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Effect of inoculated sulfur with Thiobacillus sp on some growth traits of marigold under salinity condition

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ABSTRACT

This study was performed to evaluation of inoculated sulfur with *Thiobacillus* sp on some growth traits of marigold under salinity condition. Experimental design was split split plot with 3 replications. First factor was sulfur (200 and 400 kg/ha) also second and third factor included bacteria (inoculated and no inoculated) and salinity stress (0, 15, 35 and 55 mm/L), respectively. After the experiment, some morphological characters and morphological of marigold were evaluated such as height, yield of fresh and dried flowers, number of flowers per plant, grain yield, petals, seed weight. Totally, result showed that 400kg/ha had best effect on studied characteristics, It was also found that with increased stress levels from 0 to 16 dS, the height, fresh yield of flowers, yield of flower dry weight, number of flowers per plant, grain yield, petals and seed weight, showed 45, 65, 64, 20, 78, 17 and 39 percent of reduction, respectively. On the other hand, it was determined that the use of bacteria and sulfur can reduce the effects of stress.

Introduction

Medicinal plants were one of the main natural resources of Iran from ancient times. Pot marigold (*Calendula officinalis* L.) is from Asteraceae family. This plant has medicinal properties and it is used for treatment of skin diseases (rafee *et al*., 2013). Also, Application of bio fertilizers in conventional farming systems is not common and most of the nutritional need of plants supply through chemical fertilizers for short period. Excessive and unbalanced use of fertilizers in the long period, reduce crop yield and soil biological activity, accumulation of nitrates and heavy metals, and finally cause negative environmental effects and increase the cost of production. The use of biofertilizers and organic matter are taken into consideration to reduce the use of chemical fertilizers and increase the quality of most crops. Plant growth promoting rhizobacteria are a group of bacteria that actively colonize plant roots and increase plant growth and yield. The action mechanisms of PGPRs can be divided into direct and indirect ones. Direct mechanisms include N_2 fixation, soil mineral solubilization, and production of plant growth promoting substances (auxins, cytokinins or gibberellins) and reduction of ethylene levels, among others. Indirect mechanisms include favoring colonization by other beneficial soil microorganisms, such as mycorrhizal fungi, and repressing the growth of plant pathogenic microorganisms (Lugtenberg et al,. 2009; Marulanda *et al*., 2010; Gholami *et al*, 2009). Salinity is a soil condition by high content of soluble salts. The problem of soil salinity is increasing. Soil salinity stresses plants in two ways: High concentrations of salts in the soil make it harder for roots to extract water, and high concentrations of salts within the plant can be toxic (Munns and Tester, 2008). Adverse effects of salinity on plant growth may be due to ion cytotoxicity and osmotic stress (Hussain et al, 2008). Metabolic imbalances caused by ion toxicity, osmotic stress and nutritional deficiency under saline conditions may also lead to oxidative stress (Zhu, 2002).

In this order, The aim of study was evaluation of inoculated sulfur with *Thiobacillus* sp on some growth traits of marigold under salinity condition.

Material and methods

Experimental design was split split plot with 3 replications. First factor was sulfur (200 and 400 kg/ha) also second and third factor included bacteria (inoculated and no inoculated) and salinity stress (0, 15, 35 and 55 mm/L), respectively. After the experiment, some morphological characters and morphological of marigold were evaluated such as height, yield of fresh and dried flowers, number of flowers per plant, grain yield, petals, seed weight. In order to analyze of data SAS software was used and mean comparisons were performed by using Duncan's multilateral.

Result and discussion

Height: Table1 shows result of analysis of variance on height. According to means comparison it was founded that highest means was observed by 400 kg/h sulfur application and it had an increase of 4 percent compared to 200 kg/h treatment. While sulphate in soil is a direct S source for plants, generally more than 95% of soil S is organic bonded and divided into sulphate ester S and carbon-bonded S. Although not readily plant available, organic S compounds may potentially contribute to the S supply of plants via mineralization. While sulphate esters play an important role in the short term release of sulphate, carbon-bonded S seems to be responsible for long-term mineralization (Scherer, 2001). Also, Incubated bacteria had significant on height, this result shown at table 2. The comparison of mean with Duncan test showed that the treatments of 15, 35 and 55 mmol/L resulted decreasing in 5, 5 and 1 percent in comparison to the control. According to interaction between sulfur with salinity and incubation with salinity, it was founded that sulfur and incubation led to reduction of salinity negative effects on height (Table 3).

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Table1. Analysis of variance of studied traits.

	d.f	Height	Yield of fresh flowers	Yield of dried flowers	Number of flowers per plant	Grain yield	Petals yield	Seed weight
Replication	2	132.0	674.0	136.6*	62.1	86.7	67.6	165.9*
Sulfur	1	964.7**	6895.0**	639.0**	383.0**	623.7**	584.0**	808.2**
*Error	2	9.4	67.4	6.2	3.5	5.1	5.2	7.9
Bacteria	1	178.3**	1289.2**	108.0**	48.8**	71.3**	93.6**	119.6**
Sulfur*bacteria	1	59.4*	820.4*	34.6*	50.9**	34.1*	32.0*	41.6*
Error	4	7.4	58.6	4.3	2.1	3.1	3.6	5.2
Stress	3	113.2**	319.5**	72.8**	19.7**	20.9**	14.9**	36.7**
Sulfur*stress	3	18.6*	250.3**	15.0*	2.4	8.2*	10.3**	10.2*
Bacteria*stress	3	19.0*	188.3*	17.4**	3.5*	10.3**	6.8*	11.2*
Sulfur*bacteria*stress	3	15.2	110.8	17.5**	4.5*	6.8*	8.4*	13.1*
Error	24	5.4	44.3	3.6	1.1	2.1	2.1	3.2

Kumar mentioned that Lower salinity ($3dsm^{-1}$) did not affect the germination, growth and yield attributing parameters. Higher salinity levels reduced germination, growth and yield attributing parameters

Yield of fresh flowers: The application of 400 kg/ ha showed the highest means of fresh flower weight and it led to the 9 percent increase in comparison to 200 kg/ ha treatment. One of the basic requirements in agriculture planning in order to increase the production and high quality, particularly medical plants, is the evaluation of various plants' nourishment. With appropriate soil fertility and plant nourishment not only the environment is preserved, but also the water quality, biological diversity and erosion reduction and manure efficiency increase (Dermadrosian,2001). Also, Incubated bacteria had significant on yield of fresh flowers, so that, this trait increased 29% by application of incubated bacteria. The comparison of mean with Duncan test showed that the treatments of 15, 35 and 55 mmol/L resulted decreasing in 2, 17 and 52 percent in comparison to the control. According to interaction between sulfur with salinity and incubation with salinity, it was founded that sulfur and incubation led to reduction of salinity negative effects on yield of fresh flowers (Table 3).

Yield of dry flowers: The application of 400 kg/ ha showed the highest means of dry flower weight and it led to the 35 percent increase in comparison to 200 kg/ ha treatment. Also, Incubated bacteria had significant on yield of dry flowers, so that, this trait increased 50% by application of incubated bacteria. The comparison of mean with Duncan test showed that the treatments of 15, 35 and 55 mmol/L resulted decreasing in 2, 36 and 53 percent in comparison to the control. According to interaction between sulfur with salinity and incubation with salinity, it was founded that sulfur and incubation led to reduction of salinity negative effects on yield of dry flowers (Table 3).

Number of flowers per plant: Number of flowers per plant was affected by all factors. In relation to sulfur, between 200 and 400 kg/ ha, 400 kg/ ha had best results and an increasing of 25% was observed by application of 400 kg/ ha. Also, Incubated bacteria had significant on yield of dry flowers, so that, this trait increased 42% by application of incubated bacteria. Applied salinity caused a significant reduction in Number of flowers per plant; the treatments of 15, 35 and 55 mmol/L resulted decreasing in 2, 4 and 12 percent as compared to the control. According to interaction between sulfur with salinity and incubation with salinity, it was founded that sulfur and incubation led to reduction of salinity negative effects on number of flowers per plant (Table 3). Salt tension can affect plant survival, plant height, biomass and plant morphology as well as the ability of a plant to gather water and nutrients (Parida and Das, 2005). The huge effect of salinity is deficiency in hormones (Jaleel et al., 2007).

Grain yield: This characteristic was affected by simple effects and interaction effect of treatments, 400 kg/ ha treatments led to 11% increasing as compared to 200 kg/h treatments, it was founded that using of bacteria increased grain yield about 52% but, salinity stress led to reduction of grain yield, so that, application of 15, 35 and 55 mmol/L resulted decreasing in 11, 46 and 70 percent as compared to the control. According to interaction between sulfur with salinity and incubation with salinity, it was founded that sulfur and incubation led to reduction of salinity negative effects on grain yield (Table 3). The decrease in grain yield might be caused by the salinity, which induced reduction of photosynthetic capacity leading to less starch synthesis and accumulation in the grain (Turki et al., 2012).

Table 2. means comparison of studied traits in response to simple effects.

	Height		Yield of fresh flowers (gr/plant)		Yield of dry flowers (gr/plant)		Number of flowers per plant		Grain yield (gr/plant)		Petals yield (mg/ flower)		1000seed weight (gr)	
Sulfur (kg/ha)														
200	30.4	b	11.1	b	2.8	b	3.0	b	5.8	b	30.5	b	8.1	b
400	31.9	a	12.1	a	3.8	a	3.8	a	7.3	a	34.8	a	11.1	a
bacteria														
no-incubated	28.7	b	10.5	b	2.7	b	2.8	b	4.7	b	29.6	b	6.4	b
incubated	33.7	a	12.6	a	3.9	a	4.0	a	8.4	a	35.7	a	12.8	a
Salinity (dS/m)														
0	36.3	a	16.8	a	4.7	a	3.7	a	11.8	a	35.5	a	11.7	a
15	34.3	b	16.5	a	4.7	a	3.7	a	11.7	a	34.0	b	11.2	b
35	32.8	c	16.3	b	4.6	b	3.6	b	11.2	b	33.3	bc	9.7	c
55	32.3	c	7.9	c	2.2	c	3.2	c	3.0	c	32.5	c	9.5	c

Petals yield

Table1 shows result of analysis of variance on petals yield. According to means comparison it was founded that highest means was observed by 400 kg/h sulfur application and it had an increase of 14 percent compared to 200 kg/h treatment. Also, Incubated bacteria had significant on height, this result shown at table 2. The comparison of mean with Duncan test showed that the treatments of 15, 35 and 55 mmol/L resulted decreasing in 4, 6 and 8 percent in comparison to the control. According to interaction between sulfur with salinity and incubation with salinity, it was founded that sulfur and incubation led to reduction of salinity negative effects on petals yield (Table 3).

1000Seed weight:

1000Seed weight was affected by all factors (Table 1). In relation to sulfur, between 200 and 400 kg/ ha, 400 kg/ ha had best results and an increasing of 37% was observed by application of 400 kg/ ha. Also, Incubated bacteria had significant on yield of dry flowers, so that, this trait increased 2 fold by application of incubated bacteria. Applied salinity caused a significant reduction in Number of flowers per plant; the treatments of 15, 35 and 55 mmol/L resulted decreasing in 4, 17 and 18 percent as compared to the control. According to interaction between sulfur with salinity and incubation with salinity, it was founded that sulfur and incubation led to reduction of salinity negative effects on 1000Seed weight (Table 3). Salinity is of concern because of its deleterious effect on plant growth, nutritional balance, and plant and flower marketable quality, including visual injury, flower distortion, and reduced stem length. Plant growth is detrimentally affected by salinity as a result of the disruption of certain physiological processes that lead to reductions in yield and/or quality. Growth, yield, and quality reduction may occur through a decrease in the ability of plants to take up water from the soil solution and the destruction of soil structure (Barrett-Lennard, 2003). In addition, toxicity resulting from excessive concentration of certain ions, principally Na^+ , Ca^{2+}, Mg^{2+}, Cl^-, $SO4^{2-}$and HCO_3^- as well as nutritional imbalances (Grattan and Grieve 1999), may also play important roles in the response of plants in saline environments.

Conclusion

Totally, result showed that 400kg/ha had best effect on studied characteristics, It was also found that with increased stress levels from 0 to 16 dS, the height, fresh yield of flowers, yield of flower dry weight, number of flowers per plant, grain yield, petals and seed weight, showed 45, 65, 64, 20, 78, 17 and 39 percent of reduction, respectively. On the other hand, it was determined that the use of bacteria and sulfur can reduce the effects of stress.

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