

## Original Research Article

EFFECT OF BORON ZINC AND IRON ON GROWTH AND YIELD OF SUMMER

MAIZE

### Abstract

The field experiment was conducted during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 6.9), available N (278.93 kg/ha), available P (10.8 kg/ha) and available K (206.4 kg/ha). The experiment was laid out in Randomized Block Design with 9 treatments each replicated thrice on the basis of one year experimentation. The results showed that application of Boron 0.6% + Zinc 25 kg/ha + Iron 25 kg/ha in treatment no. 8 was recorded significantly maximum plant height (205.79 cm), Plant dry weight (179067 g/plant), Crop growth rate (28.11 g/m<sup>2</sup>/day), No. of leaves/plant (13.93), No. of cob/plant (2.07), No. of row/cob (14.67), No. of seeds/row (26.00), Test weight (238.0 g), Grain yield (5.40 t/ha), Straw yield (9.60 t/ha), Harvest index (35.97), Gross returns (122400.0 INR/ha), Net return (77210.0 INR/ha) and benefit cost ratio (1.71) as compared to other treatments.

Comment [A1]: The experimental

Comment [A2]: based on

**Key word:**-Boron, Zinc, Iron Growth, Yield

### Introduction

After rice and wheat, maize (*Zea mays* L.) is one of the most significant cereal crops and plays a significant role in world agriculture. In India, it comes in third behind rice and wheat. It is produced in India for grain, for human consumption, as a component of poultry and cow feed, as well as for other industrial uses. One of the most important and strategically important crops in the world is maize, commonly known as maize. Mexico is where it first appeared. (Central America). Due to its significant role in the diets of humans and animals as well as its high yielding capacity, it is known as the "queen of cereals." It is known as a "Miracle Crop" because it effectively uses solar energy and has a tremendous potential for better output. The provision of food is greatly aided by maize. (Dragana *et al.* 2015).

Comment [A3]: One of the world's most important and strategically important crops is maize.

Additionally, boron is not translocated to new growth and is quite static in plants, although it is very mobile in soil. Sinha *et al.* (2009) Although boron decreased the concentration of starch, protein in seeds and storage organs, ascorbic acid in tomato fruits, and oil in oil seeds, the economic yield was decreased and the product's quality degraded. Boric acid, which directly improves a number of plant development features, can be applied topically to address deficits. (Zhang, 2009; Ahmad *et al.* 2012) [23, 2].

Comment [A4]: and the product decreased's quality degraded.

One of the most crucial micronutrients for the growth of numerous agricultural plants, including the widely grown rice, maize, and wheat, is zinc. Scientists are well aware that zinc has an impact on a variety of mechanisms that control the life cycles of plants. Enzymatic activity, auxin production, carbohydrate metabolism, and protein synthesis are a few metabolic activities that are critical for plant

growth and, consequently, for the effective regulation of nitrogen metabolism. Additionally, zinc activity effectively regulates a variety of physiological processes, such as pathogen pressure, heat, or drought, which increases growing plants' resilience to biotic and abiotic challenges.(Grzebisz *et al.*, 2008).

Additionally, iron is a necessary component of many proteins and enzymes that are present during respiration and photosynthesis. Since iron is immobile in plants and its mobility declines with soil pH, an excess of phosphorus may result in a deficiency. Iron deficiency in crops, especially those grown on calcareous soils, is a serious nutritional condition that stunts vegetative growth and results in significant yield and quality losses.(Abadia *et al.* 2011).

**Comment [A5]:** Iron is also a necessary component of many proteins and enzymes present during respiration and photosynthesis.

## 2. MATERIALS AND METHODS

A field experiment was conducted during Zaid season 2022 at Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbotton University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh. The experiment laid out in Randomized Block Design which consist of nine treatment combinations and three replications. The treatments details are T<sub>1</sub>: 0.3% Boron + 20 kg/ha Zinc + 20 kg/ha Iron, T<sub>2</sub>: 0.3% Boron + 20 kg/ha Zinc + 25 kg/ha Iron, T<sub>3</sub>: 0.3% Boron + 25 kg/ha Zinc + 20 kg/ha Iron, T<sub>4</sub>: 0.3% Boron + 25 kg/ha Zinc + 25 kg/ha Iron, T<sub>5</sub>: 0.6% Boron + 20 kg/ha Zinc + 20 kg/ha Iron, T<sub>6</sub>: 0.6% Boron + 20 kg/ha Zinc + 25 kg/ha Iron, T<sub>7</sub>: 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron, T<sub>8</sub>: 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron, T<sub>9</sub>: Control R.D.F(N.P.K 120:60:60).The results were documented for a several growth characteristics, including plant height, No. of leaves/plant, plant dry weight and yield parameters like No. of cobs/plant, No. of row/cob, No. of grains/row, test weight, grain yield, stover yield and harvest index.

**Comment [A6]:** The experiment in Randomized Block Design consists of nine treatment combinations and three replications.

## 3. RESULTS AND DISCUSSION

### 3.1 Growth Attributes

#### 3.1.1 Plant height

At 100 DAS, treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron was recorded maximum plant height (205.79 cm), which are significantly superior over all the treatments, However it was followed by the treatment with application of 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron, 0.6% Boron + 20 kg/ha Zinc + 25 kg/ha Iron and 0.6% Boron + 20 kg/ha Zinc + 20 kg/ha Iron (201.28, 194.56 and 189.61) and there was significant difference among other treatments.

The plant height of maize was observed to be significantly increasing throughout all crop growth stages. This could be explained by the integrated use of the micronutrient zinc, which resulted in adequate and balanced nutrient supply to the crop at the right time and place. This promoted rapid vegetative growth, which produced more internodes and leaves, thereby increasing the plant height.

**Comment [A7]:** This promoted rapid vegetative growth, producing more internodes and leaves, increasing the plant height.

The findings and the results are very similar Kumar *et al.* (2019).

#### 3.1.2 Numbers of leaves/plant

At 100 DAS, treatment with the application of 06% Boron + 25 kg/ha Zinc + 25 kg/ha Iron through micronutrients was recorded maximum number of leaves per plant (13.94), which was significantly

superior over all the treatments. However, treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron and 0.6% Boron + 20 kg/ha Zinc + 25 kg/ha Iron (13.72 and 13.13) was statistically at par with treatment 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron through micronutrients.

The longer availability of plant nutrients was the cause of the increased number of leaves per plant at all growth stages. The micronutrient zinc's synergistic effects ensure that the plant receives enough nutrients throughout the growing season. The individual plants could have produced more leaves by efficiently utilising the resources available for plant growth. The application of micronutrients also resulted in an increase in the number of leaves per plant, as was amply demonstrated by **Chandrasekar *et al.* (2000)**.

### 3.1.3 Plant dry weight (g/plant)

At 100 DAS, treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron was recorded higher plant dry weight (179.67 g), which was significantly superior over all the treatments and there was statistical difference among application of 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron and 0.6% Boron + 20 kg/ha Zinc + 25 kg/ha Iron other treatment combinations.

The application of plant nutrients in conjunction with organic and inorganic substances made plant nutrients available throughout the growth season, increased plant height, the number of leaves per plant, and total leaf area, and ultimately enhanced the production of dry matter. **The increase in leaf count may have improved the efficiency of maize's photosynthetic process and led to the production of more plant dry matter.** This was consistent with the earlier results of **Barbara *et al.* (2018)**, **Latha *et al.* (2011)** and **Ravichandra (2015)**.

**Comment [A8]:** The increase in leaf count may have improved the efficiency of maize's photosynthetic process and produced more plant dry matter.

## 3.2 Yield Attributes and Yield

### 3.2.1 Number of cobs/plant

Treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron through Inorganic fertilizers was recorded maximum number of cobs per plant (2.07), which was significantly superior over all the treatments. However, treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron and 0.6% Boron + 20 kg/ha Zinc + 25 kg/ha Iron through Inorganic fertilizers (1.97 and 1.92) and control plot receiving recommended dose of fertilizers (1.09) were statistically at par with treatment 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron.

A large amount of biomass was eventually accrued, and a large portion of assimilates were partitioned to the sink thanks to the application of nutrient sources in combination with foliar applications of zinc and boron. This resulted in improved yield structures (cobs), as demonstrated by all of the yield attributes. The finding of **Nadeem *et al.* (2014)** confirmed these results.

### 3.2.2 No. of row/cob

Treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron was recorded maximum number of row per cob (14.67), which are significantly superior over all the treatments. However the treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron and 0.6%

Boron + 20 kg/ha Zinc + 25 kg/ha Iron (14.33 and 13.67) was statistically at par with treatment 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron.

Utilizing plant nutrients from both organic and inorganic sources wisely has a positive impact on physiological The growth and yield processes then improve yield characteristics like the number of grains per row of maize. Similar outcomes were obtained by **Varalakshmi et al. (2005)**.

### 3.2.3 Number of seeds/row

Treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron was recorded maximum number of seeds per row (26.00), which are significantly superior over all the treatments. However treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron and 0.6% Boron + 20 kg/ha Zinc + 25 kg/ha Iron (24.00 and 23.33) was statistically at par with treatment 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron.

Integrated nutrition supply consistently improved yield parameters. (**Raikar et al., 2009**). Due to earlier absorption of macro- and micronutrients and their larger concentration, photosynthesis is better distributed to reproductive parts, resulting in enhanced growth and yield qualities. **Prakash et al. (2018)** also reported similar findings.

### 3.3 Test weight (g)

The test weight of maize (238.00) was recorded significantly higher the application of 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron. However the treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron and 0.6% Boron + 20 kg/ha Zinc + 25 kg/ha Iron had recorded (233.33 and 229.67) which were found significantly at par with treatment 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron.

The simulated effect of the combined administration of micronutrient fertilisers and zinc on cell proliferation and expansion is what causes the increase in cob length and girth. (**Mohsin et al. 2008**). The balanced supply of nutrients from micronutrients in combination with inorganic fertilisers during the grain filling and development stage is primarily responsible for the increase in 1000 grain weight. (**Manasa et al. 2015**).

### 3.4 Grain yield (t/ha)

Treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron was recorded higher grain yield (5.40 t/ha), which was significantly superior over all the treatments combinations.

Micronutrients are superior because they can supply nutrients in soluble form for a quiet longer time by preventing the entire soluble form from solution from coming into contact with soil and other inorganic constituents, which minimises fixation and precipitation. Additionally, plant roots can effectively compete with loss mechanisms and absorb more nutrients, which results in better yield. Similar results were obtained by (**Moghazy et al. 2014**).

### 3.5 Stover yield (t/ha)

Treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron was recorded higher stover yield (9.60 t/ha), which was significantly superior over all the treatments. However, treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron (9.45 t/ha), 0.6% Boron + 20 kg/ha Zinc + 25 kg/ha Iron (9.09 t/ha ) and 0.6% Boron + 20 kg/ha Zinc + 20 kg/ha Iron (8.65 t/ha) were statistically at par with treatment 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron.

### 3.6 Harvest index (%)

Treatment with the application of 0.6% Boron 25 kg/ha Zinc + 25 kg/ha Iron was recorded higher harvest index (35.97%), which was significantly superior over all the treatments. However, treatment with the application of 0.6% Boron + 25 kg/ha Zinc + 20 kg/ha Iron (35.38%), 0.6% Boron + 20 kg/ha Zinc + 25 kg/ha Iron (34.95%) and 0.6% Boron + 20 kg/ha Zinc + 20 kg/ha Iron (34.44%) were statistically at par with treatment 0.6% Boron + 25 kg/ha Zinc + 25 kg/ha Iron.

As a result of applying nutrients in combination, adequate biomass production, improved nutrient uptake, and improved yield metrics have led to increased yield. For maize to function well, the soil must be enriched with N and P in a form that is easily available. (Tariq *et al.* 2014).

**Comment [A9]:** For maize to function well, the soil must be enriched with N and P in an easily available form.

### 4. CONCLUSION

Based on the findings of the investigation it can be concluded that the foliar application of boron 0.6% and 25 kg/ha zinc along with 25 kg/ha iron (Treatment 8) was found to be more productive (5.40 t/ha) and commercially viable (1.71).

**Table 1. Influence of Boron, Zinc and Iron on Growth and Growth Attributes of Maize**

<b>S. No.</b>	<b>Treatments</b>	<b>Plant height (cm)</b>	<b>Leaves/plant</b>	<b>Plant dry weight (g/Plant)</b>
1.	0.3% Boron + 20kg/ha. Zinc + 20kg/ha. Iron	172.88	12.42	161.27
2.	0.3% Boron + 20kg/ha. Zinc + 25kg/ha. Iron	175.18	12.69	162.07
3.	0.3% Boron + 25kg/ha. Zinc + 20kg/ha. Iron	178.73	12.79	164.53
4.	0.3% Boron + 25kg/ha. Zinc + 25kg/ha. Iron	183.69	12.89	166.50
5.	0.6% Boron + 20kg/ha. Zinc + 20kg/ha. Iron	189.69	12.90	169.37
6.	0.6% Boron + 20kg/ha. Zinc + 25kg/ha. Iron	194.56	13.13	171.60
7.	0.6% Boron + 25kg/ha. Zinc + 20kg/ha. Iron	201.28	13.72	176.27
8.	0.6% Boron + 25kg/ha. Zinc + 25kg/ha. Iron	205.79	13.93	179.67
9.	120:60:60 kg/ha NPK (Control)	167.34	9.59	160.57
	<b>F Test</b>	<b>S</b>	<b>S</b>	<b>S</b>
	<b>SEm (±)</b>	6.96	0.5747	5.012
	<b>CD (P=0.05)</b>	20.89	1.72	15.03

**Table 2. Influence of Boron, Zinc and Iron on yield and yield attributes of maize.**

S. No.	Treatments	Cobs/Plant	Rows/Cob	Grains/row	Test weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1.	0.3% Boron + 20kg/ha. Zinc + 20kg/ha. Iron	1.18	12.20	21.33	207.87	4.01	8.38	32.14
2.	0.3% Boron + 20kg/ha. Zinc + 25kg/ha. Iron	1.31	13.00	21.67	211.13	4.13	8.49	32.67
3.	0.3% Boron + 25kg/ha. Zinc + 20kg/ha. Iron	1.48	12.97	22.33	216.83	4.22	8.66	32.82
4.	0.3% Boron + 25kg/ha. Zinc + 25kg/ha. Iron	1.71	13.33	22.67	221.83	4.42	8.73	32.62
5.	0.6% Boron + 20kg/ha. Zinc + 20kg/ha. Iron	1.82	12.67	23.00	225.00	4.70	8.95	34.44
6.	0.6% Boron + 20kg/ha. Zinc + 25kg/ha. Iron	1.92	13.67	23.33	229.67	4.90	9.09	34.95
7.	0.6% Boron + 25kg/ha. Zinc + 20kg/ha. Iron	1.97	14.33	24.00	233.33	5.20	9.45	35.38
8.	0.6% Boron + 25kg/ha. Zinc + 25kg/ha. Iron	2.07	14.67	26.00	238.00	5.40	9.60	35.97
9.	120:60:60 kg/ha NPK (Control)	1.09	12.03	20.33	207.03	3.92	8.52	31.90
	<b>F Test</b>	S	S	S	S	S	S	S
	<b>SEm (±)</b>	0.13	0.46	0.81	6.71	0.19	0.25	0.79

**CD (P=0.05)**

0.40

1.40

2.45

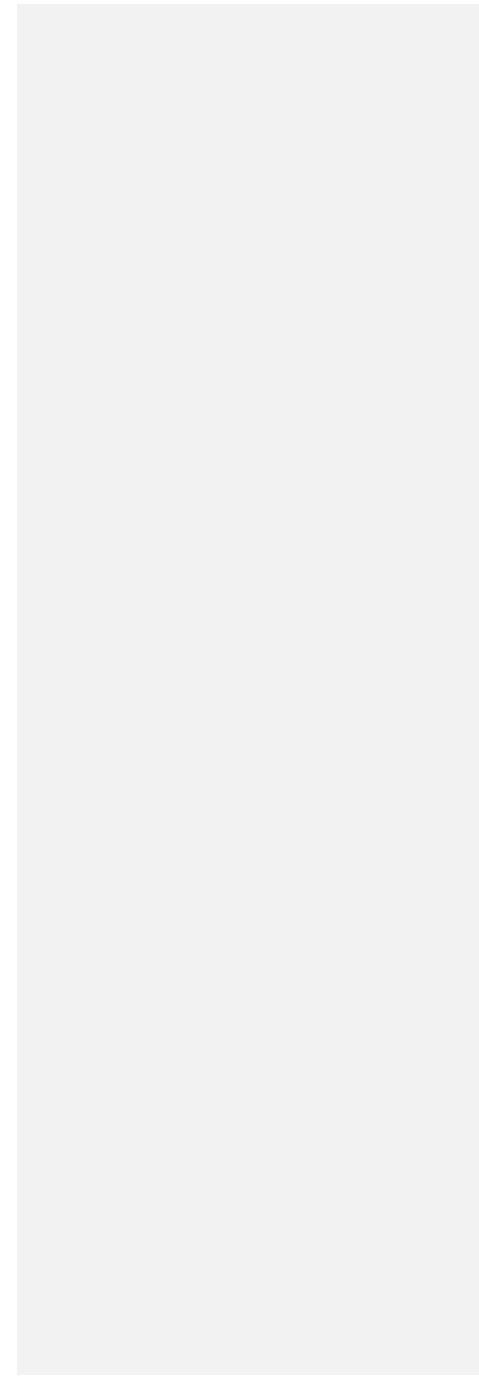
20.12

0.58

0.77

2.37

UNDER PEER REVIEW



## REFERENCES

Comment [A10]: Rewrite references in one format and according to the instructions of the journal

- Abadia J, Vazquez S, Rellan-Alvarez R, El-Jendoubi H, Abadia A, Alvarez-Fernandez A, et al. Towards a knowledge-based correction of iron chlorosis. *Plant physiology and Biochemistry*. 2011; **49**(5):471-482
- Ahmad A, Tahir M, Ullah E, Naeem M, Ayub M, Talha M. Effect of Silicon and Boron Foliar Application on growth and Yield and Quality of Rice. *Pakistan Journal of Life and Culinaris*. In *Social Sciences (Pakistan)*, 2012; 10(2):161-165.
- Barbara M Humtsoe, Joy Dawson, Praveena Rajana 2018. Effect of nitrogen, boron and zinc as basal and foliar application on growth and yield of maize (*Zea mays* L.). *Journal of Pharmacognosy and Phytochemistry*; **7**(6):1-4.
- Chandrasekar, V., Sairam, R.K., Srivastava, G.C., 2000. Physiological and biochemical responses of hexaploid and tetraploid wheat to drought stress. *Journal of Agronomy and Crop Science* **185**,209-227.
- Dragana, I.M., Jelena, V., Dejana, T., Zoran, D., Marija, K. and Sofija, B. 2015. Grain nutrient composition of Maize (*Zea mays* L.) drought tolerant populations. *Journal of Agricultural and Food Chemistry* **63**(4): 1251-1260.
- Grzebisz W., Wronska M., Diatta B., 2008. Effect of zinc foliar application on maize grain yield and its yielding components. *J. Elementol.*, **13** (1):17-28.
- Kumar, M., Singh, S., Singh, V., Singh, K., and Khanna, R. 2019. Effect of zinc and boron on growth and yield of maize. *Progressive Research – An International Journal Volume* **14** (3) : 215-221.
- Latha M.R., Savithri P., Indirani R., Kamaraj S. 2001. Influence of Zn enriched organic manures on availability of micronutrients in soil. *Madras Agricultural Journal.*; **88**.165-167. Manasa, L.P. and Devaranavadagi, 2015. Effect of foliar application of micronutrients on growth, yield and nutrient uptake of maize *Karnataka J. Agric. Sci.*, **28**(4):(474-476).
- Manasa, L.P. and Devaranavadagi, 2015. Effect of foliar application of micronutrients on growth, yield and nutrient uptake of maize *Karnataka J. Agric. Sci.*, **28**(4):(474-476).
- Moghazy AM, ElSaed SM, ElAwad SM. 2014. The influence of boron foliar spraying with compost and mineral fertilizers on growth, green pods and seed yield of pea. *Nature and Science*; **12**(7):50-57.
- Mohsin AU, Ahmad AUH, Farooq M, Ullah S. 2014. Influence of Zn application through seed treatment and foliar spray on growth, productivity and grain quality of hybrid maize. *J. Anim. Plant Sci.*; **24**(5):1494-1503.
- Nadeem, M., Tariq, A., Anjum, S.A., Randhawa, M. A., Ullah, E., Naeem, M., Qamar, R., Ashraf, U. and 2014. Influence of Zinc Nutrition on Growth and Yield Behaviour of Maize (*Zea mays* L.) Hybrids. *American J. pl. Sci.*, **5**:2646-2654.
- Prakash, P., Sharanappa and Nagaraju. 2018. Effect of Different Establishment Methods and Organic Nutrient Sources on Yield, Yield Attributes and Economics of Finger Millet (*Eleusine coracana* (L) Gaertn). *International Journal of Environmental Sciences and Natural Resources*. ISSN:2572-1119.

- Raikar, S.D., Vyakaranahal, B.S., Biradar, D.P. and Janagoudar, B.S. 2009. Effect of nutrient and pest management on seed yield and quality components in scented rice Cv. Mugad suganda. *Karnataka J. Agric. Sci.*, 22(1):61-67.
- Ravichandra K, Naga Jyothi CH, Jaipal Singh B, Joy Dawson, Krupakar A. 2015. Growth of groundnut (*Arachis hypogaea* L.) and its yield as influenced by foliar spray of boron along with rhizobium inoculation. *Indian Journal of Dryland Agricultural Research and Development*; 30(1):60-63.
- Sinha P, Khurana N, Nautiyal N. Boron stress influences economic yield and quality in crop species. *Indian Journal of Plant Physiology*. 2009; 14(2):200-204.
- Tariq, A., Anjum, S.A., Randhawa, M. A., Ullah, E., Naeem, M., Qamar, R., Ashraf, U. and Nadeem, M., 2014, influence of Zinc Nutrition on Growth and Yield Behaviour of Maize (*Zea mays* L.) Hybrids. *American J. pl. Sci.*, 5:2646-2654.
- Varalakshmi, L.R., Srinivasamurthy, C.A. and Bhaskar, S. 2005. Effect of integrated use of organic manures and inorganic fertilizers on organic carbon, available N, P and K in sustaining productivity of groundnut-finger millet cropping system. *J. Indian Soc. Soil Sci.* 53:315-318.
- Zhang J, Wang MY, Wu LH. Can foliar iron-containing solutions be a potential strategy to enrich iron concentration of rice grains (*Oryza sativa* L.). *Acta Agriculture Scandinavica Section B-Soil and Plant Science*. 2009; 59(5):389-394.