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Foliar Application of Micronutrients Enhances Wheat Growth, Yield and Related Attributes

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Abstract

Wheat is one of the most essential foods in the world. To increase its productivity, nutrient management is one of the most important factors. To assess the possible role of micronutrients in improving wheat yield, an experiment was conducted to evaluate the wheat performance by foliar application of micronutrients. Treatments consist of T_1 = No spray, T_2 = Spraying plants with tube well water (control), T_3 = Spraying plants with 1.6 kg $FeSO_4$/100 L water/acre, T_4 = Spraying plants with 3 kg $ZnSO_4$ (21%)/100 L water/acre, T_5 = Spraying plants with 1 kg $MnSO_4$/100 L water/acre, T_6 = Spraying plants with ($FeSO_4$ + $MnSO_4$), T_7 = Spraying plants with ($FeSO_4$ + $ZnSO_4$), T_8 = Spraying plants with ($ZnSO_4$ + $MnSO_4$), and T_9 = Spraying plants with ($FeSO_4$ + $ZnSO_4$ + $MnSO_4$). Results showed that foliar application of micronutrients substantially improved plant height, spike length cm, spikelets/spike, grains/spike, test weight, Tillers m^{-2}, grain and biological as well as harvest index of wheat. Among treatments, foliar application of $FeSO_4$ + $ZnSO_4$ + $MnSO_4$ remained comparatively better regarding yield related attributes of wheat.

Keywords

Micronutrients, Growth, Spikelets, Yield, Wheat

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1. Introduction

In wheat production, micronutrients play a vital role in the yield improvement [1]. Zn, Mn, B, Fe, Cu and Mo are known to be the most important micronutrients for higher plants [2]. Micronutrients occupy a major portion as they are essential for increasing the growth of plant. Their importance increases due to their role in plant nutrition and increasing the soil productivity. Leiw (1988) [3] has reported that there is a significant increase in crop production due to application of micronutrients.

Different methods are used for micronutrient application such as seed priming, soil application and fortification, but foliar application is more beneficial. Rehm and Albert (2006) [1] reported that foliar spray of ferrous sulphate for the correction of Fe-chlorosis in wheat was found better than the soil application. Both macronutrients and micronutrients are foliar applied in combination with each other, then there is a significant increase in wheat production [4] [5]. Bameri *et al*. (2012) [6] reported that root growth in wheat was improved by spraying micronutrients which led to increase in uptake of macro and micronutrients. Moreover, there is an increase in protein percentage of seed and yield components due to foliar application [7].

Day by day, the micronutrients are reducing in soil due to more dependence on synthetic fertilizers and increase in cropping intensity with high yielding [8]. According to World Health Report (2002) [9], the fifth major cause of diseases and deaths in human beings is due to Zn deficiency in developing countries. By the foliar application of micronutrients, its concentration can be increased by the process of bio fortification. Several studies (Grewal *et al*. (1997) [10] and Torun *et al*. (2001) [11]) stated that zinc fertilization not only increased wheat and oil seed rape yield, but also enhanced grain zinc contents. Moreover, application of Mn, Zn, Fe and Cu (alone or in combined form) substantially improved rice yield [12] while increase in maize yield was also observed due to Zn application [13]. Nitrogen metabolism, protein quality, chlorophyll synthesis and photosynthesis are greatly influenced by the zinc application in maize. Previously, many reports have estimated the wheat response to exogenous application of micronutrients (both soil and foliar applied), but a little is known regarding combined application of micronutrients. Therefore, the objective of this study is to check the effect of foliar application of micronutrients ($MnSO_4$, $FeSO_4$ and $ZnSO_4$) on growth and yield of wheat.

2. Materials and Methods

To find the effect of foliar application of micronutrients on yield components of wheat, an experiment was conducted at Agronomic Research Station Karor, Layyah, Pakistan during 2012. The experiment was laid out in randomized complete block design (RCBD) design with three replications. The test variety was Punjab-2011. The plot size was 7.0 m × 3.6 m. The fertilizers were applied @ 120-90-62.6 NPK kg / ha. All the P and K was applied at sowing time, while N was applied in three splits. 1/3rd N was applied with first irrigation while remaining with the later irrigation. The micronutrients were applied twice, first at tillering stage and second after 15 days before heading, by foliar application. All the other agronomic practices were kept uniform. Treatments include:

T_1 = No spray;
T_2 = Spraying plants with tube well water (control);
T_3 = Spraying plants with 1.6 kg $FeSO_4$/100 L water/acre;
T_4 = Spraying plants with 3 kg $ZnSO_4$ (21%)/100 L water/acre;
T_5 = Spraying plants with 1 kg $MnSO_4$/100 L water/acre;
T_6 = Spraying plants with ($FeSO_4$ + $MnSO_4$);
T_7 = Spraying plants with ($FeSO_4$ + $ZnSO_4$);
T_8 = Spraying plants with ($ZnSO_4$ + $MnSO_4$);
T_9 = Spraying plants with ($FeSO_4$ + $ZnSO_4$ + $MnSO_4$).

To collect the data form respected treatments, $1m^2$ was randomly thrown at three different places and then averaged to count number of tillers. Whereas for plant height (cm), spike length (cm), spikelets per spike, grains per spike and 1000 grain weight (g), 10 random plants were selected and averaged. At maturity, crop was harvested, tied in to bundles to get grain and biological yield (kg/ha). Harvest index (%) was calculated as: (grain yield/biological yield) × 100.

Statistical program MSTAT-C was used to analyze the data statistically analyzed using. Analysis of variance (ANOVA) was employed to test the overall significance of the data, while the least significance difference (LSD) test at $p \leq 0.05$ was used to compare the treatment means [14]. Figures were generated by using SigmaPlot 9.0.

3. Results and Discussion

3.1. Plant Height (cm)

The data presented in **Table 1** revealed that foliar application of micronutrients significantly increased the plant height. The maximum plant height (97.00 cm) was obtained from T_6 treatment ($FeSO_4$ + $MnSO_4$) that was statistically similar to T_7 ($FeSO_4$ + $ZnSO_4$), T_1 (No spray), T_8 ($ZnSO_4$ + $MnSO_4$) and T_9 treatments ($FeSO_4$ + $ZnSO_4$ + $MnSO_4$). The minimum plant height (85.567 cm) was observed in T_4 treatment (3 kg $ZnSO_4$) where plants were sprayed with $ZnSO_4$.

Khan *et al*. (2009) [15] reported that if wheat is treated with 10.0 $kg·Zn·ha^{-1}$ then plant height increase up to 5.8% as compared to untreated wheat.

3.2. Number of Productive Tillers/m^2

The number of tillers/plants is greatly influenced by the environment, plant nutrition and genotype. A substantial difference was found among the treatments for producing number of tillers. Statistically maximum number of tillers (292.33) were obtained in T_9 treatments ($FeSO_4$ + $ZnSO_4$ + $MnSO_4$) followed by the T_7 treatment ($FeSO_4$ + $ZnSO_4$) and T_4 treatment (3 Kg $ZnSO_4$). Whereas, considerable minimum tillers were observed in T_6 treatment ($FeSO_4$ + $MnSO_4$) (**Figure 1(a)**). These results are in accordance with Islam *et al*. (1999) [16] who corroborated that zinc application improved spike length and productive tillers/plant.

3.3. Spike Length (cm)

Spike length was meaningfully affected due to foliar application of micronutrients (**Table 1**). Considerably, maximum spike length (10.97 cm) was observed in T_7 treatment ($FeSO_4$ + $ZnSO_4$) which was statistically similar to T_8 treatment ($ZnSO_4$ + $MnSO_4$), and T_3 treatment (1.6 kg $FeSO_4$), while minimum spike length (8.733 cm) was detected in T_4 treatment (3 kg $ZnSO_4$) which was similar to T_5 treatment (1 kg $MnSO_4$). These results are in agreement with Abbas *et al*. (2009) [17] who reported that spike length may increase up to 11.8 % by applying 10 $kg·Zn·ha^{-1}$. Moreover, Blevins and Lukaszewki (1998) [18] reported that spike length may increase due to balanced availability of nutrients in the rhizosphere, their uptake and absorption by the plant.

3.4. Spikelets/Spike

Numbers of spikelets/spike were significantly affected due to foliar application of micronutrient treatments. Data presented in **Table 1** reveal that T_8 treatment ($ZnSO_4$ + $MnSO_4$) produces maximum number of spikelets

Table 1. Effect of micronutrients on growth and yield related components of wheat.

Treatments	Plant height (cm)	Spike length (cm)	Spikelets/spike	Grains/spike
T_1	93.26 ab	9.867 abcd	14.00 bc	47.667 ab
T_2	88.30 cd	10.10 abc	14.00 bc	40.00 e
T_3	86.60 d	10.367 ab	15.333 a	36.333 f
T_4	85.567 d	8.733 d	13.00 c	39.667 ef
T_5	90.40 bcd	9.067 cd	14.667 ab	43.667 cd
T_6	97.00 a	9.950 abc	15.667 a	46.667 abc
T_7	94.467 ab	10.933 a	14.667 ab	42.00 de
T_8	92.733 abc	10.367 ab	15.667 a	49.00 a
T_9	92.150 abc	9.400 bcd	15.00 ab	44.667 bcd
LSD ($p \le 0.05$)	**4.93**	**1.21**	**1.20**	**3.47**

Values sharing a letter in common do not differ significantly ($p \le 0.05$). T_1 = No spray; T_2 = Spraying plants with tube well water (control); T_3 = Spraying plants with 1.6 kg $FeSO_4$/100 L water/acre; T_4 = Spraying plants with 3 kg $ZnSO_4$ (21%)/100 L water/acre; T_5 = Spraying plants with 1 kg $MnSO_4$/100 L water/acre; T_6 = Spraying plants with ($FeSO_4$ + $MnSO_4$); T_7 = Spraying plants with ($FeSO_4$ + $ZnSO_4$); T_8 = Spraying plants with ($ZnSO_4$ + $MnSO_4$); T_9 = Spraying plants with ($FeSO_4$ + $ZnSO_4$ + $MnSO_4$).

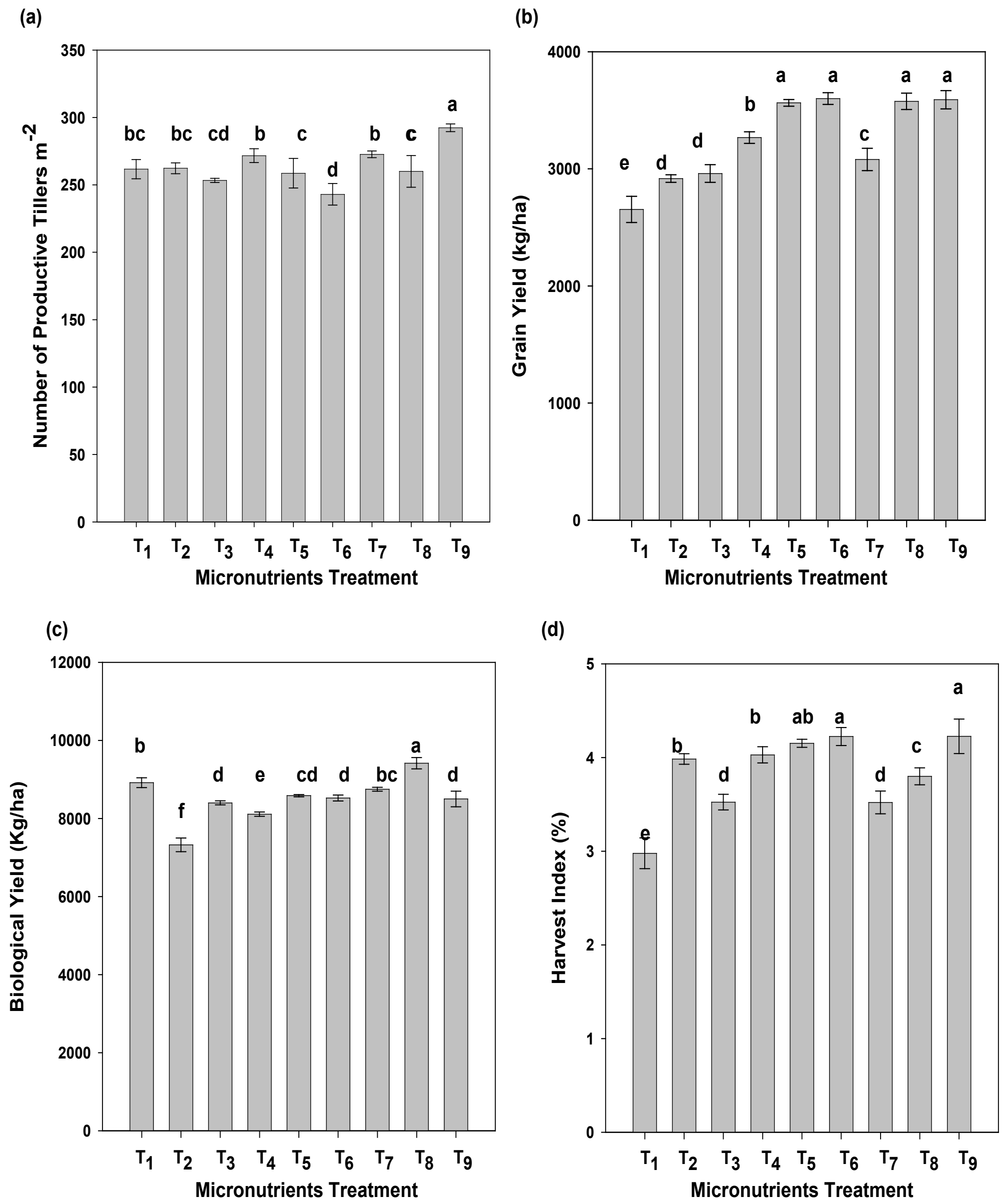

Figure 1. Effect of different micronutrients application on (a) Tillers·m^{-2}, (b) Grain yield (kg·ha^{-1}), (c) Biological yield (kg·ha^{-1}) and (d) Harvest index of wheat. T_1 = No spray; T_2 = Spraying plants with tube well water (control); T_3 = Spraying plants with 1.6 kg $FeSO_4$/100 L water/acre; T_4 = Spraying plants with 3 kg $ZnSO_4$ (21%)/100 L water/acre; T_5 = Spraying plants with 1 kg $MnSO_4$/100 L water/acre; T_6 = Spraying plants with ($FeSO_4$ + $MnSO_4$); T_7 = Spraying plants with ($FeSO_4$ + $ZnSO_4$); T_8 = Spraying plants with ($ZnSO_4$ + $MnSO_4$); T_9 = Spraying plants with ($FeSO_4$ + $ZnSO_4$ + $MnSO_4$).

(15.667) which are statistically at par with T_6 treatment ($FeSO_4$ + $MnSO_4$) and T_3 treatment ($FeSO_4$) followed by T_9 treatment ($FeSO_4$ + $ZnSO_4$ + $MnSO_4$) and T_7 treatment ($FeSO_4$ + $ZnSO_4$). Moreover, Minimum number of spikelets (13.00) were observed in T_4 treatment (3 kg $ZnSO_4$) which were similar to T_2 treatment (Spraying plants with Tube well) and T_1 treatment (No spray).

3.5. Grains/Spike

Number of grains per spike is one of the most important yield determinants. A considerable variation in number of grains per spike was observed in different treatments for foliar application of micronutrients. Maximum grains

(49.00) were produced by T_8 treatment ($ZnSO_4$ + $MnSO_4$) which was statistically similar with T_1 treatment (No spray), while Minimum number of grains (36.33) were produced by T_3 treatment (1.6 kg $FeSO_4$) which were considerably similar to T_4 treatment (3 kg $ZnSO_4$) (**Table 1**). Modaihsh (1997) [19] stated that application of Zn improves the grain yield along with biological yield of wheat and this statement support our results in relation to biomass.

3.6. Grain Yield (kg/ha)

Highest grain yield was produced by T_6 treatment ($FeSO_4$ + $MnSO_4$) which was statistically similar with T_9 treatment ($FeSO_4$ + $ZnSO_4$ + $MnSO_4$), T_8 treatment ($ZnSO_4$ + $MnSO_4$) and T_5 treatment (1 kg $MnSO_4$) whereas minimum yield was observed in T_1 treatment (No spray) (**Figure 1(b)**). Improved, 1000-grain weight, grain and straw yield due to micronutrient application by Ziaeian and Malakouti (2001) [20] and Maralian (2009) [21]. Yilmaz *et al*. (1997) [22] reported that due to foliar spray of Zn fertilizer, wheat grain yield increase 100%. Our results were similar with Khan *et al*. (2007) [23] who reported that wheat grain yield increases up to 31.6% by addition of 5 kg Zn per hectare over control.

3.7. Biological Yield (kg/ha)

Maximum biological yield was produced by T_8 treatment ($ZnSO_4$ + $MnSO_4$) followed by T_1 treatment (No spray) and T_7 treatment ($FeSO_4$ + $ZnSO_4$). However, T_2 (water spray) yielded minimum biological yield (**Figure 1(c)**). Micronutrient application has a positive and significant correlation with dry matter production of different crops [24]-[27].

3.8. Harvest Index (%)

Harvest index is the ratio of yield over biomass. Harvest index of each treatment due to foliar spray of micronutrients was noticeably different from other treatments. Maximum harvest index (42.263) was observed in T_9 ($FeSO_4$ + $ZnSO_4$ + $MnSO_4$) treatment which was statistically at par with T_6 treatment ($FeSO_4$ + $MnSO_4$). Moreover, minimum harvest index was counted in T_1 treatment (No spray) followed by T_3 treatment (1.6 kg $FeSO_4$) and T_7 treatment ($FeSO_4$ + $ZnSO_4$) (**Figure 1(d)**). Webb and Loneragan (1990) [28] also reported that there is positive relationship between the micronutrient application with biomass production of wheat.

4. Conclusion

So, it can be concluded that wheat yield can be improved by applying micronutrients ($ZnSO_4$, $FeSO_4$ and $MnSO_4$) exogenously.

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