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Short Communication

Effects of foliar application of zinc on physiological indices and yield of three spinach cultivars in Bojnourd, Iran

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Spinach (*Spinaceae oleraceae* L.) is one of the most enrichment leaf vegetable used by people in the globe. Inadequate micronutrients especially zinc in most Iranian soils have formed a major constraint to spinach production. Therefore, a study was conducted in 2008 growing season in Kohnekan region of Bojnourd to investigate the effects of foliar application of zinc on physiological indices and yield of three cultivars of spinach. A factorial experiment was laid out based on Randomized Complete Block Design (RCBD) with three replications. Treatments were three spinach cultivars (Virofly, Tehrani, and Irani) and two levels of Zinc micronutrient (foliar and non-foliar application). Results showed that Zinc micronutrient had no significant effect on total dry matter (TDM), leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR) and specific leaf area (SLA) indices. The differences among the cultivars for growth characteristics were significant, but interaction effect of Zinc levels with cultivars was not significant. Also, Zinc micronutrient had significant effect on dry matter yield. Generally the results showed that although there is no significant difference between Zinc foliar application and control, numerical difference however existed in most trait in this experiment.

Key words: Spinach, zinc micronutrient, growth, dry matter yield.

INTRODUCTION

Spinach (*Spinaceae oleraceae* L.), an annual leafy plant from *Chenopodiaceae* family, is originally a native of either central zone of the Asia or Iran (Hochmuth et al., 2003). With attention that diet of many people in the world has little amount of essential nutrient elements, especially micronutrients, it becomes necessary to raise the quality of agricultural products particularly vegetables which have been used for food. Unfortunately, the most parts of Iranian soils are calcareous and lack micronutrients (Sillanpaa, 1982). Among the micro-nutrients, Zinc is one of the necessary elements that it interferes with Indol – acetic acid formation and plant growth regulation. De Datta (1981) reported that Zinc deficiency is the second most serious nutritional disorder limiting the yield of rice. Alloway (2004) stated that the reduction of photosynthesis observed in Zinc- deficient plants can also be due, in part, to major decrease in chlorophyll content and the abnormal structure of chloroplast. Vitosh et al. (1994) reported Zinc causes to activate so many enzymes which are needful and essential for synthesis of chlorophyll and carbohydrate formation. Alam et al. (2002) stated that micronutrients are necessary for plant growth and increasing of yield. Welch et al. (1977) reported that foliar application of Zinc on spinach increased Zinc concentration in the leaves. Thalooth et al. (1988) stated that raising of dry matter in bean is the consequence of foliar application of Zinc under conditions of severe Zinc deficiency, flowering and fruiting are much reduced (Fageria, 2009). Against this background, effect of foliar application of Zinc on physiological indices and yield of three cultivars of spinach was investigated.

MATERIALS AND METHODS

This experiment was carried out in 2008 growing season at research farm of Islamic Azad University of Bojnourd in east north of Iran (37° N, 57° E, elevation 1091 m a.s.l.). The climate of region is semiarid. Mean annual precipitation is approximate 250.3.

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Table 1. Mean comparison of simple effects of physiological indices and dry matter yield of three spinach cultivars.

Factor	Level	TDM ($g.m^{-2}$)	CGR ($g.m^{-2}$)	LAI	RGR ($gr.gr^{-1}$)	SLA ($m^2.g^{-1}$)	Yield. Dry matter ($Kg.ha^{-1}$)
Cultivars	Virofly	503.6^{a}	86.79^{a}	3.37^{b}	0.14^{a}	6.80^{b}	2407^{a}
	Tehranian	451.5^{a}	24.56^{b}	5.65^{a}	0.05^{b}	11.07^{b}	1430^{b}
	Iranian	450.5^{a}	22.54^{b}	5.83^{a}	0.05^{b}	21.17^{a}	1038^{c}
Zinc	Foliar application	19.6^{a}	51.36^{a}	5.32^{a}	0.09^{a}	14.91^{a}	187.1^{a}
	non-Foliar application	19^{a}	37.90^{a}	4.57^{a}	0.07^{a}	11.11^{a}	95.5^{b}

Means within each column followed by same letters are not significantly different at 5% level (Duncan's Multiple Range Test).

Table 2. Mean comparison of interaction effects of physiological indices and dry matter yield of three spinach cultivars Means within each column followed by same letters are not significantly different at 5% level (Duncan's Multiple Range Test).

Cultivars	Zinc	TDM ($g.m^{-2}$)	CGR ($g.m^{-2}$)	LAI	RGR ($gr.gr^{-1}$)	SLA ($m^2.g^{-1}$)	Yield. Dry matter ($Kg.ha^{-1}$)
Virofly	Foliar application	461.4^{a}	99.49^{a}	3.38^{b}	0.166^{a}	7.06^{b}	2561^{a}
	non-Foliar application	439.6^{a}	74.09^{ab}	3.36^{b}	0.120^{ab}	6.53^{b}	2253^{b}
Tehranian	Foliar application	466.5^{a}	52.5^{abc}	4.98^{a}	0.108^{ab}	12.33^{b}	1661^{f}
	non-Foliar application	436.6^{a}	3.037^{c}	6.33^{a}	0.003^{b}	9.80^{b}	2033^{c}
Iranian	Foliar application	562.3^{a}	27.84^{bc}	5.37^{a}	0.062^{ab}	25.33^{a}	1706^{e}
	non-Foliar application	480.9^{a}	17.24^{bc}	6.29^{a}	0.057^{ab}	17^{ab}	1827^{d}

Means within each column followed by same letters are not significantly different at 5% level (Duncan Multiple Range Test).

Average annual temperature is 12.7°C with maximum temperature of 19.6°C and minimum of 5.7°C. Experimental soil texture was silty loam. During experiment, irrigation was applied to avoid drought stress and soil water in 1 m depth was kept above 50% of maximum available water during the all growing season. A factorial experiment was done based on RCB design with three replications. Treatments were three spinach cultivars (Virofly, Tehrani, and Irani) and two levels of Zinc (Foliar and Non-foliar application). Each plot size was 4.5 × 2.5 m. Zinc libral fertilizer (Ciba, England) was the source of foliar application (1.5 per thousand per hectare) and this treatment was applied at 8 – leaves stage. In order to study of physiological indices, samples were taken before and after the foliar application. Leaf area were calculated by destructive method with leaf area meter (Model: LI 300 – U.S.A). Samples were oven dried at 72°C for 45 h. The physiological indices including total dry matter (TDM), crop growth rate (CGR), relative growth rate (RGR), leaf area index (LAI) and specific leaf area (SLA) were computed with classical method (Hunt, 1990). Final yield (dry matter yield) were determined in each plots. All data were analyzed statistically using SAS 9.1 and means saparated using Duncan's Multiple Range Test.

RESULTS

Total dry matter (TDM) and crop growth rate (CGR)

Table 1 shows that TDM was not significantly different among cultivars and interaction effects of Zinc levels × cultivars regarding TDM were not significantly different ($P \leq 0.05$). But result of means comparison of interaction effects indicated that Irani cultivar plus foliar application had the highest TDM (562.3 $g.m^{-2}$) (Table 2). CGR demonstrated that there was a significant difference among cultivars and interaction effects (that is, Zinc levels × cultivars) was significant. Means comparison of interaction effects showed that Virofly cultivar plus foliar application had the highest CGR (99.49 $g.m^{-2}$.10 $g.m^{-2}$ (Table 2).

Relative growth rate (RGR) and leaf area index (LAI)

Table 2 revealed that there was considerable difference among the cultivars regarding RGR ($P \leq 0.05$). Means comparison of interaction effect pointed out Virofly cultivar plus foliar application had the highest RGR (0.166 $gr.gr^{-1}$) (Table 2). There was significant difference among spinach cultivars for LAI and interaction effects was significant ($P \leq 0.05$). Means comparison of interaction effects expressed that Tehrani cultivar with non - foliar application had the highest LAI with average of 6.3 (Table 2).

Specific leaf area (SLA) and dry matter yield (biological yield)

There was considerable difference among spinach

cultivars in their SLA (Table 1). Means comparison of interaction effects revealed that Irani cultivar with foliar application had the highest SLA with average of 25.33 $m^2.g^{-1}$ (Table 2).

The dry matter yield showed that there was a significant difference among both cultivars and interaction effects (Table 1). Means comparison of interaction effects showed that Virofly cultivar with foliar application had the highest dry matter yield (2561 $kg.ha^{-1}$) and Tehrani cultivar with foliar application had the least yield with average of 1661 $kg.ha^{-1}$ (Table 2).

DISCUSSION

Researchers explained that Zinc, for the reason of its role in chloroplast structure and photosynthesis electron translocation, can activate carbonic anhydrase enzyme as well as having direct effect on photosynthesis rate (Sharma and Chandel, 1990; Alloway, 2004). With take notice about role of Zinc in electron translocation at hill reaction of light stage of photosynthesis and strong role of Zinc at N-metabolism (Fageria, 2009), we concluded that Zinc foliar application could increase dry matter accumulation in spinach and obviously plant dry matter is the result of accumulation of photosynthesis materials. Virofly cultivar with Zinc foliar application had the highest yield compared to other cultivars. The superiority of Virofly cultivars can be attributed to the role of Zinc in boosting activation of photosynthesis electron translocation and reduction of SLA in Virofly which increased leaf thickness instead of leaf area, resulting in increased photosynthesis area and biological yield.

Conclusion

More comprehensive studies in future on Zinc, as its role on producing chlorophyll and forming carbohydrate, N-metabolism of the plant, improves root development and boosting crop growth and yield (Fageria, 2009; Alloway, 2004; De Datta, 1981) should be done for better understanding of Zinc role in formation of final yield per unit land area per unit time.

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