International Journal of Economic Plants 2022, 9(3):245-249

Full Research

Doi: HTTPS://DOI.ORG/10.23910/2/2022.IJEP0482

Effect of Different Methods of Zinc Application on Yield and Quality of *Rabi* Maize in West Tripura

Saurav Das[1*], Goutam Kumar Ghosh[2] and Debashish Sen[3]

[1]Dept. of Soil Science & Agricultural Chemistry, [3]Dept. of Agronomy, College of Agriculture, Tripura (799 210), India
[2]Dept. of Soil Science & Agricultural Chemistry, PSB, Sriniketan, Visva Bharati, West Bengal (731 236), India

Corresponding Author

Saurav Das
e-mail: sauravdas83@rediffmail.com

Article History

Article ID: IJEP0482
Received on 14th July, 2022
Received in revised form on 18th August, 2022
Accepted in final form on 27th August, 2022

Abstract

The present study was conducted at Experimental Farm, College of Agriculture, Tripura with an aim to find out the effect of different methods of Zn application on maize crop during *rabi* season of 2018–19 (November–February). The experiment was laid out in Randomized block design (RBD) and replicated three times. In this experiment, zinc was applied by three methods- soil, foliar and their combinations. Zinc was applied @ 10, 20 and 30 kg ha^{-1} in soil during sowing, while foliar application @ 1% Zinc was given during silking stage. Zinc was applied in the form of Zinc Sulfate in all the treatments. Recommended dose of fertilizer for maize crop @ 150:70:70 kg N, P_2O_5 and K_2O ha^{-1} were applied according to the treatment details. The application of zinc via soil and foliar @ 30 kg ha^{-1} and 1% $ZnSO_4$ recorded higher yield parameters such as number of cobs plant^{-1}, weight of cobs plant^{-1}, number of grains cob^{-1}, total weight of grains plant^{-1} and average 1000 grains weight etc. The increasing Zn rates also enhanced grain yield ha^{-1}, grain harvest index and zinc uptake in plant and maize grains in significant manner.

Keywords: Foliar, maize, *rabi*, soil, west tripura, zinc

1. Introduction

Maize (*Zea mays* L.) is one of the most adaptable emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals having highest genetic yield potential among the cerealswith wider diversity of soil, climate, biodiversity and management practices that contributes 36 % (782 mt) in the global grain production. The United States of America (USA) is the largest producer of maize contributes nearly 35% of the total production in the world and maize is the driver of the US economy (Mohanty and Swain, 2018). The USA has the highest productivity (>9.6 t ha^{-1}) which is double than the global average (4.92 t ha^{-1}). Whereas, the average productivity in India is 2.43 t ha^{-1}. In India, maize is the third most important food crops after rice and wheat. In India, maize is cultivated in 9.09 mha with a production of 23.29 mt and productivity of 2563 kg ha^{-1} (Anonymous, 2014). In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as acomponent to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. As a common staple food, fuel, and feed, maize (*Zea mays* L.) yields have continued to increase (Duvick, 2005; Nuss and Tanumihardjo, 2010).

Among the micronutrients, zinc is most crucial amongst the micronutrients that play a part in maize which is highly responsive to Zn fertilization (Benton Jones, 2003). Deficiency of Zn in soil causes deficiency in crops and on the whole, this has become problem all over the world with acute zinc deficit ranges in arid to semi-arid regions of the world (Rashid and Ryan, 2004). Many studies have confirmed that the maize grain yield increases significantly with the application of Zn fertilizer to Zn-deficient soils (Potarzycki, 2010; Liu et al., 2017). Moreover, Zn input has much less attention than Nitrogen (N), Phosphorus (P), or irrigation during the green revolution (Tilman et al., 2002; Mueller et al., 2012).

Zn plays a vital role in plants essential system such as it plays roles in nitrogen metabolism and results in improving protein quality, it also plays a most important role in protein synthesis and photosynthesis (Cakmak, 2008). Sadeghzadeh (2013) stated that zinc is essential for the normal, healthy growth and reproduction of plants. Furthermore, Zn is also responsible in formation of chlorophyll and also make the most of the biosynthesis of carotenoids, chlorophyll and eventually helpful for the photosynthetic mechanism of the plant (Aravind and Prasad, 2003). Zn is required as a structural component of a large number of proteins, such as transcription factors and metalloenzymes (Figueiredo et al., 2012).

Various technique of Zn application to crops such as soil, foliar sprays and seed treated with Zn dusting, fertigation seed priming in nutrient solution and root dipping in the nutrient solution etc are most common. Amongst these methods, foliar spray of Zn is the most efficient method. Wilhelm et al. (1988) and Savithri et al. (1999) reported that foliar application is a simple method for rapid development of plant nutritional status of maize. Deficiency of Zn has been reported from various parts of the world, Indian soils are not exception to this. Almost 50% soil of the world which are used for cereal production are Zn deficient. Zn deficiency is the most widespread micronutrient deficiency in the world (Fageria, 2002).

Bashir et al. (2012) reported that the foliar application of zinc resulted in maximum plant height of maize. Both the soil and foliar application enhanced Zn concentration and uptake in crop grain (Yilmaz et al., 1998). Denre et al. (2017) stated that application of Zinc fertilizer enhanced Zn contents and uptake in rice plant at maturity. Malakouti (2008) reported that quality and yield of crops is improved by soil and or foliar application of micronutrients.

In Tripura, zinc content of soils is moderately low in content with pH value ranging from 4.05–6.05 and in more than 90% of the soil of Tripura, pH is below 5.6. Maize is the third most grown crops in the state of Tripura. Keeping this point in view, present investigation was conducted to find out best combination of organic and inorganic fertilizers along with zinc for maximum production of maize with higher income level in sustainable manner without affecting the soil qualities.

2. Materials and Methods

The present work was conducted at Experimental Farm, College of Agriculture, Tripura, India in order to find out the effect of different methods of Zn application on maize crop during *rabi* season of 2018–19 (November–February). It is located at 23.54°N latitude, 91.19°E longitude and an altitude of 35 m above mean sea level. The experiment was carried out in RBD design with three replications. The plot size was 5×4 m, plant to plant distance was 20 cm and row to row distance was 60 cm. Maize seeds were sown with the help of drill. In the experiment, Zn application was done by three methods i.e., soil application, foliar application and their combination. Zn in the form of zinc sulfate was used in all the treatments, while recommended dose of fertilizer for maize crop (150:70:70 kg N, P_2O_5, K_2O ha^{-1}) were applied according to the treatment details. Nitrogen in the form of urea, phosphorus in the form of single super phosphate (SSP), potassium in the form of muriate of potash (MOP) were applied. N was applied in four equal splits. Irrigation was regularly given and all the cultural practices including weeding, thinning and hoeing were performed.

Table 1: Treatment details

T_1	NPK+Zn as $ZnSO_4.7H_2O$ @ 10 kg ha^{-1} as soil application
T_2	NPK+Zn as $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} as soil application
T_3	NPK+Zn as $ZnSO_4.7H_2O$ @ 30 kg ha^{-1} as soil application
T_4	NPK+Zn as $ZnSO_4.7H_2O$ @ 30 kg ha^{-1} as soil application+Foliar spray @ 1% ZnSO4.7 H_2O
T_5	NPK+Zn as $ZnSO_4.7H_2O$ @ 10 kg ha^{-1} as soil application+FYM @ 10 t ha^{-1}
T_6	NPK+Zn as $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} as soil application+FYM @ 10 t ha^{-1}
T_7	NPK+Zn as $ZnSO_4.7H_2O$ @ 30 kg ha^{-1} as soil application+FYM @ 10 t ha^{-1}
T_8	NPK+Zn as $ZnSO_4.7H_2O$ @ 30 kg ha^{-1} as soil application+Foliar spray @ 1% ZnSO4.7 H_2O+FYM @ 10 t ha^{-1}
T_9	Control (no Zn, only NPK)

2.1. Yield and yield parameters

For post-harvest studies, five randomly selected plants from each plot were harvested separately and then averaged from yield parameters such as number of cobs plant^{-1}, number of grains cob^{-1}, weight of grains cob^{-1}, 1000-grain weight. Grain yield net plot^{-1} were recorded and then calculated for ha.

2.2. Quality parameters

2.2.1. Plant analysis

Treatment wise plant samples were collected at maturity for chemical estimation. The leaves, stems and grains were dried in an oven and then ground thoroughly in a willey mill to pass through a 30-mesh sieve. These were preserved in sealed and labeled containers for chemical analysis. Zinc in maize was determined in digested sample using atomic absorption spectrophotometer (Perkin Elmer, 2380).

2.2.2. Statistical analysis

The data was statistically analyzed using analysis of variance appropriate for RBD design and the means was compared using LSD test at 0.05 significance level of probability (Steel and Torrie, 1984).

3. Results and Discussion

Before conducting experiment, different soil physico-chemical characteristics were determined. For this purpose, soil samples from the depth of 0–15 and 15–30 cm were randomly collected from the field (Table 2).

3.1. Biometric observations

3.1.1. Yield parameters

3.1.1.1. Number of cobs plant^{-1}

The data regarding effect of sources and methods of zinc application on number of cobs plant^{-1} in maize is presented

Table 2: Soil chemical properties before maize sowing

Soil properties	2018	2019
Soil depth	0–15 cm	0–15 cm
Soil pH	4.18	4.68
Organic carbon (%)	0.66	0.74
Available nitrogen (kg ha^{-1})	213.74	243.52
Available phosphorus (kg ha^{-1})	24.75	25.04
Available potassium (kg ha^{-1})	103.25	104.36
DTPA ext. Zn (mg kg^{-1})	1.44	1.47

in Table 3. Data showed that number of cobs $plant^{-1}$ were significantly affected by Zn application. The highest being the treatment T_8 which received Zn @ 30 kg ha^{-1}+Foliar spray @ 1% $ZnSO_4.7\ H_2O$. This could be due to application of zinc both in soil and foliar spray. The number of grains cob^{-1} in all the treatments were increased by Zn application in the form of $ZnSO_4$ (Singh et al., 2021).

3.1.1.2. Weight of cobs plant^{-1} (g)

Table 3 shows that weight of grains cob^{-1} (g) was significantly affected with application of different levels of zinc. Among different levels of treatment, application of NPK+Zn as $ZnSO_4.7\ H_2O$ @ 30 kg ha^{-1} as soil application+Foliar spray @ 1% $ZnSO_4.7\ H_2O$+ FYM @10 t ha^{-1} resulted in higher weight of cobs (238.85 g).

3.1.1.3. Number of grains cob^{-1}

The number of grains cob^{-1} varied in the order of $T_8>T_5>T_6>T_7>T_1>T_4>T_2>T_3>T_9$, while the number of grains cob^{-1} ranged from 295.64–428.14. Zn applied by soil & foliar spray yielded maximum number of grains. The number of grains cob^{-1} in all the treatments were increased by Zn application in the form of $ZnSO_4$ (Singh et al., 2021). The number of grains cob^{-1} is considered as a most sensitive element of maize yield to environmental influences.

Table 3: Effect of Zn application on yield parameters of maize

Treatments	Number of cobs $plant^{-1}$	Weight of cobs $plant^{-1}$ (g)	Number of grains cob^{-1}	Total weight of grains $plant^{-1}$ (g)	Average 1000-grains weight
T_1	1.85	222.64	380.28	181.25	476.54
T_2	1.86	228.35	374.18	183.76	491.10
T_3	1.84	229.16	367.89	184.67	502.18
T_4	2.13	235.81	379.73	189.65	499.43
T_5	2.19	231.80	409.32	183.58	448.49
T_6	2.19	233.47	398.36	187.35	470.30
T_7	2.49	235.30	398.24	192.34	482.97
T_8	2.65	238.85	428.14	198.21	462.95
T_9	1.73	198.70	295.64	160.32	542.28
CD (p=0.05)	0.67	4.67	14.57	3.88	NS

3.1.1.4. Total weight of grains plant^{-1} (g)

Data regarding total weight of grains is presented in Table 3. The results exhibited that total weight of grains was significantly affected by Zn application. Highest value of thousand grains weight was noted in treatment which received Zn in soil & foliar application (1% $ZnSO_4$), while lowest value was recorded from control. The maximum thousand grain weight found was due to increase in Zn fertilizer because Zn stimulates metabolic processes in seed (Sharma et al., 2013).

3.1.1.5. Average 1000-grains weight

The results for number of grains ear^{-1} are shown in Table 3. The findings showed that average 1000 grains weight was not significantly affected by Zn application. The maximum 1000 grains weight was obtained from treatment interactions (soil+foliar), whereas minimum 1000 grains weight was found in control. Similar results were obtained by Liu et al. (2020), where zinc sulphate increased the 1000-grain weight.

3.1.1.6. Average grain yield ha^{-1}(t)

Application of different levels & methods of zinc had a significant effect on average grain yields ha^{-1} (t) (Figure 1). The increase in grain yield ha^{-1} was probably due to a greater number of grains cob^{-1}, number of cobs $plant^{-1}$, more 1000 grains weight etc. Arya and Singh (2001) reported that the grain yield, stover yield, plant height, leaf area index and dry matter accumulation were highest with the application of 30 kg $ZnS0_4$ ha^{-1}

3.1.1.7. Harvest index in maize

It is observed from the data (Figure 2) that zinc level significantly influenced the harvest index during both the years. The harvest index (%) varied from 31.45–45.52. The highest value of harvest index (55.52%) was recorded when crop fertilized with $ZnSO_4.7\ H_2O$ @ 30 kg ha^{-1}. Arya and Singh (2000) found that Zn at 30 kg ha^{-1} recorded significantly higher harvest index compared with their lower doses.

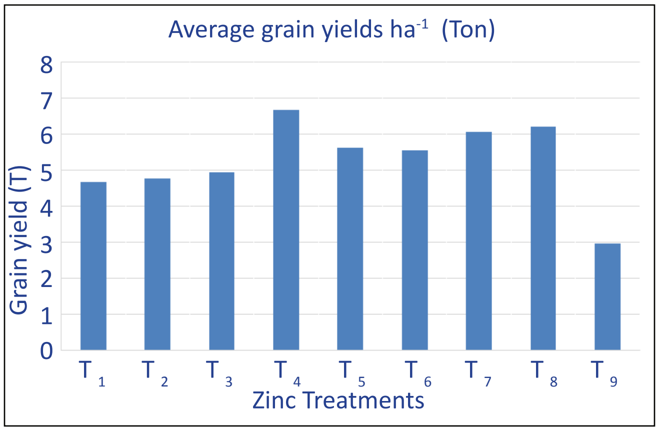

Figure 1: Effect of sources and methods of zinc application on average grain yields ha^{-1} (t) in maize

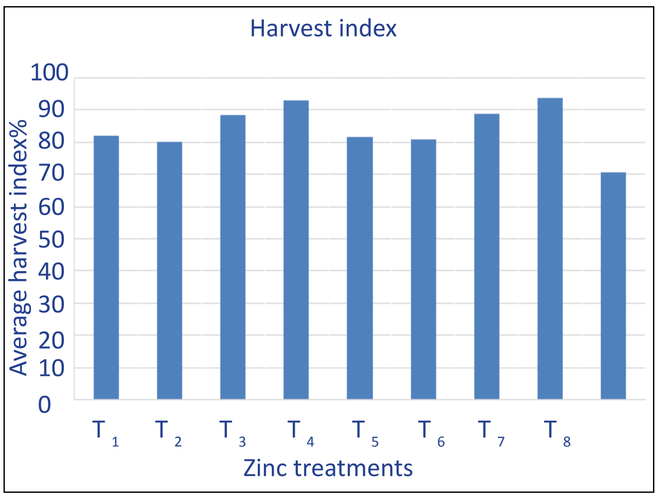

Figure 2: Effect of sources and methods of zinc application on average harvest index in maize

3.1.2. Quality parameters

3.1.2.1. Zinc concentration (mg kg^{-1}) in maize grains

The results (Figure 3) revealed that the highest value of uptake of Zn by maize grain was recorded to be 25.82 mg kg^{-1} in the treatment T_8 whereas, the lowest value of uptake of Zn by rice grain of 21.56 mg kg^{-1} was recorded in the treatment T_9 where NPK was applied as recommended but no zinc doses were applied. The results of the present study are also confirmed by the findings of Karak et al. (2006) who showed that a significant positive correlation with Zn uptake by grain and the amount of Zn applied.

3.1.2.2. Zinc content in maize plant

The results (Figure 4) revealed that the highest value of uptake of Zn in maize plant was recorded to be 93.54 mg kg^{-1} in the treatment T_8 at maturity stage of crop growth whereas, the lowest value of uptake of Zn 70.75 mg kg^{-1} was recorded in the treatment T_9 where NPK was applied as recommended but no zinc doses were applied. This could be due to the application of Zinc through soil and foliar application in T_8.

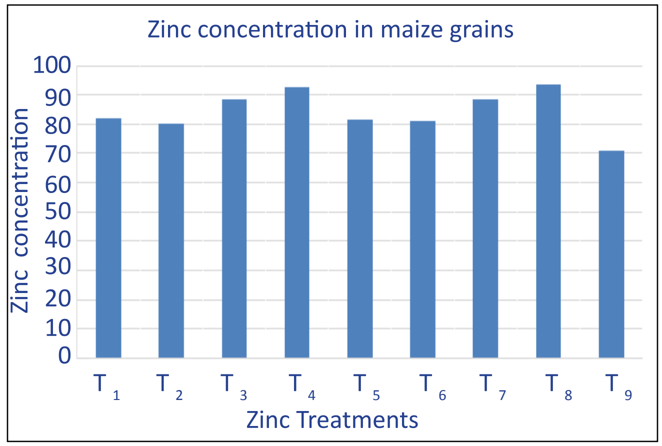

Figure 3: Effect of different levels of various fertilizers on zinc concentration (mg kg^{-1}) in maize grains

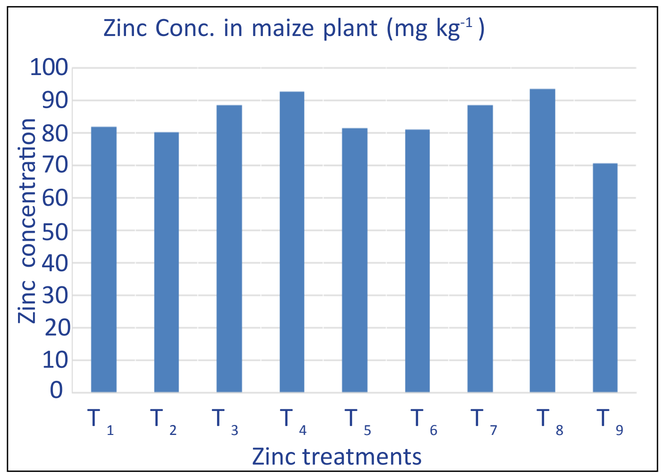

Figure 4: Effect of different levels of various fertilizers on zinc content in maize plant

4. Conclusion

Application of higher level of nitrogen and zinc gradually increased yield attributes and quality of maize. The combined application of NPK & Zn as $ZnSO_4.7H_2O$ @ 30 kg ha^{-1} as soil application+Foliar spray @ 1% $ZnSO_4.7H_2O$+FYM @ 10 t ha^{-1} is much better than their alone application. Hence Zn application by soil and foliar method not only significant for vegetative growth but also increases grain value for human needs.

5. Acknowledgement

The authors wish to thanks College of Agriculture, Tripura for providing lab facility and special thanks to his supervisor & co-supervisor for support and encouragement.

6. References

Anonymous, 2014. Annual Report 2013–2014. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, Krishibhawan, New Delhi, 37.

Aravind, P., Prasad, M.N.V., 2003. Zinc alleviates cadmium induced toxicity in *Ceratophyllum demersum* L.: A fresh

water macrophyte. Plant Physiology and Biochemistry 41(4), 391–397.
Arya, K.C., Singh, S.N., 2000. Effect of different levels of phosphorus and zinc on yield nutrient uptake of maize (*Zea mays* L.) with and without irrigation. Indian Journal of Agronomy 45(4), 717–721.
Arya, K.C., Singh, S.N., 2001. Productivity of maize (*Zea mays* L.) as influenced by different levels as phosphorus, zinc andirrigation. Indian Journal of Agricultural Sciences 71(1), 57–59.
Bashir, F., Maqsood, M., Sarwar, N., Ali, H., Mubeen, K., Shehzad, M.A., 2012. Effect of foliar application of zinc on yield and radiation use efficiency (RUE) of maize (*Zea mays* L.) under reduced irrigation conditions. Asian Journal of Pharmaceutical and Biological Research 2(1), 33–39.
Benton Jones, J.J., 2003. Agronomic Handbook. CRC Press, Boca Raton, 17–227.
Cakmak, I., 2008. Enrichment of cereal grains with zinc: Agronomic or genetic biofortification. Plant and Soil 302, 1–17.
Denre, M., Kumar, A., Prasad, R., Agarwal, B.K., Shahi, D.K., 2017. Effect of zinc application on Zn content and uptake in grain, husk and straw of hybrid rice (*Oryza sativa* L.). International Journal of Plant & Soil Science 18(1), 1–6.
Duvick, D.N., 2005. The contribution of breeding to yield advances in maize. Advances in Agronomy 86, 83–145.
Fageria, N.K., 2002. Influence of micronutrients on dry matter yield and interaction with other nutrients in annual crops. Pesquisa Agropecuaria Brasileira 37(12), 1765–1772.
Figueiredo, D.D., Barros, P.M., Cordeiro, A.M., Serra, T.S., Lourenco, T., Chander, S., Oliveira, M.M., Saibo, N.J., 2012. Seven zinc-finger transcription factors are novel regulators of the stress responsive gene OsDREB1B. Journal of Experimental Botany 63, 3643–3656.
Karak, T., Das, D.K., Maiti, D., 2006. Yield and zinc uptake in rice as influenced by sources and times of zinc application. Indian Journal of Agricultural Science 76(6), 346–348.
Liu, D., Zhang, W., Yan, P., Chen, X., Zhang, F., Zou, C., 2017. Soil application of zinc fertilizer could achieve high yield and high grain zinc concentration in maize. Plant and Soil 411(1–2), 47–55.
Liu, D.Y., Zhang, W., Liu, Y.M., Chen, X.P., Zou, C.Q., 2020. Soil application of zinc fertilizer increases maize yield by enhancing the kernel number and kernel weight of inferior grains. Frontiers in Plant Science 11, 188.
Malakouti, M.J., 2008. The effect of micronutrients in ensuring the efficient use of macronutrients. Turkish Journal of Agriculture and Forestry 32(3), 215–220.
Mohanty, S.K., Swain, M.R., 2018. Bioethanol production from corn and wheat: Food, fuel, and future. In: Ray, R., Ramachandran, S. (Eds.). Bioethanol Production from Food Crops (1st Edn.). Elsevier, 45–49.
Mueller, N.D., Gerber, J.S., Johnston, M., Ray, D.K., Ramankutty, N., Foley, J.A., 2012. Closing yield gaps through nutrient and water management. Nature 490, 254–257.
Nuss, E.T., Tanumihardjo, S.A., 2010. Maize: A paramount staple crop in the context of global nutrition. Comprehensive Reviews in Food Science and Food Safety 9(4), 417–436.
Potarzycki, J., 2010. The impact of fertilization systems on zinc management by grain maize. Fertilizers and Fertilization 39, 78–89.
Rashid, A., Ryan, J., 2004. Micronutrient constraints to crop production in soils with Mediterranean-type characteristics: A review. Journal of Plant Nutrition 27(6), 959–975.
Sadeghzadeh, B., 2013. A review of zinc nutrition and plant breeding. Journal of Soil Science and Plant Nutrition 13(4), 905–927.
Savithri, P., Perumal, R., Nagarajan, R., 1999. Soil and crop management technologies for enhancing rice production under micronutrient constraints. In: Balasubramanian, V., Ladha, J.K., Denning, G.L. (Eds.). Resource Management in Rice Systems: Nutrients. Developments in Plant and Soil Sciences (Volume 81). Springer, Dordrecht, 121–135.
Sharma, A., Patni, B., Shankhdhar, D., Shankhdhar, S.C., 2013. Zinc - An indispensable micronutrient. Physiology and Molecular Biology of Plants 19(1), 11–20.
Singh, J., Partap, R., Singh, A., Kumar, N., Krity, 2021. Effect of nitrogen and zinc on growth and yield of maize (*Zea mays* L.). International Journal of Bio-resource and Stress Management 12(3), 179–185.
Steel, R.G.D., Torrie, J.H., 1984. Principles and Procedures of Statistics: A Biometrical Approach(2ndEdn.). McGraw Hill Book Co., Singapore, 172–177.
Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S., 2002. Agricultural sustainability and intensive production practices. Nature 418, 671–677.
Wilhelm, N.S., Graham, R.D., Rovira, A.D., 1988. Application of different sources of manganese sulfate decreases take-all (*Gaeumannomyces graminis* var. *tritici*) of wheat grown in a manganese deficient soil. Australian Journal of Agricultural Research 39(1), 1–10.
Yilmaz, A., Ekiz, H., Gultekin, I., Torun, B., Barut, H., Karanlik, S., Cakmak, I., 1998. Effect of seed Zn content on grain yield and Zn concentration of wheat grown in Zn-deficient calcareous soils. Journal of Plant Nutrition 21(10), 2257–2264.

