
Salinity (ppm)	**Control**	47.00	6.58	2.32	4.03	1.70	8.97	10.67	15.83
	1500	43.00	6.06	2.68	4.60	2.25	7.62	9.86	22.72
	3000	36.75	5.31	2.38	3.74	1.96	7.63	9.58	20.34
	4500	35.42	3.71	1.75	2.84	1.21	7.74	8.95	13.45
	6000	28.00	2.56	0.90	2.40	0.95	7.74	8.69	10.75
LSD at 5%		**1.49**	**0.20**	**0.05**	**0.21**	**0.09**	**0.14**	**0.10**	**2.91**
Arginine (mM)	**Zero**	43.60	4.50	1.90	3.66	1.51	7.73	9.24	16.28
	1.25	40.07	5.48	2.16	4.21	1.77	8.36	10.13	17.32
	2.50	35.13	6.23	2.40	3.71	1.99	8.08	10.07	19.69
	5.00	33.33	3.17	1.56	2.52	1.18	7.58	8.75	13.19
LSD at 5%		**0.88**	**0.17**	**0.05**	**0.22**	**0.08**	**0.09**	**0.05**	**2.35**

Table (5): Effect of different concentrations of arginine on chemical constitute in mungbean seeds grown under salinity stress.

Treatment		**Chemical constitute in grains (mg/100 g grain weight)**					**Protein (%)**
Salinity (ppm)	**Arginine (mM)**	**Total soluble Sugar**	**Poly sacharides**	**Total charb.**	**Total amino acids**	**Prolin**	
Zero	**Zero**	21.25	32.06	53.31	50.90	11.82	20.73
	1.25	26.75	38.44	65.19	55.65	13.83	22.06
	2.50	28.95	44.67	73.62	61.90	16.65	25.12
	5.00	27.50	42.94	70.44	52.85	13.48	30.25
1500	**Zero**	21.55	31.99	53.54	44.10	12.44	23.69
	1.25	28.25	43.94	72.19	54.45	14.81	26.25
	2.50	30.25	45.62	75.87	55.85	17.80	27.13
	5.00	24.10	38.88	62.98	51.20	14.52	29.06
3000	**Zero**	17.15	25.23	42.38	43.15	13.48	20.70
	1.25	21.55	34.57	56.12	50.90	16.96	22.81
	2.50	23.35	36.02	59.37	54.35	18.11	24.19
	5.00	22.40	34.66	57.06	46.25	15.73	26.50
4500	**Zero**	15.75	23.63	39.38	40.30	14.70	18.13

	1.25	18.70	27.80	46.50	44.45	18.15	20.69
	2.50	21.10	31.71	52.81	53.50	18.61	22.81
	5.00	19.10	26.34	45.44	41.48	17.83	26.06
6000	**Zero**	15.03	22.47	37.50	38.30	16.96	16.75
	1.25	17.65	25.54	43.19	41.50	19.59	18.38
	2.50	19.35	29.84	49.19	51.95	20.63	20.44
	5.00	18.50	29.75	48.25	42.52	19.00	23.25
LSD at 5%		**0.86**	**2.78**	**3.37**	**3.36**	**0.47**	**1.44**
Mean of main effects:							
Salinity (ppm)	**Control**	26.11	39.53	65.64	55.33	13.95	24.54
	1500	26.04	40.11	66.15	51.40	14.89	26.53
	3000	21.11	32.62	53.73	48.66	16.07	23.55
	4500	18.66	27.37	46.03	44.93	17.32	21.92
	6000	17.63	26.90	44.53	43.57	19.05	19.71
LSD at 5%		**0.54**	**1.53**	**1.74**	**1.05**	**0.15**	**1.03**
Arginine (mM)	**Zero**	18.15	27.07	45.22	43.35	13.88	20.00
	1.25	22.58	34.06	56.64	49.39	16.67	22.04
	2.50	24.60	37.57	62.17	55.51	18.36	23.94
	5.00	22.32	34.51	56.83	46.86	16.11	27.02
LSD at 5%		**0.35**	**1.14**	**1.38**	**1.38**	**0.19**	**0.59**

Table (6): Effect of different concentrations of arginine on macro elements in mungbean seeds grown under salinity stress.

Treatment		**Macro elements (mg/g grains dry weight)**							**K/Na**
Salinity (ppm)	**Arginine (mM)**	**N**	**P**	**K**	**Na**	**Ca**	**Mg**	**Cl**	
Zero	**Zero**	3.37	0.61	0.49	1.59	0.80	1.20	0.16	0.31
	1.25	3.53	0.65	0.56	1.38	1.40	2.00	0.15	0.41
	2.50	4.02	0.70	0.61	1.10	1.60	2.60	0.15	0.55
	5.00	4.84	0.73	0.62	1.03	2.00	2.20	0.17	0.60
1500	**Zero**	3.79	0.56	0.39	1.72	1.60	2.20	0.19	0.23
	1.25	4.20	0.60	0.44	1.62	1.90	3.00	0.17	0.27
	2.50	4.34	0.65	0.45	1.38	2.10	3.90	0.15	0.33
	5.00	4.65	0.67	0.55	1.14	2.30	3.30	0.21	0.48
3000	**Zero**	3.32	0.47	0.34	1.95	1.80	2.80	0.22	0.17
	1.25	3.65	0.50	0.35	1.82	2.40	3.60	0.22	0.19
	2.50	3.87	0.60	0.38	1.62	2.60	4.10	0.20	0.24
	5.00	4.24	0.57	0.39	1.34	2.80	3.60	0.23	0.29
4500	**Zero**	2.90	0.38	0.24	2.54	2.10	3.10	0.23	0.10
	1.25	3.31	0.41	0.27	2.08	2.80	4.20	0.23	0.13

	2.50	3.65	0.50	0.27	1.89	2.90	4.80	0.21	0.14
	5.00	4.17	0.51	0.29	1.61	3.10	3.80	0.24	0.18
6000	**Zero**	2.68	0.32	0.18	2.93	2.40	3.60	0.24	0.06
	1.25	2.94	0.34	0.20	2.24	2.95	4.60	0.24	0.09
	2.50	3.27	0.40	0.22	2.08	3.20	5.10	0.21	0.10
	5.00	3.72	0.44	0.25	1.82	3.40	4.20	0.25	0.14
LSD at 5%		**0.23**	**0.08**	**0.06**	**0.08**	**0.27**	**0.14**	**4.19**	**0.71**
Mean of main effects:									
Salinity (ppm)	**Control**	3.94	0.67	0.57	1.28	1.45	2.00	0.16	0.47
	1500	4.25	0.62	0.46	1.47	1.98	3.10	0.18	0.33
	3000	3.77	0.54	0.37	1.68	2.40	3.53	0.22	0.22
	4500	3.51	0.45	0.27	2.03	2.73	3.98	0.23	0.14
	6000	3.15	0.38	0.21	2.27	2.99	4.38	0.24	0.10
LSD at 5%		**0.17**	**0.06**	**0.04**	**0.06**	**0.20**	**0.25**	**2.09**	**0.03**
Arginine (mM)	**Zero**	3.21	0.47	0.33	2.15	1.74	2.58	0.21	0.17
	1.25	3.53	0.50	0.36	1.83	2.29	3.48	0.20	0.22
	2.50	3.83	0.57	0.39	1.61	2.48	4.10	0.18	0.27
	5.00	4.32	0.58	0.42	1.39	2.72	3.42	0.22	0.34
LSD at 5%		**0.09**	**0.03**	**0.02**	**0.03**	**0.11**	**0.06**	**1.72**	**0.02**

Table (7): Effect of different concentrations of arginine on macro elements in leaves of mungbean at harvest grown under salinity stress.

Treatment		**Macro elements (%)**			**Na (ppm)**
Salinity (ppm)	**Arginine (mM)**	**N**	**P**	**K**	
Zero	**Zero**	2.58	0.19	2.14	265.50
	1.25	2.99	0.22	2.38	175.50
	2.50	2.65	0.20	2.26	306.50
	5.00	2.42	0.19	2.19	448.00
1500	**Zero**	2.72	0.21	2.24	383.50
	1.25	3.12	0.24	2.76	273.00
	2.50	2.77	0.21	2.65	367.50
	5.00	2.55	0.20	2.41	653.00
3000	**Zero**	2.37	0.17	2.30	633.00
	1.25	2.81	0.19	2.43	416.50
	2.50	2.42	0.16	2.03	586.50
	5.00	2.33	0.16	1.96	852.00
4500	**Zero**	2.01	0.15	2.21	823.50
	1.25	2.27	0.18	2.32	601.00
	2.50	2.01	0.15	1.93	685.00

	5.00	1.83	0.14	1.77	352.00
6000	**Zero**	1.77	0.13	2.19	1064.00
	1.25	1.92	0.15	2.24	854.50
	2.50	1.57	0.13	1.76	970.00
	5.00	1.41	0.13	1.55	1352.00
LSD at 5%		**ns**	**ns**	**ns**	**114.20**
Mean of main effects:					
Salinity (ppm)	**Control**	2.66	0.20	2.24	298.88
	1500	2.79	0.22	2.52	419.25
	3000	2.48	0.17	2.18	622.00
	4500	2.03	0.16	2.06	615.38
	6000	1.67	0.14	1.94	1060.1
LSD at 5%		**ns**	**ns**	**ns**	**68.40**
Arginine (mM)	**Zero**	2.29	0.17	2.22	633.90
	1.25	2.62	0.20	2.43	464.10
	2.50	2.28	0.17	2.13	583.10
	5.00	2.11	0.16	1.98	731.40
LSD at 5%		**ns**	**ns**	**ns**	**51.07**

Table (8):Effect of diferent concentration of arginie on electrophoratic pattern of mungbean seeds grown under saliniy stress.

Mwt	Salinity mg/l														
	control	1.25 mM arginine	2.5 mM arginine	5 mM arginine	1500	1.25 mM arginine	2.5 mM arginine	5 mM arginine	3000	1.25 mM arginine	2.5 mM arginine	5 mM arginine	4500	1.25 mM arginine	2.5 mM arginine
117.0	11.00				3.11	3.89	3.11		3.14	2.25	2.66				
104.0	11.64				4.36	5.44	5.74	3.58	3.68	4.62	5.27		3.16	3.21	3.58
100.0					7.65	3.24	3.14	2.98	5.17	5.64	6.54	6.94	3.68	5.61	5.82
92.0		3.59	5.11	5.28	4.65	4.04	4.21	4.46	3.68	3.82	4.25	5.11	3.54	4.85	4.46
90.0		7.24	9.65	9.81	2.11	3.78	4.36	4.08	3.98	3.77	3.82	4.75	4.87	4.52	5.08
80.0		5.98	5.24	4.35		4.36	4.82	4.36		3.24	4.52	5.63		5.36	4.36
71.5		6.24	4.50	4.27	4.21	4.74	5.14	9.25	3.36	4.55	6.12	7.41	3.25	4.72	5.25
70.0					8.24	8.62	8.91	9.14	8.97	9.15	9.25	9.62	9.35	9.56	10.14
60.0		4.03	5.19	6.80	5.24	6.83	6.97	4.96	4.82	5.13	5.31	5.64	3.95	4.12	4.96
51.5	12.53	7.68	3.62	5.14	5.67	4.33	5.14	5.31	5.45	5.22	4.32		4.94	5.04	5.31
44.0					6.82	5.44	5.98	5.11	10.09	9.87	8.53	7.52	12.55	10.73	9.11
36.0															
32.5		8.08	9.72	10.51	9.76	10.75	10.89	11.23	11.66	10.31	9.66	9.80	12.54	9.85	10.23
30.3	18.69	14.98	12.40	10.50	8.64	6.88	6.45	7.28	8.11	8.66	7.85	7.51	7.35	7.84	8.72
25.5	11.98	8.40	6.70	8.66	5.87	3.54	3.14	5.71	7.83	6.24	5.67	6.58	8.32	6.08	5.71
23.0	12.98	4.22	6.28	7.25									6.14	5.22	4.64
19.0	10.22				6.87				5.74				4.37		
16.5		10.05	11.14	10.67	8.69	9.17	9.87	10.21	7.82	7.98	8.63	8.75	5.62	4.03	3.91
14.5	10.96	14.31	12.23	9.65		8.71	7.26	6.98		4.36	2.75	6.43		3.14	2.96
8.0		5.20	8.22	7.11	8.11	6.24	4.87	5.36	6.50	5.19	4.85	8.31	6.37	6.12	5.76
Total number of band	8	12	13	13	17	17	17	16	17	17	17	14	17	17	17

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