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Effect of Micronutrients (Zinc, Iron And Boron) Application on The Yield And Quality of Late Sown Wheat

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ABSTRACT

A field trial was carried out at University of Agriculture, Faisalabad, during winter 2018-19, for studying the impact of Zn, Fe and B on the productivity and quality of wheat. Experimental design was randomized complete block design having eight treatments and replicated thrice. Recommended dose of fertilizer @120:85:60 NPK kg ha^{-1} was applied. Zn, Fe and B was applied at the rate of 12, 14 and 3 kg ha^{-1}, respectively. The sources of Zn, Fe and B were $ZnSO_4$, $FeSO_4$ and Borax. All other practices were followed according to standard recommendations. Data was collected and results showed that micronutrients application has significant effect on plant height, spikes $plant^{-1}$, grains $spike^{-1}$, 1000-grain weight, grain yield, biological yield and harvest index. Conclusion was that applying micronutrients (Zn, Fe and B) in soil is very useful and effective for obtaining high yield along with high quality of wheat.

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INTRODUCTION

In cereal crops, wheat is the most valuable crop because it primarily used as a main source of nutrition in Pakistan and hence it has significant worth in food security potential. After maize and rice, it is ranked as third cereal crop around the globe (FAO, 2013). Wheat subsidizes 9.1% in agriculture as well as 1.7% in Gross Domestic Product (GDP) of Pakistan. Reduction in wheat cultivated area, late and prolonged sugarcane crushing period, scarcity of water, fog and smog in country may lead to decrease in wheat yield (Economic Survey of Pakistan, 2017-2018). Underprivileged fertility level of the soil and lack of suitable crop management techniques are also other diverse reasons which are responsible for the reduction in wheat productivity in Pakistan. Deprived fertility may be due to presence of a smaller amount of plant nutrients in the soils, leaching of nutrients and excessive uptake of nutrients by the plants. In an agriculture system, macro and micronutrients both have great significance, but due to illiteracy of farmers about significant part of micronutrients on productivity of wheat. So, the soils are becoming scarce of micronutrients which may leads to low productivity of crops grown in such soils.

During 2017-2018, wheat productivity was 25.492 million tones, having a decline of 4.4 percent over the productivity of 26.674 million tones during previous year. Wheat productivity in Pakistan should be very high being a staple food but it is too low when the comparison is made with other countries in the world. So, there is dire need of different practices to enhance the wheat productivity. Wheat productivity can be enhanced by increasing cultivable area for wheat or by achieving increased yield from specific area. But under the prevailing scenario, it is challenging to spread out the cultivable area for wheat due to scarcity and availability of pure water for irrigation and other contending crops too. Therefore, for increasing wheat production, higher yield per unit area is only the substitute left in Pakistan and it is possible only by proper nutrition management of crop.

Balanced application of both macronutrients along with micronutrients is of great importance for increasing growth and yield because micronutrients are as essential as that of macronutrients. Micronutrients deficit in soil is primarily because of their lesser quantity in soil and soil features responsible for making them unavailable for root uptake (Heidarian *et al*., 2011). Micronutrients deficit like boron badly affect the plant processes (Rerkasem and Jamjod, 2004). Deficit of Zn and B causes lesser seed formation and consequential yield loss because they play a significant role in pollination and seed formation (Ziaeyan and Rajaiea, 2004). Boron deficiency in soil leads to decline in crop growth and development. So, crop growth and productivity can be increased by application of this micronutrient (Ali *et al*., 2009). Boron deficit interrupts at least 16 functions in plants like pollen germination and flowering (Wang *et al*., 2003) grain setting in wheat (Tahir *et al*., 2009) and to complete development of the seed (Brown *et al*., 2002). Zinc not only a structural and functional cofactor of various enzymes but it also plays a vital role as metal components of enzymes (Grotz and Guerinot, 2006). So, it is very important for various biochemical processes in plants. It has been recorded that combined application of B and Zn leads to considerable increase in wheat yield and its yield components (Ali *et al*., 2009). It has been also found that cereal crops productivity can be enhanced by the use of zinc either applied in soil or to plants as spray on them (Jiang *et al*., 2007). Many studies have exposed that B application to soil alone or mixed with some other nutrients significantly enhances productivity and quality of crop. In plant growth and development, iron also plays several important roles like other micronutrients i.e. respiration, biosynthesis of chlorophyll, expands the performance of photosystem and chloroplast development (Havlin *et al*., 2014; Eskandari, 2011). Plants growing in soil that have lesser amount of iron are unable to accrue adequate amount of iron in its eatable parts which result in nutrition complaints in human body (White *et al*., 2009). It has been also recorded that plant productivity is limited due to poor Fe availability (Bybordi and Mamedov, 2010). By keeping this in view, the current study was performed to determine Zn, Fe and B on the yield and quality of late sown wheat.

MATERIALS AND METHODS

This trial was carried out at University of Agriculture, Faisalabad in winter season (2018-19). Geographically, experimental site was located at 31°30'N, 73°05'E and 214 meters above mean sea level. The climatic condition of experimental site is given in figure 1 to 4. The physical and chemical characteristics of soil of experimental area is shown in Table 1. Eight treatments were distributed to the field following the principle of Randomized Complete Block Design (RCBD) and there were three replications of each treatment. The experimental plots were ploughed by 2-3 ploughing via cultivator. The land was irrigated before 15-20 days of sowing. At appropriate moisture conditions, rotavator and cultivator were used to prepare fine seedbeds. Hand seed drill was used for seed sowing with the distance of 22.5cm from row to row. Seed variety UJALA 2016 at the rate of 100 kg ha^{-1} was used. The net plot size was 5m × 1.80 m. All other practices were done according to standard recommendations. The micronutrients were applied to soil at the rate of Zn (12 kg ha^{-1}), Fe (14 kg ha^{-1}), B (3 kg ha^{-1}) as a single dose and as a combination of different micronutrients as follows: (F_0 =Control , F_1= Zinc, F_2= Iron,F_3= Boron, F_4= Zinc+ Iron, F_5= Zinc+ Boron, F_6= Iron+ Boron, F_7= Zinc+ Iron+ Boron). The data collected was evaluated by using Fisher's analysis of variance and means of treatments were compared with LSD test at 5% probability level (Steel *et al*., 1997).

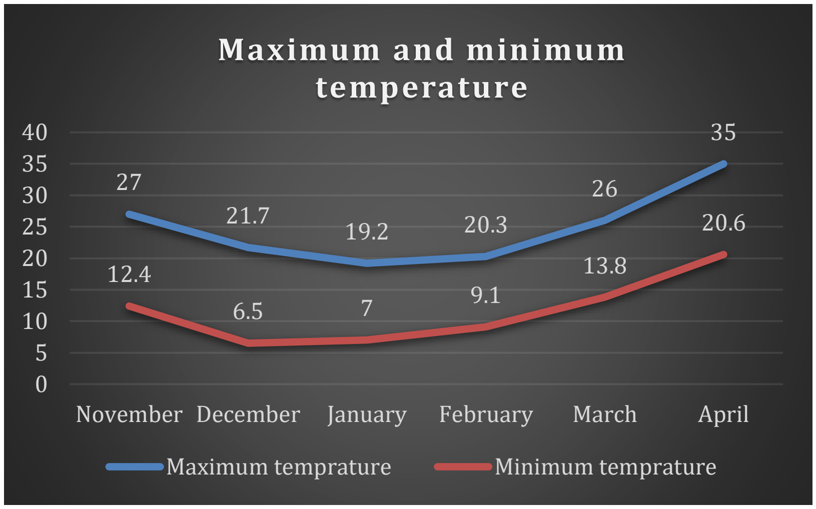

Figure 1. Mean monthly average min. and max. Temperature (^0C) from November to April during 2018-19.

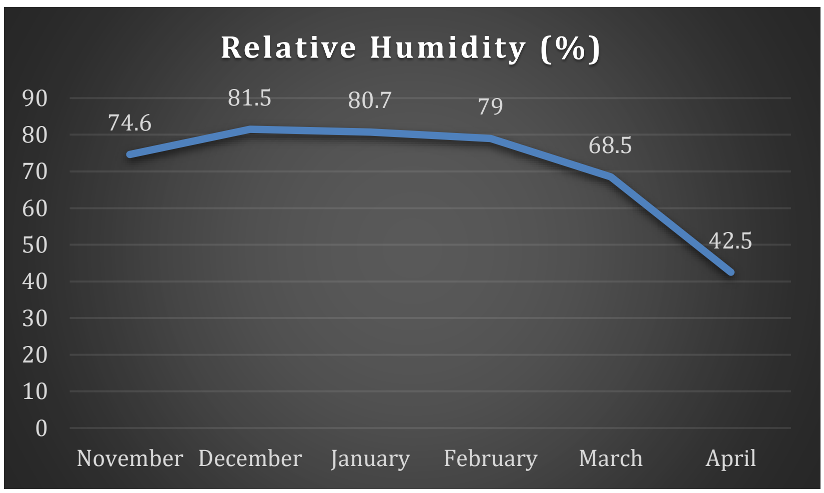

Figure 2. Mean monthly relative humidity (%) from November to April during 2018-19.

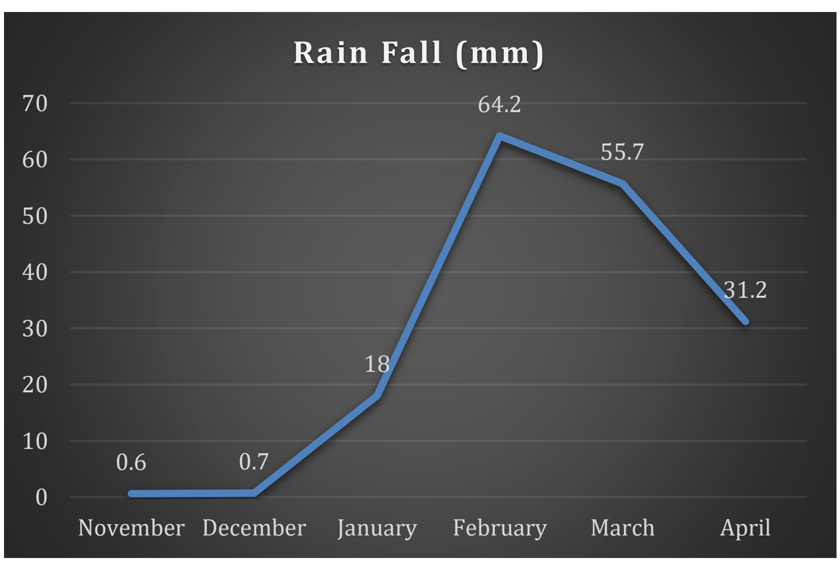

Figure 3. Mean monthly rainfall (mm) from November to April during 2018-19.

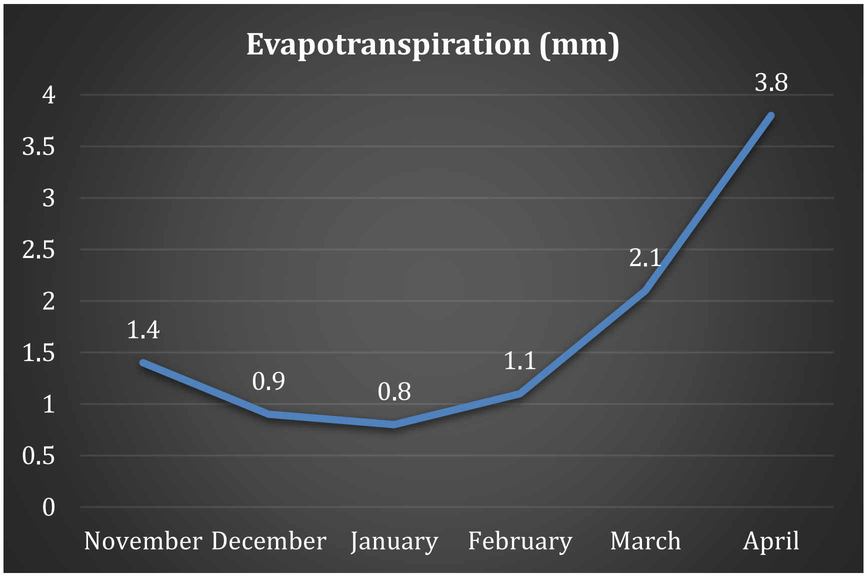

Figure 4. Mean monthly evapotranspiration (mm) from November to April during 2018-19.

Table 1. Soil analysis result for physical and chemical characteristics (Normal soil).

Physiochemical characteristics	Values
Texture	Loamy soil
pH	7.87
EC	2.1 d S m^{-1}
Sodium Absorption Ratio (SAR)	1.6 (mmol L^{-1})
Organic matter	0.60%
Phosphorus	4.03 ppm
Potassium	281 ppm
Test element (Zn) DTPA (0.02 M)	0.2 mg kg^{-1} Soil

RESULTS AND DISCUSSION

The yield, yield components and quality results are under as follow:

Plant height

Result exposed that, plant height was significantly influenced by individual and combined addition of Zn, Fe and B Table 2. The highest plant height 110.53 cm was in treatment F_4 (Zn+ Fe), followed by F_3 and F_5 treatments, respectively. While, the lowest plant height (98.89 cm) was obtained in F_0 (control) as reported in Table 2. It has been found that micronutrients such as Zn, Mn and Fe play role in chlorophyll enhancement and thus these may lead to boost up plant height and yield. Zinc also helped in increasing plant height by enhancing the internodal distance as reported by (Kaya *et al.*, 2000). Likewise, (Chaudry *et al.*, 2007) resulted from his work that different micronutrients (Zn and Fe) expressively increase the yield while comparing with control. Therefore, by supplying micronutrients to plants by any of the application methods, the productivity and quality of crops are enhanced (Malakouti, 2008).

Yield components

Zn, Fe and B application individually and collectively leads to significant increase in all yield related components as compared to the control F_0 Table 2. The highest value of spikes plant^{-1} was noted from the treatment F_5 (Zn+B). There were no noteworthy differences among F_1, F_2, F_4, F_7 and control for spikes plant^{-1}. The highest value of grains spike^{-1} (47.47) was in F_5 (Zn+B), while the F_2, F_7 and control exhibited low values for grains spike^{-1} Table 2. The results obtained from 1000-grain weight were almost alike to the trend attained for spikes plant^{-1}. The highest 1000-grain weight (48.66 g) was recorded in F_6 followed by F_5 and F_4 treatments, respectively. Current results are similar to reported by (Guenis *et al.*, 2003) as they advocated noticeable increase grains spike^{-1} with boron application.

Grain yield

Zinc, Fe and B individually and collectively expressively impacted the grain yield Table 2. The maximum grain yield (6104 kg ha^{-1}) was in treatment F_5 (Zn+B) and followed by F_6 (Fe+B) 5257 kg ha^{-1} and F_3 (B) 4581 kg ha^{-1}, respectively Table 2. Significantly, the minimum grain yield (2559 kg ha^{-1}) was produced by the control followed by F_8 (Zn + Fe + B). Current findings are similar to (Torun *et al*., 2001; Zorita *et al*., 2001), who have reported an enhancement in grain yield with zinc nutrition. Likewise, these results are also in accord with (Arif *et al*., 2006). Reduced grain yield in F_4 (Fe+ Zn) can be attributed to antagonism between Fe and Zn. Similarly, (Alloway, 2008) also exposed competitive inhibition between both Zn and Fe during their uploading in the xylem tissue.

Biological yield

The data obtained analyzed indicated that the highest values for biological yield were gained in treatment F_5 (Zn+B) Table 2. Biological yield increased by 24% in F_5 (Zn+ B) compared to the control. The lowest biological yield attained in control, followed by F_8 (Zn+Fe+B), Table 2. Same outcomes were obtained by (Torun *et al*., 2001) who stated that the increase in dry matter productivity via application of zinc and boron over control. Zn also plays an imperative role in biomass production ((Kaya *et al*., 2000; Cakmak, 2008). Individual Zn and Fe applications produced better effects than that of their combined application. Decrease in biological yield in F_7 treatment (Zn+Fe+B) may be due to antagonism among Zn, Fe and B in combined dose. Zayed *et al*, (2011) showed same results as in current study.

Harvest index

The results showed that soil applied micronutrients either applied individually or collectively resulted in increasing harvest index Table 2. Harvest index increased by 11.98% in (Zn+B), while compared with the control as F_5 treatment already caused maximum grain and biological yield. The increase in studied characters may be because of the role of micronutrients in enhancement of photosynthetic activity and assimilates translocation to seeds which may lead to increase in enzymatic and biological processes.

Grain protein contents (%)

Data related to grain protein contents is given in Table 2. Treatment F_4 showed statistically the highest percentage (12.9%) than rest of treatments. Minimum protein percentage was recorded in control. The role of micronutrients in plants physiological processes i.e. amino acid biosynthesis, activation of bio enzymes, and starch utilization, enhanced the accumulation of assimilates in seeds, which result in more protein contents in grains (Rasul *et al*., 2015; Khan *et al*., 2010)). Zn and Fe are significant elements of enzyme structure and play role in biosynthesis of amino acid and which are the building blocks of protein, so the micronutrients boost protein contents in grain (Bybordi and Mamedov, 2010). Rasheed *et al*, (2004) documented an increase in protein contents in grain by the use of micronutrients.

Grain carbohydrates content (%)

The data in Table 2 describes micronutrients causes significant increase in carbohydrates contents in grains. Maximum percentage was found in F_5 followed by F_6. On the other hand, the control is statistically at par with F_2. The micronutrients play a dynamic role in carbohydrates manufacturing, metabolic reactions, nitrogen fixation, membrane integrity, starch utilization, enzymes system as a co-factor and phytochrome activities (Monreal *et al*., 2015; Bameri *et al*., 2012).

CONCLUSION

This conclusion drawn is that, micronutrients particularly zinc, iron and boron individually or in combined form had constructive effects on wheat yield and its components. All three micronutrients in combination (Zn+Fe+B) significantly reduced wheat yield and yield components. Negative effects of treatment (Zn+Fe+B) on wheat growth may be due problems during micronutrients uptake and antagonism among them. The two-fold combination (Zn+B) worthily enhances yield and the components when compared to other treatments.

Table 2. Mean comparison of studies traits in wheat as affected by micronutrients.

Treatments	Plant height(cm)	Total No. of tiller(m^{-2})	No. of productive tillers (m^{-2})	No. of spikelet's spike^{-1}	No. of grains spike^{-1}	1000 grain weight (g)	Grain yield kg ha^{-1}	Biological yield kg ha^{-1}	Harvest index (%)	Protein contents (%)	Carbohydrates contents (%)
F_0 (Control)	98.89 g	239.67 e	214.0 h	16.93 e	36.63 e	40.67 e	3414.0 e	11663 f	29.44 a	10.40 g	65.2 f
F_1(Zn) [12kg ha^{-1}]	102.67 ef	309.67c	249.67 e	178.03 cd	41.73 cd	44.0 cd	3815.7 c	13113 cd	29.12 a	11.0 e	66.2 e
F_2 (Fe) [14kg ha^{-1}]	104.65 de	298.67 cd	238.67 f	17.80 cde	39.50 de	40.67 e	3787.3 cd	12533 de	30.23 a	10.9 e	66.06 e
F_3 (B) [3kg ha^{-1}]	108.74 ab	349.33b	280.67 c	18.80 bc	43.83 bc	46.67 bc	4124.3 b	13633 bc	30.27 a	10.60 f	66.7 d
F_4 (Zn+Fe) 12+14 [kg ha^{-1}]	110.53 a	344.33b	260.67 d	18.30 bc	42.77 c	47.67 b	3960.0 bc	13160 cd	30.13 a	12.83 a	68.06 b
F_5 (Zn+B) 12+3 [kg ha^{-1}]	108.23 bc	355.0 b	316.67 a	20.67 a	47.47 a	48.66 ab	4404.7 a	14417 a	30.60 a	12.50 b	67.3 c
F_6(Fe+B) 14+3 [kg ha^{-1}]	106.06 cd	383.67 a	292.33 b	19.27 b	46.47 ab	51.08 a	4373.0 a	14240 ab	30.72 a	12.16 c	68.63 a
F_7(Zn+Fe+B) 12+14+3 [kg ha^{-1}]	101.14 fg	277.0 d	230.0 g	17.20 de	38.80 e	41.33 de	3546.3 de	12235 ef	29.05 a	11.40 d	67.0 cd
$LSD_{0.05}$	2.2720	26.432	1.2385	1.0667	2.8786	3.0302	241.21	736.21	3.0224	0.1867	0.3021

CONFLICT OF INTEREST

The authors have not declared any conflict of interests.

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