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Enrichment of marigold (*Calendula officinalis*) seeds influences seedling vigor and essential oil yield in flowers

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Abstract

Most of soils in Iran are deficient in micro-elements. Enrichment of seeds is found to be as suitable method for overcoming micronutrient deficiencies. Marigold is a herbal medicinal plant. In order to study evaluate of seed enrichment by some of micro-nutrients on seedling establishment and yield of marigold two laboratory and field experiments were carried out on marigold (*Calendula officinalis* L.) at the Islamic Azad University, Tabriz, Iran, during 2012. Treatments were 0.5%, 1%, 1.5% and 2% Zinc or Manganese, such as 14.5, 29, 43.5 and 58 g Zinc or 19, 38.5, 58 and 77 g Manganese per liter water, respectively. Each treatment involved weighing nearly 10 g of the seed in a glass cup, adding 20 m L of the priming and allowing the seed + solution mixture to sit covered with plastic. Enrichment at the concentrations of 1%; 1.5%, 2% of zinc or manganese increased final germination percentage of marigold seeds in comparison to the control. The data show that mean seedling vigor index can be increased by seed enrichment with zinc sulfate and manganese sulfate, compared to the control. Seeds enriched in 1% Zinc had higher seedling vigor index, but a greater improvement in the Zinc concentration of the solution did not further increase in seedling vigor index. When seeds primed in the highest concentration of manganese, marigold statistically produced flower yield similar to unprimed treatment. Significant increase in essential oil yield of marigold due to seed enrichment treatments relative to not-enrichment was expected. Enrichment of marigold seeds positively influenced seedling vigor and essential oil yield in flowers.

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Introduction

Most of soils in Iran are deficient in micro-elements. Enrichment of seeds is found to be as suitable method for overcoming micronutrient deficiencies. Harris *et al.* (1999) showed that Enhancing of Zinc content in crop seeds could be highly effective for increasing maize yield. In recent years, some works has been done on the invigoration of seeds to improve the germination rate and uniformity of growth and reduce the emergence time of some field crops (Basra *et al.*, 2003). Treatments with lower concentrations of Zinc and Manganese give a positive and significant increase over control (Mirshekari, 2010).

Marigold is a herbal medicinal plant. It belongs to the genus of *Calendula*, in the family of Compositae (Omidbeigi, 2009). Its extract has in some way refreshing and comforting effects (Jimenez-Medina *et al.*, 2006; Bolderston *et al.*, 2006). The objective of this study was to evaluate of seed enrichment by some of micro-nutrients on seedling establishment and yield of marigold.

Materials and methods

Two laboratory and field experiments were carried out on marigold (*Calendula officinalis* L.) at the Islamic Azad University, Tabriz, Iran, during 2012, in a loam soil with pH of 8.2 and organic matter of 0.85%. Tabriz is located at the north-west of Iran, East Azarbaijan Province, and its climate is semi-arid and cold. The experimental field had been in a sugar beet-wheat rotation cycle for the last two years. The experimental area was ploughed in the fall and biofertilized with 6 t ha^{-1}. Fields were cultivated, disked, furrowed and then plotted in the 23th March before sowing the seeds. Treatments were 0.5%, 1%, 1.5% and 2% Zinc or Manganese, such as 14.5, 29, 43.5 and 58 g Zinc or 19, 38.5, 58 and 77 g Manganese per liter water, respectively. Each treatment involved weighing nearly 10 g of the seed in a glass cup, adding 20 m L of the priming and allowing the seed + solution mixture to sit covered with plastic (Table 1). Final germination percentage was calculated as described by Larsen and Andreasen equation (2004);

$$FGP=\Sigma n / N \times 100,$$

Where, n is number of seeds that had germinated at each counting and N is total seeds in each treatment. Seedling vigor index was calculated according to Abdul-Baki and Anderson equation (1973);

$$SVI = SDW \times FGP,$$

Where, SDW is seedling dry weight.

Fertilizers used were 140 kg per hectare from phosphated ammonium and 60 kg per hectare of urea, respectively. The plots were 4 × 2 square meter. The essential oil of marigold flowers was isolated by hydro distillation using Clevenger's apparatus. All data were statistically analyzed using MSTAT-C software.

Results and discussion

ANOVA results of the study have been depicted in Table 2. Enrichment at the concentrations of 1%; 1.5%, 2% of zinc or manganese increased final germination percentage of marigold seeds in comparison to the control (Figure 1). The mean final germination percentage from primed seeds with zinc and manganese were 79%, but only 71% from control plots. The beneficial effect of enrichment on seed emergence is in consistent with reports of farmers' perceptions of the effects of enrichment on some medicinal plants; i.e. cumin (*Cuminum cyminum* L.) and marigold (*Calendula officinalis* L.). There are many papers comparing germination speed of different crops nutrient enrichment over non-primed one. In this study, the presence of zinc + manganese in mixture improved final germination percentage up to 94.5%. In some studies of pre-treatment, Harris *et al.* (1999) reported that enrichment treatment reduced emergence time, which reflected the effect of seed treatment on time to germination value. Lower germination (%) was obtained from treatment of sweet pepper (*Capsicum annum* L.) with microelements at the higher concentration by Diniz *et al.* (2009). Also, maximum field emergence of Raya (*Brassica carinata* L.) was noted in zinc sulfate and manganese sulfate (Arshad Ullah *et al.*, 2002).

Our experiment resulted there was a significant and positive reaction to seed enrichment with zinc sulfate and manganese sulfate separately or in combination with a view to marigold seedling vigor index. The data show that mean seedling vigor index can be increased by seed enrichment with zinc sulfate and manganese sulfate, compared to the control. It is revealed that seed enrichment with zinc sulfate and manganese sulfate may result positive effect on seedling vigor index of the crop, that is in good agreement with those findings by Rahnmaye Badr and Soltani (2011) on cumin (*Cuminum cyminum* L.) in Iran, that the seedlings under enriched seeds with combination of zinc sulfate and manganese sulfate had 18% higher seedling vigor index against control. In this study, seeds enriched in 1% Zinc had higher seedling vigor index, but a greater improvement in the Zinc concentration of the solution did not further increase in seedling vigor index. Similarly, the seedling vigor index in manganese-primed seeds was reduced, when manganese concentration was 1.5% and 2% (Figure 2).

Table 1. Comparison of zinc and manganese content in marigold seeds before and after treatments.

Micronutrients	Concentrations in		
	Enriched solution (%)	Seeds before enriched (mg kg^{-1})	Seeds after enriched (mg kg^{-1})
Zinc	0.5	8.3	83.2
	1		89.0
	1.5		89.8
	2		91.8
Manganese	0.5	4.9	90.0
	1		98.1
	1.5		106.0
	2		107.0

Table 2. Mean squares of seed enrichment method on studied variables.

		Mean squares			
SV	df	FGP (%)	SVI (%)	Flower yield (g/m^2)	Essential oil yield (mL/100g flower)
Replication	2	289.087	100.111*	609.111*	19.883
Treatment	2	800.000**	84.840*	600.004*	70.102**
Error	22	125.089	19.522	158.110	10.022
CV%	-	11.52	22.01	24.11	26.00

*: P<0.05 **: P<0.01.

Dry flower yield was positively influenced by the treatments. The highest yield was recorded in seed soaking treatments in 1% zinc + 1.5% manganese, 1.5% manganese and zinc solutions. When seeds primed in the highest concentration of Manganese, marigold statistically produced flower yield similar to unprimed treatment (Figure 3). Flower essential oil yield among treatments ranged from 0.12 m L to 0.27 m L per 100 g dry weight in 0.5% manganese and 1% zinc + 1.5% manganese solutions, respectively (Figure 4). All the seed treatments gave a significant increase in essential oil yield over control. Significant increase in essential oil yield of marigold due to seed enrichment treatments relative to not-enrichment was expected. Because, the higher essential oil yield was produced in primed seeds by 1% zinc + 1.5% manganese solution, followed by 1.5% manganese, which had higher flower yield.

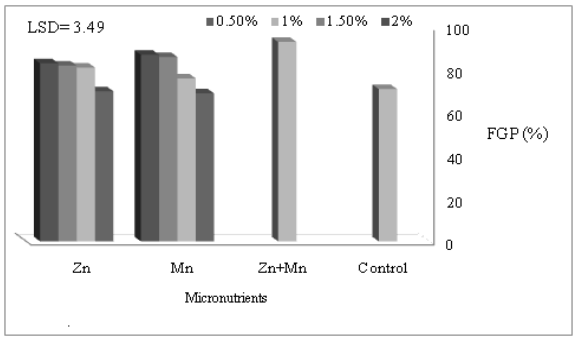

Fig. 1. Effect of seed priming on final germination percentage (FGP) of marigold.

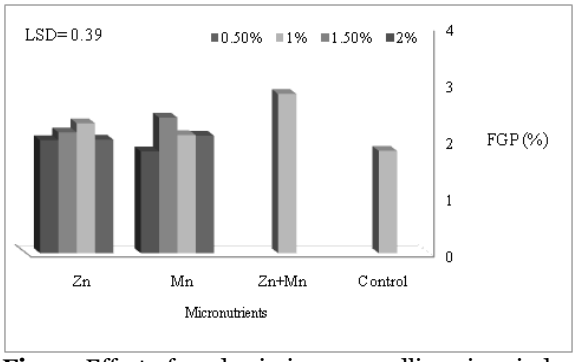

Fig. 2. Effect of seed priming on seedling vigor index (SVI) of marigold.

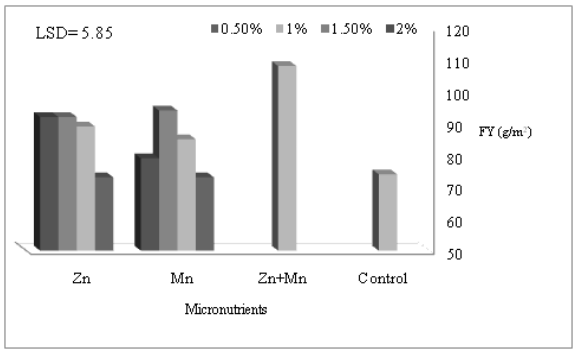

Fig. 3. Effect of seed priming on flower yield (FY) of marigold.

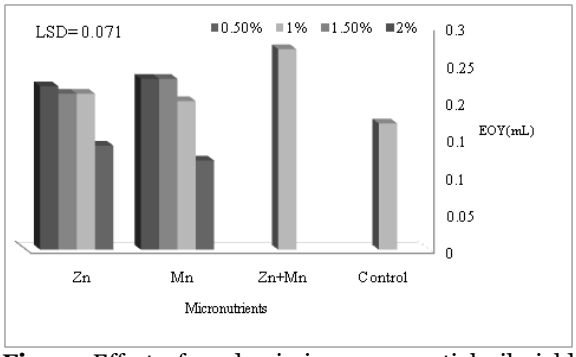

Fig. 4. Effect of seed priming on essential oil yield (EOY) of marigold.

Conclusion

Enrichment of marigold (*Calendula officinalis*) seeds influences seedling vigor and essential oil yield in flowers.

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