The Designation of Micronutrients Foliar Application Influence on Rice (Oryza Sativa L. cv. Shiroodi) Yield and Yield Components

Ashkan Daneshtalab Lahijani (ashkan.daneshtalab1367@gmail.com)
Islamic Azad University Chalus Branch: Islamic Azad University Nowshahr and Chaloos Branch
https://orcid.org/0000-0003-3568-5321

Amir abbas Mosavi
Islamic Azad University Chalus Branch: Islamic Azad University Nowshahr and Chaloos Branch

Morteza Moballeghi
Islamic Azad University Chalus Branch: Islamic Azad University Nowshahr and Chaloos Branch

Original article

Keywords: rice, foliar application, micronutrients, chlorophyll a, grain yield

DOI: https://doi.org/10.21203/rs.3.rs-119603/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
Abstract

Pursuant to micronutrients critical role in the plant nutrition and metabolism, accurate determination of the best term of foliar application as a practical plant nutritional pathway has substantial circumstances in the novel agricultural approaches. In order to properly assess micronutrients liquid fertilizer with commercial name of Royesh no and mentioned ingredients (Fe EDTA 0.1%, Zn EDTA 0.05%, B 0.02%, Cu EDTA 0.05%, and Mn EDTA 0.05%) influence on Shiroodi cultivar yield, this investigation implemented in the Iran Rice Research Institution (Amol, Mazandaran) during two consecutive years (2017-2018). This extensive research conducted in the form of RCBD with eight treatments and three independent replications. The treatments were T0 (control), T1 (one foliar application) to T7 (seven foliar applications). The frequent intervals of foliar applications were seven days and the first foliar application done nine days after transplantation. The results revealed that the micronutrients application effect was significant about plant dry weight, grain yield, 1,000 grains yield and harvest index. Also, the interaction of the year and foliar application was significant about seed Zn content, chlorophyll b and 1,000 grains yield. According to statistical data, it can be concluded that T4 with 4257 kg/ha grain yield compare to control yield 3499.1 kg/ha that indicated 20 percentage approximate enhancement about foliar application treatments, four leaf spraying with 2 liters/ 1000 liters of water dosage of micronutrients could affect grain yield and yield components of rice (shiroodi cv.) significantly through increasing the number of tillers/plant, improvement of panicle length and increasing the number of grains/ panicle. The micronutrients supply through leaves is more effective procedure in the field of rice nutrition compare to soil application method due to higher absorption velocity.

Introduction

Due to growing trend of population amplification and increasing requirement of the strategic foods supply like rice, lack of appropriate product yield and decreasing the rice cultivation area due to environmental restrictions and humans activities, obtaining the novel agricultural approaches is the determinative factor to access food security. Approximately 50% of the daily calories of the human body are provided by consuming cereals such as rice, wheat and corn. Although rice is in the second place in terms of importance, but in the Asian countries it is crucial both from a nutritional and economic point of view (Zibae 2013). Since rice provides 21% of the required energy as well as 15% of human protein needs, the level of production and the quality of produced rice is very important (Gnanamanickam ss 2009). The producing higher quality crops requires the adoption of new plant nutrition methods such as foliar spraying, proper pest and disease management, and the use of high-yield cultivars adapted to climatic and farm characteristics that produce marketable products for consumers and profitable for farmers. Increasing the level of efficiency will not be possible without accurate knowledge of the morphological and physiological characteristics of the rice and the plant nutritional needs in the different vegetative and reproductive periods. The research has shown that the simultaneous use of macro and micronutrients in different growth stages, according to farm conditions such as climate, soil characteristics and cultivar features, through affecting the plant metabolism and increasing the intracellular reactions in various dimensions such as increasing vegetative growth, increment of the number and length of panicles, as well as increasing plant resistance to pests and diseases and, environmental stresses have been effective in field of the rice production enhancement. In this relation Hosseinzade and his colleagues (2012) reported that by evaluating the effect of the concentration and consumption time of micronutrients on yield and yield components of rice grain elements of Deylamani and Shiroodi cultivars, the results revealed that grain yield per hectare, harvest index, number of tillers and 1000-grain weight has shown significant different and also the best foliar spraying time And it was clustering. Furthermore, Liew and his colleagues (2012) proved that foliar application of copper and boron elements had a significant effect on reducing the contamination of rice plant diseases and consequently on increasing its yield. According to research, micronutrients are slightly needed by the plant, but their deficiency reduces the growth and yield of rice crops. On the other hand, Zayed and his colleagues (2011) expressed that the application of individual and combined micronutrients had a significant effect on the growth rate of rice in both years of the experiment. Also, Furoharnia and colleagues (2010) reported that the foliar application of different levels of micro-mineral fertilizer has been significant on rice yield and the most economical stage of foliar application is the initial pedicle phase. The Shiroodi cultivar was introduced in 2008, which is obtained from the intersection of Caspian and Tarom Deylamani cultivars. This cultivar, with its high yield and good cooking quality, also has a very good marketability in terms of grain shape (IRRI 2015). The crops often absorb and use less than half of the fertilizer used, and the rest may be added to groundwater and rivers, causing biological pollution. Also, by binding to soil particles, it can cause salinity and pollution of agricultural soils and air pollution (Nolan and Stoner 2000). Therefore, the foliar application method, while providing the nutrients needed by the plant in a timely manner, also plays a significant role in reducing biological pollution. Micronutrients include boron, chlorine, copper, iron, manganese, molybdenum, nickel and zinc. In this study, simultaneous and foliar application of boron, copper, iron, manganese and zinc considered to investigate their influence on morphological, physiological and yield characteristics of rice. The concentration of trace elements is less than 0.025% or 250 ppm in the dry matter of the plant. The plant nutrients are not able to be absorbed by the plant without ionic charge, except boron, which is absorbed by plants without ionic charge (boric acid). The rest of them have ionic charge so that they can be absorbed by the plant and participate in the plant metabolism (Jones and Olson-Rutz 2016). With considering the results of other investigations that conducted in the field of present research and perceiving the unfavorable and unexpected yield of rice fields, especially in the northern provinces of the country like Mazandaran, proper nutrition of rice farms seems to be a determining factor in improving yield on a large scale. Also, the vital role of micronutrients in plant nutrition, such as increasing the productivity of macronutrients and activating critical enzymes that directly affect crop performance, the importance of this research and other complementary researches is more clear in order to determine the appropriate amount, composition and timing of application of these elements in relation to the yield and yield components of Shiroodi rice cultivar and other cultivars. The questions raised can be posed in this way, will the agronomic characteristics of rice in the foliar spraying treatments be significantly different from other treatments and control? And which treatments will be functionally and infrastructurally cost-effective for farmers?

Methods And Materials

The present study was conducted in Iran Rice Research Institute (Mazandaran Deputy, Amol city) with geographical coordinates of longitude 52.3 degrees north, latitude 26.28 degrees east and altitude 23 meters above sea level in field conditions. According to meteorological divisions, this region has mild wet summers and relatively cold winters. The required information regarding the characteristics of the soil at the test site was randomly sampled from the surface
The results of combined analysis of variance of biennial data showed that the effect of micronutrient foliar application treatment was significant at 1% probability level for traits such as seed Zn content, plant dry weight, chlorophyll a and b, carotenoids, leaf greenness, grain yield, 1000-grain weight and harvest index were (Table 1). In this regard, the interaction of foliar application and year for seed Zn content, chlorophyll b, carotenoids and 1000-grain weight was significant at 1% probability level. Also, the simple effects of micronutrients foliar application on chlorophyll a, carotenoid content, plant dry weight, seed Zn content, grain yield and 1000-grain weight were significant (Table 4). The statistical results showed that the highest number of tillers per plant T4 (24), the highest plant height T4 (156.8 cm), the highest dry weight of plant T7 (44.4 gr / m2), the highest number of seeds per cluster T3, T4 (149) and the highest cluster lengths T3 (30.8 cm) were obtained when the plants received micronutrients through the leaves. On the other hand, the lowest index of grain yield and 1000-grain weight were related to the control (Table 3).

The results of combined analysis of variance showed that foliar application of micronutrient fertilizer on the concentration of zinc in rice grain was significant at the level of 1% and also the interaction of year and foliar application was significant in this regard (Table 4). In this regard, the comparison of the biennial mean showed that the highest concentration (about three times the normal limit) was related to T6 (67.02 mg.kg⁻¹) and the lowest was related to the control (Fig. 1a). It seems that foliar application of zinc-containing micronutrient fertilizer at different vegetative and reproductive stages of rice has significantly increased the content of zinc in the grain in foliar application treatments compared to the control. In this regard, Jiang and his colleagues (Jiang et al., 2008)
reported that this could be related to the connections between the xylem and phloem vessels in the wheat panicle and the exchange of elements between them. Also Ishimaru and his colleagues (Ishimaru et al., 2005) expressed that in the study of zinc transport within the rice plant tissue, it was reported that this element is stored in the plant after being absorbed through the stomata and transferred to the leaves. This causes the transfer of zinc from decaying leaves at the end of the growth period through the phloem to the seed and thus plays a role in increasing the amount of this element in the seed.

**Leaf chlorophyll content**

The content of chlorophyll a was significantly affected by the use of micronutrients at a probability level of 1% in foliar treatment compared to the control treatment based on statistical results (Table 4). The highest number of chlorophyll a was related to T4 with 0.56 and four times foliar application and the lowest was related to T2 with 0.29 with mg.g-1fwt unit (Fig. 1b). Considering the significance of the results of the mentioned trait, it is possible that the foliar spray of micronutrients that play a crucial role in the synthesis of chlorophylls such as zinc, iron and copper could have a significant effect on increasing the chlorophyll content of cell. In a similar study by Server and his colleagues (Sarwar et al., 2013), they reported phenological response of rice to different levels of micronutrients under calcareous soil conditions in all treatments was significant, especially in tillering stage except full flooding treatment increased in both years of research. The use of zinc alone or in combination with boron increased the chlorophyll content of rice.

As can be seen in Table 4, the chlorophyll b content was affected by the foliar application of micronutrients, so that the difference between the content of chlorophyll b and the control was significant at the level of 1% probability. The interaction effect of year and foliar application was also significant for this trait at 1% probability level. The comparison of mean data in two consecutive years showed that the highest number of chlorophyll b was related to T4 with 1.42 and the lowest was related to T6 with 0.88 with mg.g-1fwt unit (Fig. 1c). The simultaneous supply of essential micronutrients affecting the formation of chlorophyll pigments seems to increase the chlorophyll content of rice through foliar application during the tillering and stem formation stages, which increases light absorption and accelerates photosynthetic processes. In a similar study by Zayed et al. (2011) expressed chlorophyll content (SPAD index) was significantly improved as a result of receiving micronutrients compared to the control when the rice plant received micronutrients and also the treatment of iron, zinc and manganese was found to have the highest value among the studied traits.

**Carotenoids**

According to Table 4, the amount of carotenoids increased significantly (at a probability level of 1%) compared to the control when micronutrients were used, and the interaction of foliar application and year was also significant at the same level. The highest number of carotenoids was related to T4 with 0.429 and the lowest number was related to T2 with 0.253 with mg.g-1fwt unit based on the comparison of the mean of statistical data during two years of experiment (Fig. 1d). Due to the role of micronutrients used, the activation of enzymes responsible for the synthesis of proteins such as zinc along with copper, which is an essential element for the formation of pigments, may have played a role in the structure and activation of vital enzymes and facilitating intracellular reactions. According to the Gomez-Garcia and Choa-Alejo (2013) opinion, it seems that in line with the theories proposed in this field, increasing the amount of carotenoids in the studied foliar spraying treatments compared to the control is due to the determinative role of these elements. Pursuant to most accepted theories, carotenoids are synthesized by the three genes cl, c2, y, as well as several enzymes involved in the synthesis of carotenoids in chili peppers, although little is known about the molecular mechanism of this process.

**Plant height, panicle length and plant dry weight**

The statistical results indicate the influence of foliar application of micronutrient fertilizer on plant height was not significant (Table 4). In this relation, the interaction effect of foliar application and year was not significant, too. The results of comparing the mean data over two years show that the highest plant height was related to T4 (156.8 cm) with four sprays of micronutrient liquid fertilizer and the lowest was related to the control (113 cm) without foliar application (Fig. 1e). The increment of plant height in foliar treatments was probably due to a significant increase in stem length due to an increase in internode distance in result of enhanced production of plant growth hormones, which plays a critical role in zinc content that increased cell division and photosynthesis rate. Arif et al. (2012) reported that integrated application of zinc and boron has been the best fertilizer balance for further growth and yield response of rice and also increased plant height, number of tillers, panicle length, number of seeds per plant, number of fertile spikes, and dry weight.

Regarding the panicle length, which is directly related to the number of grains, the results of combined analysis of statistical data during two consecutive years of experiment showed that the effect of micronutrient fertilizer foliar application treatment on the length of panicle was not significant (Table 4). This was while the interaction effect of foliar application and year also had no significant influence. Also, according to the results of comparing the two-year average of the data, the highest cluster length was related to T3 (30.8 cm) and the lowest was related to the control (28.1 cm) (Fig. 1f). It seems that increasing the transfer of nutrients and minerals and increasing the productivity of these elements along with regulating plant hormone levels, enhancement of cell division due to increasing concentration of plant growth regulators within plant tissue has a significant influence on cluster length in micronutrient foliar application treatments. Also in a similar study by Zayed et al. (2013) reported that plant dry weight, leaf area index, chlorophyll content along with plant height and cluster length showed a significant increase compared to the control after receiving micronutrients.

According to the outlets, there was a significant difference (at the level of 1% probability) between plant dry weight of foliar and control treatments as a result of combined analysis (Table 4). The highest plant dry weight was related to T5 and the lowest amount was related to the control (Fig. 1g). Obviously, increasing plant dry weight is directly related to increasing plant height, increment of the number of tillers per plant and also increasing the volume of the root system, which can be caused by improving the growth rate of rice plant as a result of receiving micronutrients through leaf that affect the plant metabolism. In a search in the present study, Hossein Abadi et al. (2006) also reported that the results showed that micronutrients can only partially increase plant dry weight by improving growth conditions and affecting wheat yield.

**Leaf greeness**
The difference in leaf color diagram number was significant according to the results of combined analysis of variance at the level of 1% probability (Table 4). But the interaction of foliar application and year was not significant for this trait. Based on the results of comparing the average data during two years, T4 (number 3.84) had the highest number of leaf color diagram for Shiroodi cultivar and the lowest value was related to the control (number 2.5) (Fig. 1h). The facilitating processes related to nitrogen metabolism, improving the rate of decomposition and synthesis, as well as accelerating nitrogen reduction reactions are some of the factors that have contributed to the significance of leaf color diagram in foliar spraying treatments compared to the control. The results indicate an increase in the productivity of basal nitrogen fertilizers that used in the investigation. In this regard, Maralian et al. (Maralian et al., 2008) also reported that micronutrient foliar application had a significant effect on traits such as LCC, number of tillers and number of fertile tillers at a probability level of 1 percent.

Grain yield and its yield components

Total grain yield was significantly lower (at the level of 1% probability) compared to micronutrient treatments when nutrients were not used (Table 4). This trend was similar to the statistical results on traits such as number of tillers and number of panicles per plant. However, there was no significant difference between grain yield of micronutrient treatments. The comparison of the biennial average of the data showed that the highest grain yield was related to T4 (4257 kg / ha) with four sprays and the lowest was related to the control (3499 kg / ha) (Fig. 1i). In connection with the effective factors in increasing the grain yield of rice plants, in which the foliar application of micronutrients may have played a direct role, it can be facilitated by the inoculation process, which is manganese roles, grain formation and maturation which boron is effective, activation of enzymes responsible for protein synthesis which is zinc role. Furthermore, facilitate the reduction of nitrate and sulfate processes, which are the role of iron, and to accelerate the metabolism of carbohydrates in which copper is effective. In this regard, Mahendra et al. (2017) stated that the application of zinc sulfate significantly affected the number of tillers, plant height, number of seeds per panicle, 1000-seed weight, harvest index and biological yield. There has also been a significant increase in the availability of primary and secondary macronutrients.

The 1000-grain weight was also affected by zinc, iron, manganese, boron and copper and a significant difference was observed between foliar and control treatments at the level of 1% probability (Table 4). Also, the interaction effect of foliar application and year showed a significant difference. In this regard, comparison of data averages over the two years showed that the highest 1000-grain weight was related to T4 with (29.8 gr) and the lowest was related to control (25 gr) (Fig. 1j). It is likely that increasing the productivity of macronutrients in which iron, boron and manganese directly affect, and increasing the fertility of clusters, have played the largest role in enhancing the 1000-grain weight and significance of micronutrient treatments. In this regard, Hosseinzadeh et al. (2012) also reported that in the study of micronutrient foliar application time, it was shown that foliar application time had a positive and significant effect on the number of filled grains per panicle, 1000-grain weight and maximum grain yield. The foliar application 40 days after transplanting had the greatest effect. In a investigation to study the effect of zinc on maize Sadeghi et al. (2017) reported that the comparison of the mean of treatments showed that with increasing the amount of element application, 1000-grain weight, the number of seeds per panicle, the amount of available Zn in corn grain, grain protein percentage and grain yield increased.

In this experiment, the effect of different times of micronutrients foliar application on the rice harvest index was significant at the level of 1% probability (Table 4). The highest harvest index was related to T4 (42%) which was not significantly different from other foliar spraying treatments. The lowest harvest index was related to the control (34%) (Fig. 1k). By affecting the yield-related indices and yield components of rice, it is obvious that the harvest index, which is directly related to grain yield, has also been affected by micronutrient spraying. Therefore, it is possible that increasing grain yield as well as 1000-grain weight had a direct influence on the significance of the harvest index. In this regard and in a similar study, Ghasemi et al. (2013) reported that the highest harvest index and maximum 1000-grain weight were obtained under the interaction of three factors for treatment with zinc, iron and manganese sulfate fertilizers.

Conclusion

The results revealed that the micronutrients application effect was significant about plant dry weight, grain yield, 1,000 grains yield and harvest index. Also, the interaction of the year and foliar application was significant about seed Zn content, chlorophyll b and 1,000 grains yield. According to statistical data, it can be concluded that T4 with 4257 kg/ha grain yield compare to control yield 3499.1 kg/ha that indicated 20 percentage approximate enhancement about foliar application treatments, four leaf spraying with 2 liters/1000 liters of water dosage of micronutrients could affect grain yield and yield components of rice (shiroodi cv) significantly through increasing the number of tillers/plant, improvement of panicle length and increasing the number of grains/panicle. The micronutrients supply through leaves is more effective procedure in the field of rice nutrition compare to soil application method due to higher absorption velocity. The substantial micronutrients supply through foliar application can be more effective nutritional procedure, due to the higher efficiency of this method compared to soil application of them. Due to the low mobility of micronutrients in the soil structure in results of the physicochemical constraints (like abnormal pH and EC in the most farms, which are due to improper use of soil-based fertilizers at the beginning and middle of the growing season), leaf spraying of essential nutrients is a determinative factor about plant nutrition and increment of the rice production.

Declarations

Ethical Approval and Consent to participate

Hereby, all of the participants approved the content and achievements of the investigation and, we will undertake the results responsibilities of the paper.

Consent for publication

We (the article authors) announce our complete consent for the survey and publication of the present paper in the Rice Journal.
Availability of supporting data

The corresponding author is responsible for providing the supplementary data and information for further process by editorial broad.

Competing interests

We approved that the paper content and achievements will not have any conflict with another investigation.

Funding

The authors confirmed that the participants did not receive any fund and financial support during the research procedure.

Authors’ contributions

The first author had determinative and operational role during the investigation implementation. The second and third authors had supervision role for the paper correct execution.

Acknowledgements

Not applicable

References


### Tables

#### Table 1- The farm soil analysis

<table>
<thead>
<tr>
<th>Soil texture</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>Mn (ppm)</th>
<th>Cu (ppm)</th>
<th>B (ppm)</th>
<th>Zn (ppm)</th>
<th>Fe (ppm)</th>
<th>Absorbable K (ppm)</th>
<th>Absorbable P (ppm)</th>
<th>OC (%)</th>
<th>Ca Carbonate (%)</th>
<th>pH</th>
<th>EC (ds/m)</th>
<th>Depth of sampling (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si-L</td>
<td>22</td>
<td>48</td>
<td>30</td>
<td>7.06</td>
<td>7.73</td>
<td>-</td>
<td>1.3</td>
<td>62</td>
<td>96</td>
<td>2.8</td>
<td>2.6</td>
<td>34</td>
<td>7.9</td>
<td>1.09</td>
<td>0.30</td>
</tr>
</tbody>
</table>

#### Table 2- The micronutrients liquid fertilizer analysis

- **Fe**: 0.1 (w/w%)
- **B**: 0.02 (w/w%)
- **Zn**: 0.05 (w/w%)
- **Cu**: 0.05 (w/w%)
- **Mn**: 0.05 (w/w%)

#### Table 3- The effect of micronutrients foliar application treatments on yield and yield attributes of rice (cv. *Shiroodi*)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>T0</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest index (%)</td>
<td>34.2b</td>
<td>34.9b</td>
<td>39.8a</td>
<td>40.4a</td>
<td>41.8a</td>
<td>40.7a</td>
<td>40.2a</td>
<td>41.8a</td>
</tr>
<tr>
<td>1,000 grains weight (gr)</td>
<td>3074.1e</td>
<td>3962.7d</td>
<td>3964.6c</td>
<td>4024.7b</td>
<td>4257a</td>
<td>4234ab</td>
<td>4224.5ab</td>
<td>4224.5ab</td>
</tr>
<tr>
<td>Grain yield (kg.ha⁻¹)</td>
<td>0.304c</td>
<td>0.313c</td>
<td>0.258d</td>
<td>0.334c</td>
<td>0.429a</td>
<td>0.373b</td>
<td>0.373b</td>
<td>0.338bc</td>
</tr>
<tr>
<td>Carotenoid (mg.g⁻¹fwt)</td>
<td>0.91c</td>
<td>1.08b</td>
<td>0.93c</td>
<td>0.98bc</td>
<td>1.42a</td>
<td>1.33ab</td>
<td>0.88d</td>
<td>0.91c</td>
</tr>
<tr>
<td>Chlorophyll b (mg.g⁻¹fwt)</td>
<td>0.36d</td>
<td>0.35d</td>
<td>0.29e</td>
<td>0.39cd</td>
<td>0.56a</td>
<td>0.46bc</td>
<td>0.47b</td>
<td>0.39d</td>
</tr>
<tr>
<td>Chlorophyll a (mg.g⁻¹fwt)</td>
<td>2.54d</td>
<td>3.52abc</td>
<td>3.43bc</td>
<td>3.78ab</td>
<td>3.83a</td>
<td>3.51abc</td>
<td>3.80a</td>
<td>3.50abc</td>
</tr>
<tr>
<td>Leaf greenness</td>
<td>38.4a</td>
<td>40.3a</td>
<td>43.2a</td>
<td>39.6a</td>
<td>43.7a</td>
<td>41.4a</td>
<td>43.7a</td>
<td>41.8a</td>
</tr>
<tr>
<td>Plant dry weight (kg)</td>
<td>28.1b</td>
<td>28.3b</td>
<td>28.7b</td>
<td>30.8a</td>
<td>28.2b</td>
<td>28.9ab</td>
<td>28.9ab</td>
<td>28.9ab</td>
</tr>
<tr>
<td>Panicle length (cm)</td>
<td>142.7d</td>
<td>151bc</td>
<td>147.4c</td>
<td>153.3ab</td>
<td>156.8a</td>
<td>154.2ab</td>
<td>151.2bc</td>
<td>156.8a</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>62.98d</td>
<td>61.76c</td>
<td>63.88c</td>
<td>65.02b</td>
<td>65.11b</td>
<td>67.02a</td>
<td>67.02a</td>
<td>66.87a</td>
</tr>
<tr>
<td>Seed Zn content (mg.kg⁻¹)</td>
<td>52.98d</td>
<td>61.76c</td>
<td>63.88c</td>
<td>65.02b</td>
<td>65.11b</td>
<td>67.02a</td>
<td>67.02a</td>
<td>66.87a</td>
</tr>
</tbody>
</table>

#### Table 4- The combined analysis of the effects of micronutrients foliar application on yield and plant traits of *Shiroodi* rice cultivar over two years
<table>
<thead>
<tr>
<th>s.o.v</th>
<th>df</th>
<th>mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Seed Zn content</td>
</tr>
<tr>
<td>Year</td>
<td>1</td>
<td>29.72**</td>
</tr>
<tr>
<td>eRROR 1</td>
<td>4</td>
<td>2.23</td>
</tr>
<tr>
<td>Foliar application</td>
<td>7</td>
<td>1619.57**</td>
</tr>
<tr>
<td>FA*Year</td>
<td>7</td>
<td>18.16**</td>
</tr>
<tr>
<td>ERROR 2</td>
<td>28</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>C.V (%)</td>
<td></td>
<td>4.8</td>
</tr>
</tbody>
</table>

ns, *, and **= not significant, significant at P level of 0.05 and 0.01, respectively.