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Effects of nitrogen application and spraying of boron and manganese on growth traits of two potato cultivars

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Abstract

In order to study the effects of boron and manganese micronutrients and nitrogen levels on growth traits of two potato cultivars an experiment was done using a factorial-split plot layout with randomized complete block design in three replications in 2012. The factorial combination of micronutrient×nitrogen was the main factor. Micronutrient application in 4 levels included: 1. control (m_1) 2. boron spraying (m_2) 3. manganese spraying (m_3) 4. boron+manganese spraying (m_4), and nitrogen application was in 2 levels of: 1. application of 100% of crop need to nitrogen (n_1) 2. Application of 75% of crop need to nitrogen (n_2) and the cultivar factor as sub-plot was in 2 levels of 1. Sprit cultivar (c_1) and 2. Marfona cultivar (c_2). Results showed that the effect of micronutrient on plant height, leaves number and shoot weight was statistically significant. The highest rates of mentioned traits was recorded in the treatment of m_4 (boron+manganese). The effect of nitrogen application on plant height, leaves number and shoot weight was significant. The effect of cultivar on total traits was significant. Sprit cultivar was superior than Marfona with respect to vegetative traits. Considering the results Sprit cultivar in conditions similar to the region of this experiment may record higher rates of growth and yield characteristics than Marfona cultivar. Moreover dual application of boron and manganese can be resulted in remarkable improvement in agronomic traits of potato.

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Introduction

Potato (*Solanum tuberosum* L.) is a leading staple food in the diet of the world's population which is also used as animal feed (Eleiwa *et al.,* 2012; Levy *et al.,* 2013). Potato provides a part of daily caloric needs of human and delivers many essential nutrients and vitamins including potassium, phosphorus, manganese, magnesium, folate, vitamin C and vitamine B-6 (Haynes *et al.,* 2012). Potatoes provide a bulk dry matter and yield per unit area in comparison with other crops such as cereals, therefore potato is considered as a heavy nutrient requiring crop (Haynes *et al.,* 2012; Bari *et al.,* 2001). Nitrogen (N) is an important nutrient influencing the quality and yield of potato tubers and vegetative growth of the plant (Westermann and Kleinkopf, 1985; Vos, 1997; Eleiwa *et al.,* 2012). Potatoe is highly responsive to N fertilization and N is generally the most limiting nutrient in potato production (Belanger *et al.,* 2000). On the other hand excess nitrogen application may delay tuber initiation and reduce the yield and quality of tubers (Marschner, 1995; Crozier *et al.,* 2000).

Micronutrients are essential elements for plant growth and development which are utilized in trace amounts by plants. Among micronutrients boron (B) and manganese (Mn) play several important physiological roles in plants. Boron is involved in cell elongation, nucleic acid synthesis, hormone responses and membrane function. Some of the major symptoms of boron deficiency in plants are necrosis of young leaves, terminal buds, tubers, fleshy roots and fruits (Taiz and Zeiger, 2002). Manganese activates several enzymes such as decarboxylases and dehydrogenases in plant cells. One of the vital functions of manganese is its role in the light reactions of photosynthesis through which oxygen is produced from water-oxidizing process (Marschner, 1995). The common symptom of manganese deficiency in plants is intervenous chlorosis with small necrotic spots on leaves (Taiz and Zeiger, 2002).

Micronutrient deficiency is prevailing in the soils of many Asian countries such as Iran due to the calcareous type of soils, high pH and low content of organic matter (Malakouti, 2008). In spite of knowing the importance of nitrogen and physiological roles of boron and manganese in plants, there is no information regarding the effects of combined application of N, B and Mn on growth traits of potato in Kurdistan region, thus this trial was aimed to study the growth response of two potato cultivars to the spraying of B and Mn with the application of N levels.

Materials and methods

Experiment layout and treatments

This research was conducted during the spring and summer 2012 in Ghorveh region, Kurdistan, west of Iran. The experiment was arranged in a factorial-split plot layout with randomized complete block design in three replications. The factorial combination of micronutrient (M) × nitrogen (N) was the main factor. Micronutrient application in 4 levels included: 1. control (m_1) 2. boron spraying (m_2) 3. manganese spraying (m_3) 4. boron+manganese spraying (m_4), and nitrogen application was in 2 levels of: 1. application of 100% of crop need to nitrogen (n_1) 2. Application of 75% of crop need to nitrogen (n_2) and the cultivar factor (C) as sub-plot was in 2 levels of 1. Sprit cultivar (c_1) and 2. Marfona cultivar (c_2). Each sub-plot comprised of four wide ridges, four m in length with 75 cm space between ridges and 25 cm between plants on each ridge.

Measurements

Different traits including plant height, number of days from sowing to 50% flowering, number of leaves per plant and shoot weight were recorded.

Statistical analysis

The collected data were subjected to analysis of variance using the SAS software version 9.1 (SAS Institute, Cary, NC). Means of treatments were compared by Duncan's multiple range test at the 0.05 level of significance.

Results

Results revealed that the main effects of micronutrient, nitrogen and cultivar and the interaction effect of micronutrient×cultivar on the traits of plant height, leaves number per plant and shoot weight were statistically significant ($P \leq 0.01$). Plant height and shoot weight were also affected by the interaction effect of nitrogen×cultivar (Table 1). Number of days from sowing to 50% flowering was significantly affected by cultivar factor so that Marfona cultivar recorded a shorter vegetative stage compared with Sprit cultivar (Fig. 1), wherease the effect of micronutrient, nitrogen and the interaction effects on flowering time of potato plants were not significant (Table 1). Means comparison analysis showed that the mixed application of boron+manganese (m_4 treatment) resulted in remarkable increase in plant height, leaves number and shoot weight (Table 2), moreover with increasing the rate of nitrogen application (n_1 treatment) these growth traits were improved (Table 3) and Sprit cultivar was superior than Marfona with respect to growth characteristics (Tables 2 and 3). Analysis of the interaction effect of micronutrient and cultivar (M×C) showed that the highest rates of growth parameters were recorded by m_4c_1 treatment (application of boron+manganese on Sprit cultivar) (Table 2). Furthermore the means comparison of nitrogen and cultivar (N×C) interaction revealed that n_1c_1 treatment (application of 100% of crop need to nitrogen on Sprit cultivar) led to the greatest rates of plant height and shoot weight (Table 3).

Table 1. Analysis of variance of potato growth parameters affected by micronutrient, nitrogen and cultivar factors.

Source of variation	df	Mean squares			
		Plant height	Days to 50% flowering	Leaves number per plant	Shoot weight
Replication	2	14.741^{ns}	7.054^{ns}	1.169^{ns}	8.611^{ns}
Micronutrient (M)	3	550.330^{**}	0.631^{ns}	64.610^{**}	230.325^{**}
Nitrogen (N)	1	333.011^{**}	29.610^{ns}	62.563^{**}	537.742^{**}
M×N	3	0.779^{ns}	0.326^{ns}	0.966^{ns}	3.446^{ns}
E_a	14	2.872	6.594	0.740	4.359
Cultivar (C)	1	27795.556^{**}	76.255^{*}	11711.251^{**}	10826.416^{**}
M×C	3	181.845^{**}	1.732^{ns}	24.890^{**}	156.561^{**}
N×C	1	50.779^{**}	2.660^{ns}	6.497^{ns}	24.027^{*}
M×N×C	3	1.494^{ns}	0.731^{ns}	2.152^{ns}	1.248^{ns}
E_b	16	1.487	9.613	1.482	4.427
CV (%)		1.27	5	3.29	1

ns, * and **: Non significant and significant at 5 and 1% levels of probability, respectively.

Table 2. Interaction effect of micronutrient and cultivar (M×C) on plant height, leaves number and shoot weight.

Micronutrient	Cultivar	Plant height (cm)	Leaves number per plant	Shoot weight (g/plant)
m_1 (control)	c_1 (Sprit)	108.6 d	47.9 c	216.8 d
	c_2 (Marfona)	68.2 g	20.5 e	195.6 e
m_2 (boron)	c_1 (Sprit)	115.3 c	52.5 b	224.4 c
	c_2 (Marfona)	71.7 f	21.0 e	196.9 e
m_3 (manganese)	c_1 (Sprit)	123.0 b	53.2 b	230.1 b
	c_2 (Marfona)	72.4 f	21.4 de	195.9 e
m_4 (boron+manganese)	c_1 (Sprit)	133.3 a	57.0 a	235.3 a
	c_2 (Marfona)	75.4 e	22.7 d	198.0 e

Different letters in each column indicate significant differences at $P \leq 0.05$ according to Duncan's multiple range test.

Table 3. Interaction effect of nitrogen and cultivar (N×C) on plant height and shoot weight.

Nitrogen	Cultivar	Plant height (cm)	Shoot weight (g/plant)
n_1 (100%)	c_1 (Sprit)	123.7 a	230.7 a
	c_2 (Marfona)	73.5 c	199.3 c
n_2 (75%)	c_1 (Sprit)	116.4 b	222.6 b
	c_2 (Marfona)	70.3 d	194.0 d

Different letters in each column indicate significant differences at $P \leq 0.05$ according to Duncan's multiple range test.

Discussion

Application of both micronutrients of boron and manganese in this experiment significantly improved growth parameters of potato plants as compared with control plants. In this regard the promoting effect of manganese was more expressive compared to boron, so that the recorded rates of plant height and shoot weight in m_3 treatment were statistically higher than which recorded by m_2 (boron application) treatment, suggesting the more effective role of manganese in promoting of plant growth. Manganese is involved in synthesis of vital biomolecules such as chlorophyll, indole acetic acid (IAA), lignin and amino acid in plants, moreover manganese plays role in maximizing the photosynthesis rate resulting in plant growth promotion (Morgan *et al.,* 1976; Gross, 1981; Mukhopadhyay and Sharma, 1991). Furthermore combined application of boron and manganese improved the growth traits of potato plants more than which recorded by single application of manganese. This result may be ascribed to synergistic effects of boron and manganese, in other words combined application of these micronutrients can be more effective in plant growth stimulating than their single application. Improvement of growth parameters and increasing of dry matter accumulation in various plants through boron and manganese application has earlier been reported by other authors (Carpena *et al.,* 2000; Shaaban *et al.,* 2006; Ziaeyan and Rajaie, 2009; Orhue and Nwaoguala, 2010).

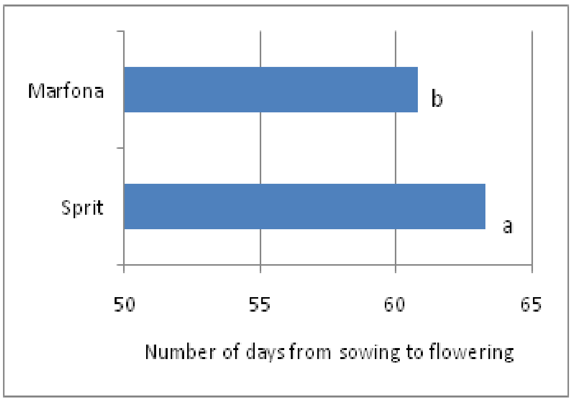

Fig. 1. Means comparison of days number from sowing to 50% flowering in two potato cultivars.

Significant increase in growth traits of potato plants resulting from application of 100% of crop need to nitrogen (n_1 treatment) as compared with n_2 treatment (application of 75% of crop need to nitrogen) indicated the positive response of the plant in exploiting nitrogen for growth enhancement. Results of other studies similarly showed that dry matter accumulation and growth of potato plants may be increased with increasing the rate of nitrogen fertilizer application (Sincik *et al.,* 2008; Zebarth *et al.,* 2008). Nitrogen is one of the main nutrients which directly plays vital roles in chlorophyll synthesis and growth processes especially the vegetative growth of plants. Supplying the plants with nitrogen fertilizers will resulted in increasing of foliar growth of plant, therefore the availability of nitrogen will resulted in maximizing the efficiency of radiation absorption and photosynthesis improvement.

Conclusion

According to the results of this experiment it seems that the Sprit cultivar may be more efficient in terms of growth and development compared to Marfona cultivar under the regional conditions of this experiment. Moreover it is concluded that combined application of boron and manganese and supplying the complete nitrogen requirements of potato plants, improve the crop growth and development which subsequently may result in high productivity and performance of the plant.

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