

Full Length Research Paper

The effect of gibberellic acid (GA₃) on minerals of Mungbean (*Vigna radiata* L. Wilczek) irrigated with different levels of saline water

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The experiment was carried out to study the effect of gibberellic acid (GA₃) on minerals of mungbean (*Vigna radiata* L. Wilczek) irrigated with different levels of saline water. Salt concentration of water for treated were 0, 50, 100 and 150 mM NaCl and 200 mg/l gibberellic acid (100 mg/L as seed pre-soaking and 100 mg/L as foliar application) were used. Results showed that plants treated with saline water had higher content of sodium and chlorine and lower content of potassium and magnesium. The highest content of Cl⁻ of roots and shoots (10.82 and 16.40 mg mineral ion/gr dry weight, respectively) and Na⁺ of roots and shoots (16.55 and 46.15 mg mineral ion/gr dry weight, respectively) were gained from treatment number 4 (150 mM NaCl + 0 mg/l application of gibberellic acid) that significantly differed from other's ($p \leq 0.01$). Also, results indicated that different levels of saline water (50, 100 and 150 mM NaCl) caused marked decreases in content of positive cations (K⁺, Ca²⁺ and Mg²⁺) and salt stress has also been found responsible for an increase of mineral distribution. At last we found that irrigation with saline water adversely affects growth and productivity of plants and application of gibberellic acid hormone overcome the effects of salt stress and improved the growth parameters.

Key words: Mungbean (*Vigna radiata* L. Wilczek), saline water, gibberellic acid (GA₃), seed pre-soaking, foliar application.

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is one of the most important legumes due to nitrogen fixation, early maturity and ability to fit well into a crop rotation program. It can be grown in a wide range of environments and is still widely grown in Southeast Asia, Africa, South America and Australia (Oplinger et al., 1997). Irrigation with saline water is considered as the major factor affecting field crop production under arid and semi- arid conditions. One of the approaches to increase plant production is to expand the cultivation of them in the soils irrigated with saline waters.

Irrigation with saline water adversely affects germination, growth, physiology and productivity of plants by causing ionic and osmotic stresses (Iterbe-Ormaetxe et al., 1998). Salt stress has also been found responsible

for an increased respiration rate, ion toxicity, mineral distribution and permeability (Sudhir and Murthy, 2004; Gupta et al., 2002) and inefficiency of photosynthesis (Munns, 2002). Some researchers reported that salt stress (NaCl) caused decreases in germination, shoot and root lengths in mungbean. Raptan et al. (2001) found that salinity leads to decrease in dry matter and biomass and decreased root, stem and leaf weights, plant height of mungbean. Rabie (2005) found that salinity caused decrease in mungbean growth and plant height. Chakrabarti and Mukherji (2003) found that NaCl concentrations caused greatest reductions in growth, N₂ fixation and total-N contents. Growth changes in salinized plant appear to be associated with high electrolyte levels contributing to toxicity and or osmotic adjustment and turgor maintenance (Morgan, 1984).

Gibberellic acid (GA₃) is known to be importantly concerned in the regulation of plant responses to the external environment (Chakrabarti and Mukherji, 2003). Also, application of another plant growth bio-regulator

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Table 1. Results of analysis of variance (MS) for various characters.

Sources of variations (S.O.V)	**Growth parameters					
	Time till emergence (h)	Percentage of seedlings emergence (%)	Root length (cm)	Shoot length (cm)	Root dry matter (g/plant)	Shoot dry matter (g/plant)
Between	3712.50	2986.19	17.52	129.98	0.001	0.008
Within	46.50	4.44	0.09	4.23	0.000	0.001

** All parameters differed significantly at 0.01 level of probability ($p \leq 0.01$).

has increased the salt tolerance of many crop plants (Hoque and Haque, 2002). Therefore, GA₃ and its use can be able to overcome to variable extents the adverse effects of stress imposed by NaCl solution.

MATERIALS AND METHODS

An experiment was carried out to study the effect of gibberellic acid (GA₃) on minerals of mungbean (*Vigna radiata* L. Wilczek) irrigated with different levels of saline water. The experiment was conducted in the Department of Crop Production and Plant Breeding, College of Agronomy, University of Tehran, Karaj, Iran during the spring and summer seasons of 2006 - 2007. Salt concentration of water for treated were 0, 50, 100 and 150 mM NaCl and 200 mg/L gibberellic acid (100 mg/L as seed pre-soaking and 100 mg/L as foliar application) were used for ameliorate the adverse effects of salt stress. Each treatment that were previously soaked in 100 mg/L GA₃ solution, sprayed with solution of 100 mg/L GA₃ at the stage of four leaf plant (14 day after emergence) as foliar application. The control plants were sprayed with double distilled water. Gibberellic acid obtained from Sigma Chemical Company St. Louis, U.S.A. Plastic pots (30 cm in diameter) were filled with 10 kg of sterilized and washed sandy soil. The seeds of mungbean (*Vigna radiata* L. Wilczek), Var. NM-92 were obtained from Agricultural Research Center, Dezfol, Khozestan. Mungbean seeds were sterilized by 0.01% HgCl₂ solution for 3 min, rinsed using double distilled water and then sown in the pots.

The treatments were as follows;

- 1 = 0 mM NaCl + 0 mg/L gibberellic acid (control).
- 2 = 50 mM NaCl + 0 mg/L gibberellic acid.
- 3 = 100 mM NaCl + 0 mg/L gibberellic acid.
- 4 = 150 mM NaCl + 0 mg/L gibberellic acid.
- 5 = 0 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).
- 6 = 50 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).
- 7 = 100 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).
- 8 = 150 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid)

Irrigation with saline water containing 50, 100 and 150 mM NaCl were started just after sowing. The control treatment was irrigated with distilled water as growth progress till harvest. Also, all the treatments equal were fed by using the complete Hogland solutions once per week. Each pot was irrigated by distilled water or saline water once per week. All pots were kept inside an open air wire house exposed to normal day length and the atmospheric conditions during the experiment were as follows; relative humidity 68% and temperature 24 - 26°C. After one week from emergence, thinning was done to leave five uniform seedlings in each pot.

Growth measurements (like shoot and root length, shoot and root dry weight) were carried out at 28 days after emerging. Sodium, potassium and calcium content of shoot and root of seedlings were measured by flame emission spectrophotometer (B-700E) and magnesium content was estimated by atomic absorption spectrometry (FMD) (Ward and Johnston, 1962). Chloride ion concentration was measured by the silver nitrate titration method (Jackson and Thomas, 1960). Dry mass per plant was recorded by drying the plants at 74°C for 48 h.

The experiment was laid out on completely randomized design (CRD), which each treatment four times replicated. The data were statistically analyzed by MSTATC (Version 1.42, Michigan State University, USA) and Duncan's New Multiple Range Test was used for compared the means of treatments at 0.01 and 0.05 levels of probability.

RESULTS

Growth parameters

Experimental data showed that irrigation with saline water at levels of 50, 100 and 150 mM NaCl had progressive decrease of the percentage of emergence and progressive increase of time till emergence. On the other hand, the plants treated with saline water germinated very late after non-treated plants and the plants which its seeds pre-soaked in gibberellic acid. Early emergence related to the treatment number 5 (0 mM NaCl + (100 mg/L as pre-soaking + 100 mg/L as foliar application of gibberellic acid) (51 h) and treatment number 1 (control) (54 h) that significantly differed from others. Maximum percentage of emergence related to the control (98%) that statistically had difference with other treatments but was statistically at par with treatment number 5 (97%). Different levels of saline water caused marked decreases in root and shoot lengths and dry matter of shoots and roots (Tables 1 and 2). Maximum values of root lengths (9.22 cm), shoot lengths (21.05 cm) and shoot dry matter (0.202 gr/plant) were gained from control that significantly had difference with others, but was statistically at par with treatment number 5. Also, maximum root dry matter was recorded by the control and treatment number 5 (0.067 g/plant).

- 1 = 0 mM NaCl + 0 mg/L gibberellic acid.
- 2 = 50 mM NaCl + 0 mg/L gibberellic acid.
- 3 = 100 mM NaCl + 0 mg/L gibberellic acid.
- 4 = 150 mM NaCl + 0 mg/L gibberellic acid.

Table 2. The effect of seed pre-soaking and foliar application of gibberellic acid (100 mg/L as seed pre-soaking and 100 mg/L as foliar application) on growth parameters.

*Treatments	**Parameters					
	Time till emergence (h)	Percentage of seedlings emergence (%)	Root length (cm)	Shoot length (cm)	Root dry matter (g/plant)	Shoot dry matter (g/plant)
1 (control)	54 ab	98 a	9.22 a	21.05 a	0.067 a	0.202 a
2	66 bc	83.5 c	7.87 b	14.85 b	0.032 c	0.083 b
3	90 d	81 c	6.87 c	11.45 b	0.032 c	0.079 b
4	138 f	21 e	4.02 d	7.20 c	0.027 d	0.055 b
5	51 a	97 ab	9.10 a	20.40 a	0.067 a	0.086 b
6	66 bc	93 b	9.00 a	19.35 a	0.040 b	0.085 b
7	78 cd	83.2 c	7.42 bc	13.75 b	0.041 b	0.081 b
8	114 e	46.7 d	4.22 d	6.55 c	0.026 d	0.067 b
S \bar{X} at 0.01	3.41	1.053	0.15	1.03	0.0005	0.016

** All parameters differed significantly at 0.01 level of probability ($p \leq 0.01$). Means not sharing at letter in common in a column differ significantly

5 = 0 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).

6 = 50 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).

7 = 100 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).

8 = 150 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).

Minerals

Plants treated with saline water (non-treated with GA3) (the treatments number 2, 3 and 4) had higher content of sodium and chlorine and lower potassium and magnesium (Table 3). The highest content of Cl⁻ of roots and shoots (10.82 and 16.40 mg mineral ion/gr dry weight, respectively) and Na⁺ of roots and shoots (16.55 and 46.15 mg mineral ion/gr dry weight, respectively) were gained from treatment number 4 (150 mM NaCl + 0 mg/L gibberellic acid) that significantly differed from other's ($p \leq 0.01$). Also, The lowest content of Cl⁻ of shoots (6.00 mg mineral ion/gr dry weight) and Na⁺ of roots and shoots (4.69 and 11.15 mg mineral ion/gr dry weight, respectively) related to the treatment number 5 that significantly had difference with others, but was statistically at par with the control ($p \leq 0.01$). In these results, values of Cl⁻ and Na⁺ (roots and shoots) gradually increased by increasing the salt concentration of water. Furthermore, application of gibberellic acid (the treatments number 5 - 8) was reduced adsorption and accumulation of Cl⁻ and Na⁺ of roots and shoots of seedlings (Tables 3 and 4).

1 = 0 mM NaCl + 0 mg/L gibberellic acid.

2 = 50 mM NaCl + 0 mg/L gibberellic acid.

3 = 100 mM NaCl + 0 mg/L gibberellic acid.

4 = 150 mM NaCl + 0 mg/L gibberellic acid.

5 = 0 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).

6 = 50 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).

7 = 100 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).

8 = 150 mM NaCl + (100 mg/L as seed pre-soaking + 100 mg/L as foliar application of gibberellic acid).

Also, results indicated that different levels of saline water (50, 100 and 150 mM NaCl) caused marked decreases in content of positive cations (K⁺, Ca²⁺ and Mg²⁺). The highest content of K⁺ of roots and shoots (10.74 and 8.98 mg mineral ion/ gr dry weight, respectively) was associated with control that significantly had difference with other treatments and statistically at par with treatment number 5. Further, content of K⁺ (root and shoot) gradually decrease by increasing the salt concentration of saline water (the treatments number 2 - 4), which lowest content of K⁺ (root and shoot) (6.3 and 5.2 mg mineral ion/ gr dry weight, respectively) were obtained from the treatment number 4 (150 mM NaCl + 0 mg/L application of gibberellic acid). Application of gibberellic acid significantly affected content of Ca²⁺ (root and shoot). The highest content of Ca²⁺ of root and shoot (6.50 and 7.35 mg mineral ion/ gr dry weight, respectively) associated with the control. Furthermore, content of Ca²⁺ (root and shoot) gradually decrease by increasing the salt concentration of water (the treatments number 2 - 4) (Tables 3 and 4).

DISCUSSION

Results showed that irrigation with saline water adversely affects growth and productivity of plants and application of gibberellic acid hormone overcome the effects of salt stress and improved the growth parameters. Also, results

Table 3. Results of analysis of variance (MS) for minerals.

Sources of variations (S.O.V)	Minerals									
	**Cl ⁻		**Na ⁺		K ⁺		Ca ²⁺		Mg ²⁺	
	Root	Shoot	Root	Shoot	*Root	**Shoot	**Root	*Shoot	^{ns} Root	**Shoot
Between	2577	59.01	66.24	526.16	13.65	9.52	8.77	11.28	0.86	6.48
Within	0.07	0.20	0.36	2.45	6.32	2.18	1.55	3.40	1.51	0.88

^{ns} Non- Significant *P ≤ 0.05 **P ≤ 0.01.

Table 4. The effect of seed pre-soaking and foliar application of gibberellic acid (100 mg/L as seed pre-soaking and 100 mg/L as foliar application) on minerals

*Treatments	Minerals (mg mineral ion/gr dry weight)									
	**Cl ⁻		**Na ⁺		K ⁺		Ca ²⁺		Mg ²⁺	
	Root	Shoot	Root	Shoot	*Root	**Shoot	**Root	*Shoot	^{ns} Root	**Shoot
1 (control)	4.62 c	6.47 ab	4.70 a	11.18 a	10.74 a	8.98 a	6.50 a	7.35 a	3.20 a	4.70 b
2	5.92 d	10.50 c	6.20 b	24.60 c	9.30 ab	7.30 ab	5.45 a	5.70 abc	2.90 a	4.63 b
3	8.12 e	13.40 e	12.23 d	32.35 e	7.52 ab	7.00 ab	4.38 ab	4.80 abc	2.60 a	3.90 b
4	10.82 f	16.40 f	16.55 e	46.15 f	6.30 b	5.20 b	2.70 b	2.76 c	1.86 a	2.98 b
5	4.53 c	6.00 a	4.69 a	11.15 a	11.10 a	9.12 a	6.30 a	7.68 a	3.25 a	4.98 b
6	3.40 a	6.55 ab	7.67 c	20.32 b	8.35 ab	9.47 a	5.80 a	6.70 ab	3.05 a	4.83 b
7	4.00 b	7.30 b	7.83 c	23.33 bc	10.85 a	9.05 a	4.80 ab	5.00 abc	2.90 a	4.38 b
8	7.62 e	11.70 d	7.03 bc	28.54 d	7.225 ab	6.58 ab	2.75 b	4.20 bc	2.65 a	7.45 a
S \bar{x} at	0.01	0.135	0.23	0.303	0.78	-	0.74	0.62	-	0.469
	0.05	-	-	-	-	1.26	-	-	0.92	0.61

^{ns} Non- Significant; *P ≤ 0.05; **P ≤ 0.01

Means not sharing a letter in common in a column differ significantly.

indicated that different levels of saline water (50, 100 and 150 mM NaCl) caused marked decreases in content of positive cations (K⁺, Ca²⁺ and Mg²⁺) and plants treated with saline water (non-treated with GA₃) (the treatments number 2, 3 and 4) had higher content of sodium and chlorine and lower potassium and magnesium (Table 3). It is conceivable that the application of GA₃ stimulated plant establishment and early growth and may have improved nodulation through positive effect on seedling roots. On the other hand, the inhibitory effects of salinity on growth parameters seemed to be decreased by GA₃ application. Chakrabarti and Mukherji (2002) found that GA₃ can overcome the adverse effect of salinity of mungbean plants. The role of GA₃ in overcoming the harmful effects of salinity on growth may be due to the change in the endogenous growth regulators which affects plant water balance and or decreasing root resistance to water flow.

The influence of GA₃ on the mechanism of ions uptake may be related to its effect on membrane permeability and rate of ion entry through the membrane, or enhances their translocation to the shoot (Chakrabarti and Mukherji, 2002). In this respect, Hernandez et al. (1993) reported that salinity increased Na⁺ and Cl⁻ content of plants while K⁺ level decreased. Moreover, it was suggested that, the

effect of salinity on mineral ions was due to decrease in xylem exudation rate, leaf water potential, relative water content (RWC) and water retention capacity concurrently with increased of water saturation deficit and water uptake capacity (Kabir et al., 2004).

Conclusion

As a conclusion, we found that irrigation with saline water adversely affects growth and productivity of plants. Salt stress has also been found responsible for an increase of mineral distribution. Furthermore, application of gibberellic acid overcomes the growth parameters under the salinity tension. On the other hand, the deleterious effects of salinity decreased by application of gibberellic acid.

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