International Journal of Botany Studies
ISSN: 2455-541X; Impact Factor: RJIF 5.12
Received: 07-04-2020; Accepted: 05-05-2020: Published: 12-05-2020
www.botanyjournals.com
Volume 5; Issue 3; 2020; Page No. 46-49

Agronomic Bio-fortification of bread wheat (*Trticum aestivum* L.) as influenced by applied zinc and Iron rates in a field experiment

Syed Ayyaz Javed[1*], Ghulam Sarwar[2], Ali Afzal[3], Ali Raza Malik[4], Muhammad Mazhar Iqbal[5], Tayyaba Naz[6]

[1, 2, 4] Department of Soil and Environmental science, College of Agriculture, University of Sargodha, Pakistan

[3] Provincial Pesticide Reference laboratory, Institute of Soil Chemistry and Environmental Sciences, Kala Shah Kaku, Sheikhupura, Pakistan

[5] Soil and Water Testing laboratory Chiniot, Ayub Agricultural Research Institute, Department of Agriculture, Government of Punjab, Pakistan

[6] Saline Agriculture Research Centre, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan

Abstract
Deficiency of micronutrient in soils of Asian continent including Pakistan is widespread due to alkaline and calcareous nature of soils. Therefore, in these regions Bio-fortification of crops with micronutrients is considered as a significant technique to improve nutritional value in cereal grains like wheat and rice. A field study was performed during the year of 2018-2019 to ascertain the effect of zinc and iron supplementation in wheat crop using three different modes of application in Sargodha region of Pakistan. Research was comprised of seven treatments along with required doses of NPK (120:80:60) as T_1 as control, T_2-T_5 as soil fertilization with zinc and iron in different ratios T_6 as Foliar spray of micronutrients (Zn and Fe), T_7 as seed priming with solution of zinc and iron. Field was designed as Randomized complete block design (R.C.B.D).All the growth and physiochemical attributes of study were analyzed in laboratory of Soil Science Department of College of Agriculture, University of Sargodha, Pakistan. It was evident from the results that fertilization of Zn and Fe through soil in high amount (T_5) influence the concentration of Zn and Fe in wheat grains and plant biomass significantly as well as also increase the other growth parameters such as plant height, spike length, biomass of plant, grain yield, 1000 grain weight and protein contents. Similarly results of foliar application of Zn and Fe (T_6) and seed priming (T_7) were also at par.

Keywords: malnutrition, zinc, iron, biofortification, seed priming, wheat, yield

1. Introduction

Cereal crops are characteristically low in Fe and Zn fixations. Therefore, the technique for bio-fortification cereal grains with Zn and Fe is profoundly favored around the world. Bio-fortification is the enrichment of micronutrient in staple foods by different methods such as biotechnology and agronomic application of micronutrients. In agronomic bio-fortification micronutrients are applied to the plant through seed, foliar and soil application during its development and growth whereas in genetic method breeding procedures are utilized to change the hereditary makeup of plant [4]. Developing countries are facing problem of high population than developed countries causing shortage of food among people. At present, around 65 % of the total populace is starving [3]. Right now, 40% of total populace is deficient in micronutrient particularly, because of which various types of infections, incapability among kids, flawed social economy and medical issues are spreading [12].

Generally Asian soils (especially Pakistan) are rich in calcium carbonate (CaCO3) and poor in organic contents with high pH value due to semi-arid regions. As per the recent report, scarcity of micronutrients particularly Zn and Fe cause decline in crop yield and yield components [10]. Extensive utilization of macronutrients there association between high yielding crops and other nutrients are the root causes of essential nutrient deficiency in soil.

Curtailment of micronutrient in crop plants has become a universal problem due to high population in developing countries [14]. There is also a principal problem of essential micronutrient deficiency in modern high yielding wheat varieties of crops causing low concentration of nutrients in human diet [6]. Cakmak, Pfeiffer and McClafferty (2010) [4] reported that human diet is decreasing in essential nutrients with rising of wheat yield, consequently showing adverse effects on human health. Micronutrients have critical significance in plants phenotype and its cell structure which improves the yield and yield attributes [5]. Zinc is required for the accurate functioning of auxin digestion, enzymatic activity and synthesis of protein contents. It also acts as a metal constituent in a succession of catalysts and performs a considerable function in structuring of membrane [13]. Likewise, Iron (Fe) is also an essential micronutrient and has its importance in human body. It gives oxygen to the tissues from lungs that is separated in the form of hemoglobin and acts as an electron carrier with in cell [9]. Keeping in view this discussion a research was performed to evaluate the effectiveness of agronomic bio-fortification of wheat with Zn and Fe through three different modes of micronutrient application (soil, foliar and seed priming) because Agronomic bio-fortification approach demonstrates more significant results to combat micronutrient deficiency human beings [2].

2. Materials and Methods

2.1 Experimental site

The research was done during the year of 2018-19 in the research field of Soil Science Department located in College of Agriculture, university of Sargodha to investigate the impact of micronutrients (Zn and Fe) application through three different types of modes such as soil, seed and foliage. In order to perform research soil analysis was performed to select non saline and non sodic soil. The size of experimental field was 3.5 kanal and was divided into different blocks according to required design (R.C.B.D). The field was cultivated with different crops permanently. Based on initial soil analysis all plots received 120 kg N ha^{-1} (urea,46% nitrogen), 80 kg P_2O_5 ha^{-1} (DAP, 46% P_2O_5) and 60 kg K_2O ha^{-1}(SOP 50% K_20) at the time of sowing. All plots received same doses of NPK as basal nutrition. The Zn and Fe were fertilized as a $ZnSO_4$ (33%) and $FeSO_4$ (20%) respectively in four differet concentrations. Field was analyzed before cultivation.

Table 1: Initial physico-chemical characterization of soil at the experimental site. (0-12 cm depth)

Parameters	Values
Texture	Clay loam
pH	7.8-7.9
ECe (dS m^{-1})	0.46-0.62
O.M **(%)**	0.48-0.64
Available K (ppm)	102-172
Available P (ppm)	2.8-4.4
Zinc (ppm)	0.17- 0.30
Iron (ppm)	1.84-2.13

2.2 Treatments Layout

The field designed according to seven treatments and three replications as R.C.B.D. The treatment plan is mentioned below.

Table 2

T1	**Control (NPK @ 120:80:60) RDF**
T2	Soil fertilization with ZnSO4 and FeSO4 @ 15 and 20 Respectively
T3	Soil fertilization with ZnSO4 and FeSO4 @ 30 and 40 Respectively
T4	Soil fertilization with ZnSO4 and FeSO4 @ 45 and 60 Respectively
T5	Soil fertilization with ZnSO4 and FeSO4 @ 60 and 80 Respectively
T6	Foliar spray of solutions having Zn and Fe @ 0.1 % and 0.2 %
T7	Seed treatment with Zn and Fe solution @ 1 % each.

Macronutrients were incorporated in all plots of treatment with recommended ratio. Nitrogen was applied as Urea; Phosphorus was applied as DAP and potassium was applied in the form of SOP.

2.3 Wheat Husbandry

Wheat variety Galaxy 2013 seeds were found from AARI Research Institute of Faisalabad Punjab. The wheat seeds were broadcasted at 50 kg $acre^{-1}$ on November 5, 2018. The Zn and Fe primed seeds were sown on appropriate soil moisture level. Zinc and iron were sprayed at two critical stages of wheat i.e. booting and grain formation stages. All the required cultural practices were performed. The data of agronomic parameters was recorded during the growth and development of crop till the maturity. Grains yield and yield attributes including plant height, spike length, grain yield, 1000-grain weight and shoot dry weight were recorded from each plot. The Zn and Fe concentration in soil (after harvesting of crop), grains and in dry plant biomass were determined as well as concentration of protein contents in plants were also determined following standard methods.

2.4 Determination of Zn and Fe

Micronutrients from soil and plants were analyzed according the method explained by Lindasy and Norvell (1978) [8] using atomic absorption spectrophotometer (AAS).

2.5 Protein Concentration:

The protein contents in wheat grains were measured in percentage by using following formula

$$\text{Protein contents (\%)} = \text{N \%} \times 6.25$$

2.6 Data Analysis

All the measured data was interpreted in Statistics 8.1 software and treatment means were identified by applying Least Significant Difference (LSD) test at significance level of $p \leq 0.05$.

3. Results and Discussion

The results illustrated that all growth parameters such as plant height, spike length, weight of plant biomass, 1000 grains weight, grain yield and similarly concentration of protein in grains was increased appreciably ($p \leq 0.05$). The maximum value of plant height (111 cm), spike length (16 cm), plant biomass (14.85 $t.ha^{-1}$), 1000 grain weight (53 g), grain yield (5.20 $t.ha^{-1}$) and protein contents (19.38 %) was noted in T_5 where Zn and Fe were applied through soil @ 60 & 80 kg ha^{-1} as shown in figure 1.Likewise minimum values were observed in T1 as control treatment. Similarly, high application of zinc and iron through soil also increase micro nutrient concentration (Zn & Fe) in grains, plant biomass and soil after harvesting of wheat at maturity. Similarly T_5 also showed maximum Zn and Fe values in case of grains (42.33 mg kg^{-1}, 323.33 mg kg^{-1}), biological yield (80.67 mg kg^{-1}, 235.67 mg kg^{-1}) and in post-harvest soil (1.34 mg kg^{-1}, 4.70 mg kg^{-1}) and lowest values were evident by T_1 as a control treatment in grain yield and all yield parameters as shown in table 1 and 2. The tables are also pointing out that spraying of micronutrients solution (Zn and Fe @0.1 and 0.2 %) and seed priming @ 1% Zn and 1% Fe solutions give affective results after nutrients applied through soil (T_5, T_4 & T_3). The overall trend was observed as T5>T4>T3>T6>T7>T2>T1 for all the measured traits and for post-harvest soil Zn and Fe concentration the treatment order was observed as T5>T4>T3>T2>T7>T6>T1 as shown in figure 2. It was demonstrated by table 3 and table 4 that all the treatments (T_5, T_4 &T_3) where Zn and Fe was applied through soil in high concentration showed best values followed by treatments applied through foliar application (T_6), seed priming (T_7) and control as T_1 (without zinc and iron). This may be due to the plant response to high concentration of zinc and iron through soil. Because Pakistani soils are calcareous in nature which have limited amounts of available zinc and iron. Application of these micronutrients in high concentration can give better results for yield and yield attributes as well as increase concentration of zinc and iron in grains, plant biomass and in soil after harvesting at maturity. Plant height, spike length, plant biomass, 1000 grain weight, grain yield and

protein contents were improved considerably by increasing concentration of DTPA extractable zinc and iron in soil when compared with control. Our findings are quite similar with Riffat *et al.* (2007) [11] and Khattab *et al.* (2016) [7] who showed that increased fertilization of zinc through soil showed positive results toward zinc uptake, plant height, spike length and shoot dry matter and grain yield. Similarly, Ziaeian and Malakouti (2001) [15] also estimated that fertilization of Fe and Zn increased concentration of Fe and Zn in grains, protein contents in grains and all yield attributes of plant as well. It is also believed that due to deficiency of zinc in soil plants bear low photosynthesis activity. So, after fertilization of zinc and iron in soil the photosynthetic activity in plant increased and chlorosis will decrease and plant shows dramatic positive changes in yield and yield components. In addition, it is also understood that by fertilization of zinc and iron through soil enhances concentration of these micronutrients in soil. Our results relate with findings of cakmak *et al.*, (2010); Abbas, Khan, Khan, Husssain and Hussain (2009) [4,1] who showed that increased zinc and iron application through soil significantly increased zinc and iron in soil.

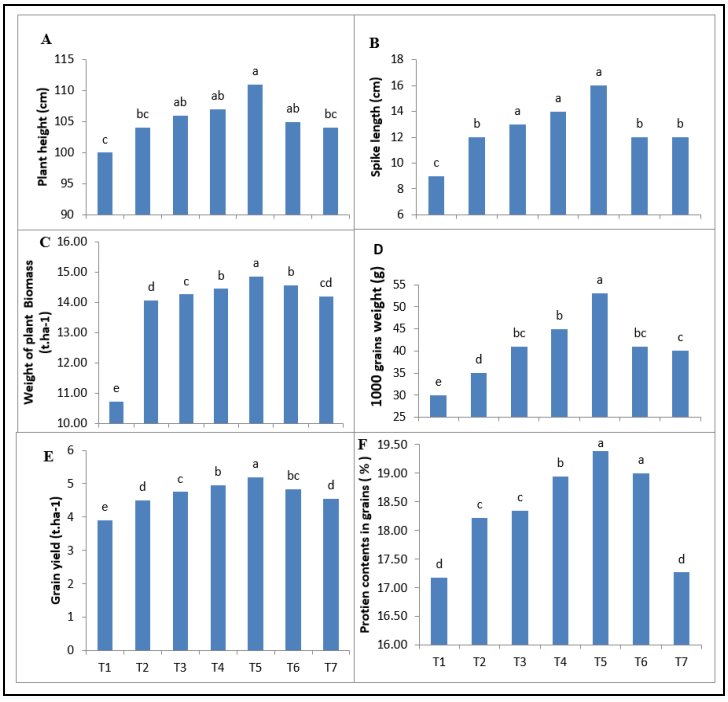

Fig 1

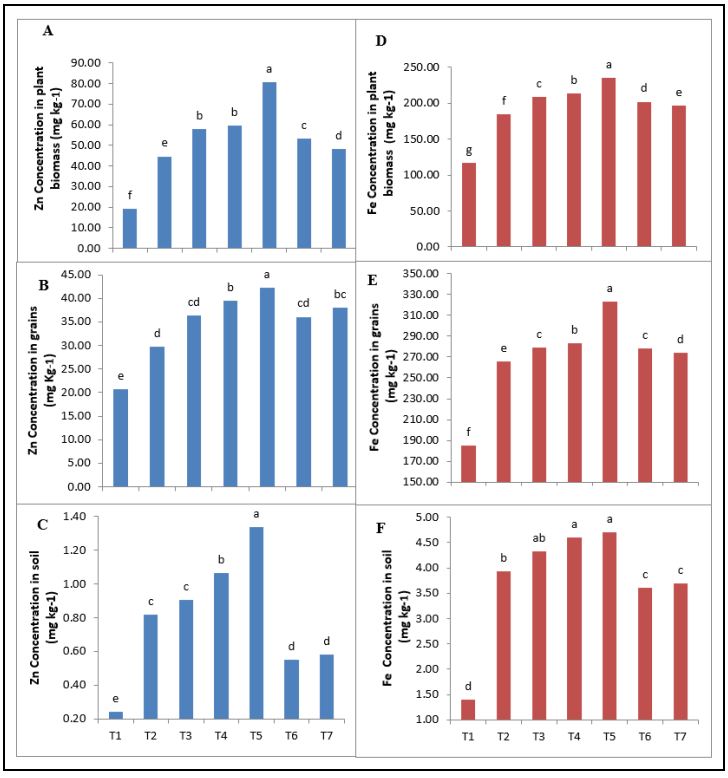

Fig 2

Table 3: Effect of Zn nd Fe application on grain yield and yield components

Sr.	Treatments	Plant height (cm)	Spike length (cm)	Weight of Plant biomass (t. ha^{-1})	1000 grain weight (g)	Grain yield (t. ha^{-1})	Protein contents (%)
T1	Control (recommended dose of NPK)	100 c	9 c	10.73 e	30 e	3.90 e	17.18 d
T2	Zinc and iron @15 and 20 kg ha^{-1} in soil respectively	104 bc	12 b	14.07 d	35 d	4.50 d	18.22 c
T3	Zinc and Iron @ 30 and 40 kg ha^{-1} in soil respectively	106 ab	13 a	14.26 c	41 bc	4.75 c	18.35 c
T4	Zinc and Iron @ 45 and 60 kg ha^{-1} in soil respectively	107 ab	14 a	14.44 b	45 b	4.95 b	18.94 b
T5	Zinc and Iron @ 60 and 80 kg ha^{-1} in soil respectively	111 a	16 a	14.85 a	53 a	5.20 a	19.38 a
T6	Foliar spray of Zn and Fe @ 0.1 and 0.2 % solution	105 ab	12 b	14.55 b	41 bc	4.84 bc	19.00 a
T7	seed treatment @ 1% Zn and 1% Fe solution	104 bc	12 b	14.18 cd	40 c	4.55 d	17.27 d
	LSD = <0.05	6.24	1.66	0.17	2.34	8.43	1.11

Table 4: Effect of Zn and Fe fertilization on concentration of Zn and Fe in soil, grains, biomass.

Sr.	Treatments	Zinc in plant biomass (mg kg^{-1})	Zinc in grains (mg kg^{-1})	Zinc in soil after harvesting (mg kg^{-1})	Iron in plant biomass (mg kg^{-1})	Iron in grains (mg kg^{-1})	Iron in soil after harvesting (mg kg^{-1})
T1	Control (recommended dose of NPK)	19.33 f	20.78 e	0.24 e	116.67 g	185.33 f	1.40 d
T2	Zinc and iron @15 and 20 kg ha^{-1} in soil respectively	44.67 e	29.70 d	0.82 c	184.00 f	266.00 e	3.94 b
T3	Zinc and Iron @ 30 and 40 kg ha^{-1} in soil respectively	58.00 b	36.37 cd	0.90 c	208.33 c	279.00 c	4.33 b
T4	Zinc and Iron @ 45 and 60 kg ha^{-1} in soil respectively	59.67 b	39.50 b	1.07 b	214.00 b	283.00 b	4.60 a
T5	Zinc and Iron @ 60 and 80 kg ha^{-1} in soil respectively	80.67 a	42.33 a	1.34 a	235.67 a	323.33 a	4.70 a
T6	Foliar spray of Zn and Fe @ 0.1 and 0.2 % solution	53.33 c	36.08 cd	0.55 d	202.00 d	278.67 c	3.60 c
T7	seed treatment @ 1% Zn and 1% Fe solution	48.33 d	37.95 bc	0.58 d	196.33 e	274.33 d	3.70 c
	LSD = <0.05	10.04	8.76	0.30	96.27	23.48	0.64

Conclusion

This study concluded that fertilization of $ZnSO_4$ and $FeSO_4$ in high concentration through soil (T_5> T_4> T_3) increased zinc and iron in grains, plant biomass and in soil significantly after harvesting of crop at maturity. It also showed significant results in yield and yield attributes. However according to literature foliar application perform well in increasing concentration of zinc and iron in grains and plant biomass but due to deficiency of micronutrients in calcareous soils of Pakistan application of micronutrients in high concentration showed most significant results than foliar application alone and seed priming. While results indicated by T_6 and T_7 were also at par. The lowest values of results were given by control treatment as T_1.

References

1. Abbas G, Khan MQ, Khan MJ, Hussain F, Hussain I. Effect of iron on the growth and yield contributing parameters of wheat (*Triticum aestivum* L). journal of animal and plant sciences. 2009; 19(3):135-139.
2. Alloway BJ. Soil factors that are associated with zinc deficiency in cereal crops and humans. Environmental Geochemistry and Health. 2009; 31:537-548.
3. Anonymous. Economic survey of Pakistan 2018-2019. Ministry of food, agriculture and livestock (federal bureau of statics), Islamabad, 2019, p16-21.
4. Cakmak I, Pfeiffer WH, McClafferty B. Biofortification of durum wheat with Zinc and Iron. Cereal chemistry. 2010; 87(1):10-20.
5. Dewal GS, Pareek RG. Effect of phosphorus, sulphur and zinc on growth, yield and nutrient uptake of wheat (Triticum aestivum). Indian Journal of Agronomy. 2004; 49(3):160-162
6. Fan MS, Zhao FJ, Weather SJ, Poulton PR, Dunham SJ, McGrath SP. Evidence of decreasing mineral density in wheat grain over the last 160 years. Journal of Trace Elements in Medicine and Biology. 2008; 22:315-324.
7. Khattab EA, Afifi MH, Badr EA, Amin GA. Effect of timing and rate of zinc on wheat yield. International Journal of Chem. Tech. Research. 2016; 9(8):82-86.
8. Lindsay WL, Norvell WA. Development of a DTPA soil test for zinc, iron, manganese and copper, Soil Science society of America Journal. 1978; 42(3):421-428
9. Mascotti DP, Rup D, Thach RE. Regulation of iron metabolism: translational effects mediated by iron, heme and cytokines. Annual Review of Nutrition. 1995; 15**:**239-261.
10. Rashid A, Ryan J. Micronutrient constraints to crop production in soils with Mediterranean type characteristics: A Review. Journal of Plant Nutrition. 2004; 27(6):959-975.
11. Riffat S, Samim MK, Mahmud R. Effect of zinc on yield and zinc uptake by wheat on some soils of Bangladesh. Journal of Soil Nature. 2007; 1(1):07-14.
12. Sanchez PA, Swaminathan MS. Cutting world hunger in half. American Association for the Advancement of Science. 2005; 307(5708):357-359.
13. Tisdale SL, Nelson WL, Beaten JD. Zinc In soil Fertility and Fertilizers. Fourth edition, Macmillan Publishing Company, New York, 1985, pp**:**382-391.
14. Welch RS, Graham RD. A new paradigm for world agriculture: meeting human need, productive, sustainable, nutritious. Field crop Research. 1999; 60:1-10.
15. Ziaeian AH, Malakouti MJ. Effect of Fe, Mn, Zn and Cu fertilization on the yield and grain quality of wheat in the calcareous soils of Iran. Plant Nutrition - Food Security and Sustainability of Agro-ecosystems (Eds W.J. Horst, *et al*., Kluwer, Dordrecht, The Netherlands, 2001, 840-841.