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Research article

EFFECT OF SEEDS PRIMING WITH MICRONUTRIENTS ON GROWTH, SEED YIELD AND MUCILAGE OF PLANTAIN

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ABSTRACT: The quality of the seeds of medicinal plants is an important factor in their growth and development and yield under field conditions. Therefore, the methods for improving their vigor such as the priming especially with micronutrients required for the germination is an important factor in enhancing their yield. The objective of the present study was to examine the effect of seed priming with different concentrations (0, 0.5, 1.0, 1.5, 2.0 and 2.5%) of micronutrients (Fe, Zn, B, Mn) on the growth and yield characteristics of plantain. It was found that seeds primed with 1.0, 1.5, 2.0 and 2.5% Zn significantly increased leaf area. Their priming with 1.5, 2.0 and 2.5% Fe resulted in the highest leaf area. Under the priming with Mn, the highest leaf area was obtained with the concentrations of 1.0, 1.5, 2.0 and 2.5%. Total biomass was increased with Zn, Fe and Mn treatment and was decreased with B treatment. Furthermore, the application of Fe, Zn and Mn at the concentrations of 0.5, 1.0 and 1.5% significantly increased seed yield. The highest coefficient of seed expansion was related to Zn concentrations of 1.5 and 2.0% and Fe concentrations of 2.0 and 2.5%. Given the results and the importance of seed yield and coefficient of mucilage expansion, it is recommended to prime plantain seed with 1.5% Zn, Fe and Mn and to avoid their priming with B.

Keywords: germination, micronutrients, plantain, priming, seed, yield.

INTRODUCTION

Medicinal herbs are important economical plants which are used in traditional and modern medicine in both raw and processed forms. Some species of plantagiaceae are known as important sources of natural mucilage production throughout the world. Mucilage is mainly used as meline and in addition to its diverse applications in medicine, food and cosmetics industries, it is consumed as gel for preparing laboratorial culture media [9]. Early establishment of seedlings following rapid seed germination is an effective factor in increasing seed yield through accelerating canopy closure. It is of even more importance in northern latitudes where environmental conditions are under-optimum for the growth of the plants, the growth period from sowing to harvesting is relatively short and the growth or daily accumulation of biomass is concentrated in a short period of time [2]. Therefore, crop growers need seeds with high germination in order to produce considerable crops. Seed vigor and viability are two important qualities of seeds that affect the growth of the plants [13]. Most medicinal plants have low germination and slow growth rate. Their low germination indices have posed them to degradation and extinction more than other plants. Thus, improvement in their germination indices would be a great step forth in conserving these species in addition to their domestication and removing the need for their gathering from the nature [4].One method for enhancing seed quality is priming which can improve germination percentage, germination rate, germination under diverse environmental conditions and the growth of the seedlings. Seed priming accelerates the emergence of the seedlings, improves plant tolerance to drought, causes earlier flowering, and increases the yield in semi-arid regions [5].

Priming allows the seed to uptake water in a controlled manner to the extent that the preliminary germination activities are commenced including the activation of the hormones and enzymes and the dissolution of stored nutrients. But, the exit of the rootlets is inhibited and the seeds are dried to make them maintainable until sowing.In the method of soaking in distilled water, the seeds are treated with distilled water with no chemicals. This priming induces metabolic activities of germination and the resulting sugars can be used for protein synthesis during germination which improves germination rate and uniform growth of the plants [14].
The arable soils in Iran suffer from severe deficiency of micronutrients, particularly Zn and Fe, for such reasons as their high lime content, low organic matters, high bicarbonate content of irrigation water and excessive application of phosphate fertilizers [12]. The treatment of seeds with micronutrients brings these microelements to the seedlings making them stronger which, in turn, results in better growth and establishment of the seedlings. In addition, much less quantities are required [15]. Given the facts mentioned above, the objective of the present study was to examine the effect of plantain seeds treatment with different concentrations of nutrient solutions on their germination and the growth of the plants.

MATERIALS AND METHODS

The study was carried out in laboratory and greenhouse of research station of Islamic Azad University of Tabriz located in Karkaj lands (Long. 46°17' E., Lat. 38°05' N, Alt. 1360 m.) in 2011. The study was a factorial experiment based on a Randomized Complete Block Design with three replications in which the studied treatments included seeds germination, growth and seed yield of plantain (*Plantago major* L.). The factors studied in laboratory included factor A devoted to micronutrients (Zn, Fe, Mn, B) and factor B devoted to different concentrations of micronutrients including solutions of 0.5, 1.0, 1.5, 2.0 and 2.5% for $FeSO_4.7H_2O$ (26% Fe) corresponding to 26.3, 52.5, 78.8, 105 and 131.2 g l^{-1}, the concentrations of 0.5, 1.0, 1.5, 2.0 and 2.5% for H_3BO_3 (17% B) corresponding to 29.5, 59, 88.5, 118 and 147.5 g l^{-1}, the concentrations of 0.5, 1.0, 1.5, 2.0 and 2.5% for $ZnSO_4.H_2O$ (12% S and 35% Zn) corresponding to 14.5, 29, 43.5, 58 and 72.5 g l^{-1}, and the concentrations of 0.5, 1.0, 1.5, 2.0 and 2.5% for $MnSO_4.3H_2O$ (15% S and 26% Mn) corresponding to 19, 38.5, 58, 77 and 97 g l^{-1} as well as distilled water as control. Each replication was composed of 21 treatments and 63 pots in greenhouse. Plantain seeds were of Mashad landrace procured from Isfahan Pakan Bazr Co.
Before the study, the viability of seeds was measured. A part of primed seeds was oven-dried at 70°C and then, it was ground. The ground seeds were digested in an acidic mixture of 10 ml HNO_3 + 4 ml $HClO_3$. Then, Zn, Mn and Fe contents were measured by Perkins-Elmer atomic absorption device at the wavelengths of 213.9, 279.5 and 248.3 nm, respectively, and B content was determined by spectrophotometer at 420 nm [8]. After priming, these stages were repeated to find the variations of the content of these elements in seeds.

Priming method

The priming procedure was as follows: about 3 g of plantain seeds was placed in a plastic container, after adding 15 ml of the solution with different concentrations of the micronutrients, for 12 hours. Then, the seeds were washed with distilled water for three times to remove the excessive salts. The next stage was in a greenhouse with 9-litre pots. This stage was commenced in April and was continued for about six months after the emergence of the seeds. The seeds were emerged, on average, 6-7 days after sowing and the seedlings were emerged, on average, 8 days after sowing. The measured traits included time to emergence, total biomass, leaf area, seed number, seed yield, harvest index, and coefficient of mucilage expansion. Data distribution normality test and analysis of variance for the studied traits as well as their means comparison were done by MS-TATC software and the graphs were drawn by MS-Excel. The means were compared by Duncan multiple range test at 1 and 5% probability levels.

RESULTS AND DISCUSSION

Analysis of variance for the studied traits

Analysis of variance for the measured traits (Table 1) revealed that the micronutrient significantly affected total biomass, leaf area, seed yield, and harvest index at 1% probability level and time to emergence at 5% probability level.
The impact of the concentration of micronutrients was significant on time to emergence, seed number and seed yield at 1% probability level and on total biomass and the coefficient of mucilage expansion at 5% probability level, too.
The interactions between micronutrients and their concentrations were significant for time to emergence, leaf area, seed number, harvest index, and the coefficient of mucilage expansion at 1% probability level.

Time to seedlings emergence

Means comparison for time to seedlings emergence showed the significant effect of micronutrient concentrations on this trait. When Zn was applied, the shortest time to seedlings emergence was obtained under the concentrations of 1.5 and 2.0% Zn which was 56 and 58% shorter than that under control, respectively. Zn concentration of 0.5% had the least effect reducing this trait by 37% as compared to control (Figure 1).

Table 1.Analysis of variance (means of squares) of the effect of seed priming with different concentrations of micronutrients on the studied traits of plantain.

Sources of variation	Df	Time to emergence	Total biomass	Leaf area	Seed number	Seed yield	Harvest index	Coefficient of mucilage expansion
Micronutrient	3	3.02*	12.021**	29900 **	12.021^{ns}	297.7**	24.066**	0.021^{ns}
Concentration	5	69.068**	0.505*	0.037^{ns}	19.20 **	73.155**	0.037^{ns}	1.905*
Micronutrient × concentra-tion	15	48.028**	0.153^{ns}	25987.1 **	2.752**	0.0067^{ns}	22.095**	5.897**
Error	48	10.910	0.171	4689.240	0.38	0.0025	4.06	0.416
C.V. (%)		29.23	25.88	20.20	26.80	25.15	20.99	20.80

ns, * and ** show non-significance and significance at 5 and 1% level.

When Fe was applied, the shortest time to emergence (8 days) was observed under the concentrations of 2.0 and 2.5%. This treatment shortened time to emergence by 55% as compared to control under which the seedlings needed 18 days to emerge. The next concentrations resulted in the highest increase in time to emergence were 1.5, 1.0 and 0.5%, respectively (Figure 1). Under the treatment with Mn, the concentrations of 1.0, 1.5, 2.0 and 2.5% resulted in the greatest decrease in time to emergence. Statistically talking, no significant differences were observed between these concentrations in terms of time to emergence. Mn concentration of 0.5% had the least effect on this trait among different treatments. It was found that B concentrations of 0.5, 1.0 and 1.5% did not significantly influence time to emergence. Under B concentrations of 2.0 and 2.5%, the seeds did not germinate. So, time to emergence was zero under these treatments.

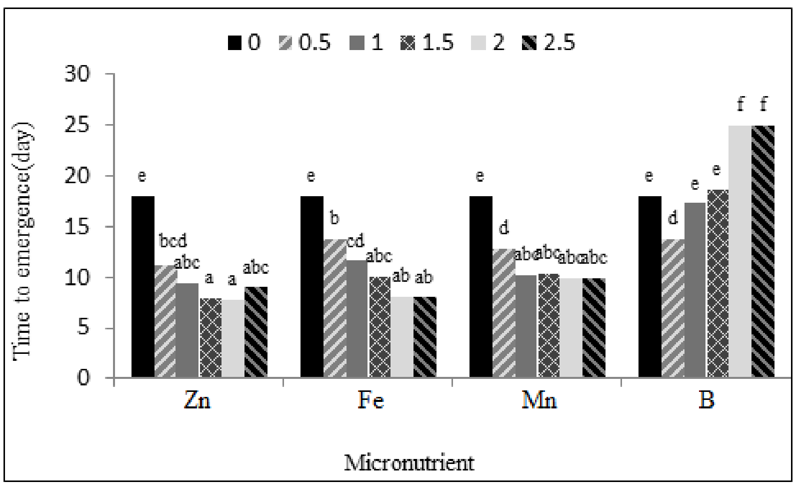


Figure 1.Means comparison for time to emergence of seedlings as affected by different concentrations of micronutrients.

Seed priming shortened time to the emergence of seedlings and reduced the protection of seeds against biotic and abiotic factors during the critical period of seedling establishment. In addition, this treatment resulted in uniform emergence of seedlings leading to their uniform establishment and yield improvement. The yield increase caused by hydropriming can also be explained by the rapid and optimum establishment of the plants and their use of nutrients, soil moisture and solar radiation [11].

Total biomass

Means comparison for total biomass as affected by micronutrients showed that Zn, Fe and Mn significantly increased total biomass, but B decreased it significantly. Abdolrahmani *et al*. (2010),[1] stated that in Zn-deficient soils plants of Zn-rich seeds produced higher dry matter and absorbed Zn with higher efficiencies at the later growth stages.

Means comparison for total biomass as affected by different concentrations of micronutrients indicated that the concentrations of 0.5, 1.0 and 1.5% increased total biomass significantly, but the concentrations of 2.0 and 2.5% did not result in significant differences in this trait. In terms of total biomass, no significant difference was observed between the concentrations of 0.5, 1.0 and 1.5% of micronutrients (Figure 2(a), (b)).

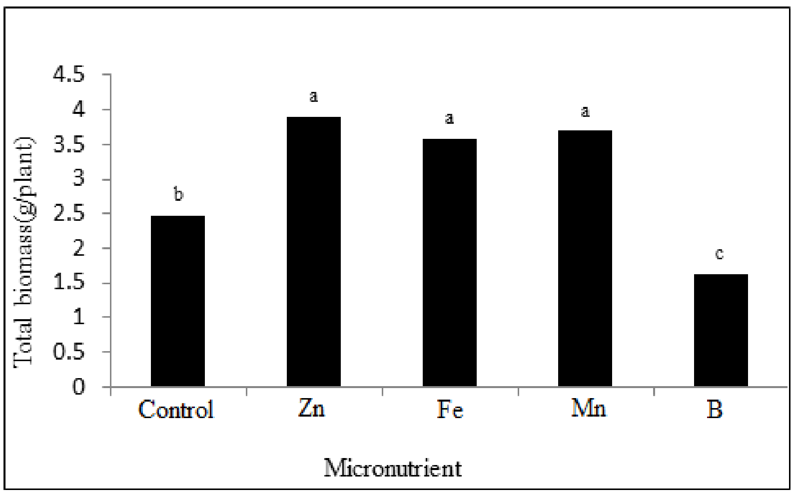
Leaf area

According to means comparison for leaf area as influenced by different concentrations of micronutrients, the treatment with 1.0, 1.5, 2.0 and 1.5% Zn concentrations resulted in the higehst leaf areas of 424, 424, 418 and 411 cm, respectively. Zn concentrations of 1.0, 1.5, 2.0 and 2.5% brought about 37, 37, 35 and 34% increase in leaf area. Among different levels of Zn priming, the concentration of 0.5% had the least effect on leaf area which was 18% higher than that under control with the leaf area of 310 cm (Figure 3).The improvement in plant green cover caused by priming is reportedly associated with early emergence and successful establishment of the seedlings [7]. Hence, early emergence of plants causes the plants to have higher green cover because they better exploit the resources.

With regard to priming with Zn, the concentrations of 1.0, 1.5 and 2.5% resulted in the highest increase in leaf area. The concentrations of 0.5 and 2.0 increased leaf area as compared to control, but to a lesser extent.

Among different levels of priming with Fe, treatment with the concentrations of 1.5, 2.0 and 2.5% resulted in higher leaf area than other concentrations. These three concentrations which had no significant differences resulted in leaf areas of 409, 415 and 408 cm. Out of different Fe concentrations, priming with 0.5% Fe had no significant influence on leaf area of plantain.

(a)



(b)

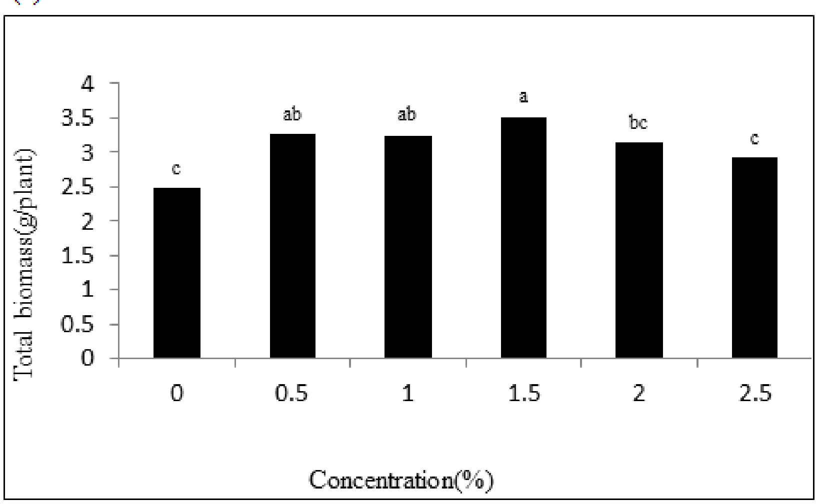


Figure 2.Means comparison for total biomass as affected by (a): micronutrients (b): different concentration.

The highest increase in leaf area as affected by priming with Mn was devoted the concentrations of 1.0, 1.5 and 2.5%. Like priming with Zn, the other two concentrations of Mn, i.e. 0.5 and 2.0%, increase leaf area as compared to control, but to a lesser extent. Priming with B concentrations of 0.5, 1.0 and 1.5% did not result in significant differences in leaf area as compared to control (Figure 3).

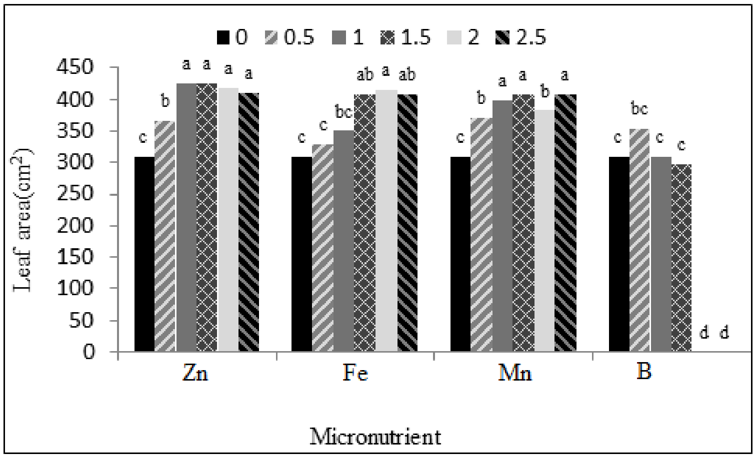


Figure 3.Means comparison for leaf area as affected by different concentrations of micronutrients.

Seed number

Means comparison for seed number as influenced by different concentrations of micronutrients revealed that the concentrations of 0.5, 1.0 and 1.5% significantly increased seed number, but the concentrations of 2.0 and 2.5% resulted in significant loss of seed number. The highest number of seeds was found to be 1311 and 1334 which were 16 and 18% higher than that under control (Figure 4). In a study on wheat,Talebian *et al*. (2012), [3] showed that seeds priming increased grain number per plant as compared to control. In the present study, seed number as affected by priming with Zn was increased by 21.6% as compared to control.

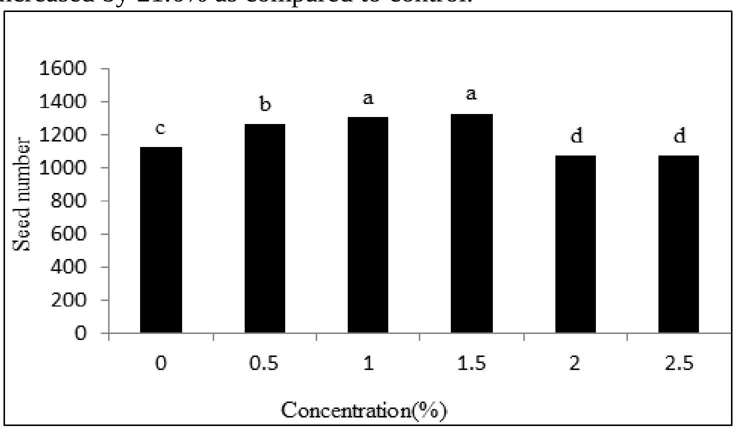
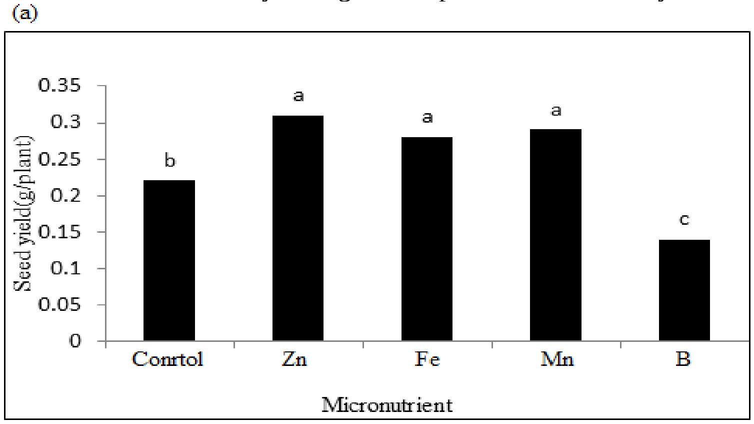


Figure 4.Means comparison for seed number as affected by different concentrations of micronutrients.

Seed yield

According to means comparison for seed yield as affected by micronutrients, the application of Zn, Fe and Mn significantly increased seed yield, but B brought about a significant loss in this trait. Zn, Fe and Mn application increased seed yield by 41, 27 and 32% as compared to control, respectively. This increase can be related to rapid, optimal establishment of the plants and their greater ability in using nutrients, soil moisture and solar radiation. Therefore, better use of nutritional resources due to early emergence of plants can eventually result in seed yield increase.

(a)



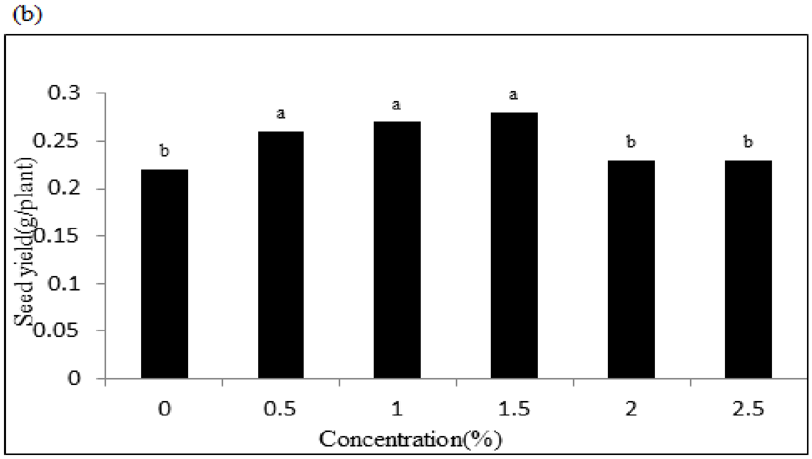


Figure 5.Means comparison for seed yield as affected by (a): Micronutrients (b): Different Concentrations.

Abdolrahmani *et al*. (2010), [1] studied the effect of seed priming with Zn and P containing solutions (10, 50 and 100 mM) on seed growth, seedling establishment and grain yield of barley cv. Abi. Seeds priming with 10 mM Zn + 50 mM P and 10 mM Zn + 100 mM P increased autumn barley grain yield by 41%, on average. They stated that seed priming was an inexpensive method for improving germination with some advantages for barley under Zn and P limitation. Means comparison for seed yield as influenced by different concentrations of micronutrients revealed that the concentrations of 0.5, 1.0 and 1.5% significantly enhanced seed yield, but the concentrations of 2.0 and 2.5% had no significant impact. The three former concentrations did not bring about significant differences in seed yield increasing seed yield by 18, 23 and 27% as compared to control, respectively. Mirshekari (2012), [10] examined the effect of 0.5, 1.0, 1.5 and 2.0% B and Fe on germination and yield of dill. The highest seed yield was observed under Fe concentrations of 1.5% and B concentration of 1% which was 20% higher than that under control. Farooq *et al*. (2012),[6] stated that the grain yield of wheat was increased with the increase in the concentration of Mn in priming solution (Figure 5(a),(b)).

Harvest index

On the basis of means comparison for harvest index as influenced by different concentrations of micronutrients, the lowest harvest index was 13.5% obtained under the application of Zn and Mn with the concentration of 2.0%. Under Fe application too, the lowest harvest index was observed in the concentration of 1.5%, and under B application, the concentration of 0.5% resulted in significant loss of harvest index. The other concentrations had no significant effect (Figure 6).

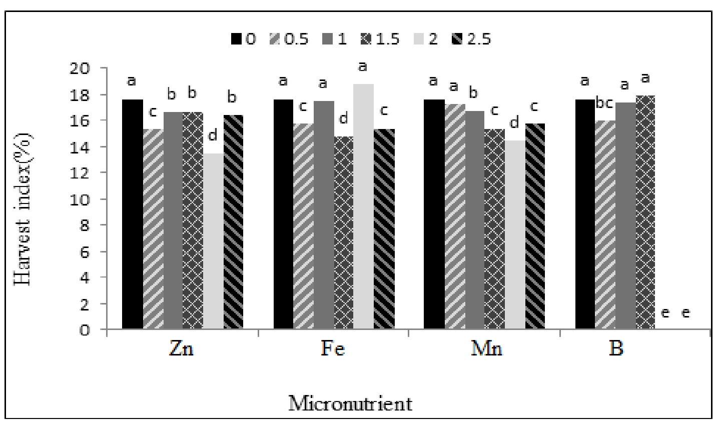


Figure 6.Means comparison for harvest index as affected by different concentrations of micronutrients.

Coefficient of seed expansion

Means comparison for the coefficient of seed expansion as influenced by different concentrations of micronutrients indicated that B concentrations of 0.5, 1.0 and 1.5% had no significant influence on this trait, and under the concentrations of 2.0 and 2.5%, the coefficient was zero because the plants did not emerge. The application of 0.5% Mn did not significantly impact this trait. Other concentrations increased it significantly. The highest coefficient of seed expansion was observed under Mn concentration of 2.5% which increase it by 34% as compared to control. Among Fe treatment levels, the concentrations of 0.5 and 1.0% had no significant effect on the coefficient of seed expansion. But, the other concentrations improved it significantly. Among Zn treatment levels too, the concentrations of 0.5, 1.0, 1.5, 2.0 and 2.5% increase it significantly.

The highest coefficient of seed expansion under the application of Zn was caused by the concentrations of 1.5 and 2.0% with no significant difference with the concentrations of 2.5% which were 38 and 38% higher than that under control (Figure7).

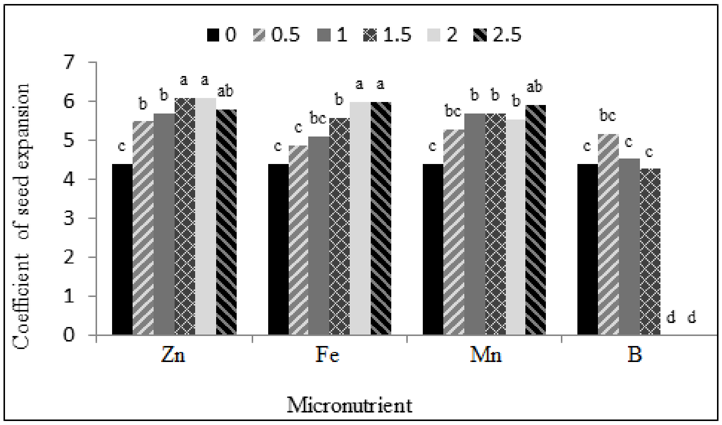


Figure 7.Means comparison for coefficient of expansion as affected by different concentrations of micronutrients.

CONCLUSION

Time to emergence was shortened with the priming with Fe, Zn and Mn. Priming with these micronutrients increased total biomass, but priming with B reduced it. In addition, the concentration of 1.5% resulted in the highest increase in the biomass of plantain. Priming the seeds with Zn, Mn and Fe significantly increased leaf area. Seed yield was significantly increased with the application of 0.5, 1.0 and 1.5% Fe, Zn and Mn. Given the results and the importance of seed yield, it is recommended to prime the seeds of plantain with Zn, Fe and Mn at the concentration of 1.5% and to avoid their priming with B. The highest coefficient of seed expansion was obtained under Zn concentrations of 1.5 and 2.0% and Fe concentrations of 2.0 and 2.5%. The highest number of seeds was obtained under the concentrations of 1.0 and 1.5% of the micronutrients.

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