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 T₁ = No spray, T₂ = Spraying plants with tube well water (control), T₃ = Spraying plants with 1.6 kg FeSO₄/100 L water/acre, T₄ = Spraying plants with 3 kg ZnSO₄ (21%)/100 L water/acre, T₅ = Spraying plants with 1 kg MnSO₄/100 L water/acre, T₆ = Spraying plants with (FeSO₄ + MnSO₄), T₇ = Spraying plants with (FeSO₄ + ZnSO₄), T₈ = Spraying plants with (ZnSO₄ + MnSO₄), and T₉ = Spraying plants with (FeSO₄ + ZnSO₄ + MnSO₄). 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 FeSO₄ + ZnSO₄ + MnSO₄ 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 (MnSO₄, FeSO₄ and ZnSO₄) 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:

T₁ = No spray;
T₂ = Spraying plants with tube well water (control);
T₃ = Spraying plants with 1.6 kg FeSO₄/100 L water/acre;
T₄ = Spraying plants with 3 kg ZnSO₄ (21%)/100 L water/acre;
T₅ = Spraying plants with 1 kg MnSO₄/100 L water/acre;
T₆ = Spraying plants with (FeSO₄ + MnSO₄);
T₇ = Spraying plants with (FeSO₄ + ZnSO₄);
T₈ = Spraying plants with (ZnSO₄ + MnSO₄);
T₉ = Spraying plants with (FeSO₄ + ZnSO₄ + MnSO₄).

To collect the data form respected treatments, 1m² 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 ≤ 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 observed from T6 treatment (FeSO4 + MnSO4) that was statistically similar to T7 (FeSO4 + ZnSO4), T1 (No spray), T8 (ZnSO4 + MnSO4) and T9 treatments (FeSO4 + ZnSO4 + MnSO4). The minimum plant height (85.567 cm) was observed in T4 treatment (3 kg ZnSO4) where plants were sprayed with ZnSO4. 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/m²

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 T9 treatments (FeSO4 + ZnSO4 + MnSO4) followed by the T7 treatment (FeSO4 + ZnSO4) and T4 treatment (3 Kg ZnSO4). Whereas, considerable minimum tillers were observed in T6 treatment (FeSO4 + MnSO4) (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 wasmeaningfully affected due to foliar application of micronutrients (Table 1). Considerably, maximum spike length (10.97 cm) was observed in T7 treatment (FeSO4 + ZnSO4) which was statistically similar to T8 treatment (ZnSO4 + MnSO4), and T3 treatment (1.6 kg FeSO4), while minimum spike length (8.733 cm) was detected in T4 treatment (3 kg ZnSO4) which was similar to T5 treatment (1 kg MnSO4). 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 Lukaszewski (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 T8 treatment (ZnSO4 + MnSO4) produces maximum number of spikelets.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Spike length (cm)</th>
<th>Spikelets/spike</th>
<th>Grains/spike</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>93.26 ab</td>
<td>9.867 abcd</td>
<td>14.00 bc</td>
<td>47.667 ab</td>
</tr>
<tr>
<td>T2</td>
<td>88.30 cd</td>
<td>10.10 abc</td>
<td>14.00 bc</td>
<td>40.00 e</td>
</tr>
<tr>
<td>T3</td>
<td>86.60 d</td>
<td>10.367 ab</td>
<td>15.333 a</td>
<td>36.333 f</td>
</tr>
<tr>
<td>T4</td>
<td>85.567 d</td>
<td>8.733 d</td>
<td>13.00 c</td>
<td>39.667 ef</td>
</tr>
<tr>
<td>T5</td>
<td>90.40 bcd</td>
<td>9.067 cd</td>
<td>14.667 ab</td>
<td>43.667 cd</td>
</tr>
<tr>
<td>T6</td>
<td>97.00 a</td>
<td>9.950 abc</td>
<td>15.667 a</td>
<td>46.667 abc</td>
</tr>
<tr>
<td>T7</td>
<td>94.467 ab</td>
<td>10.933 a</td>
<td>14.667 ab</td>
<td>42.00 de</td>
</tr>
<tr>
<td>T8</td>
<td>92.733 abc</td>
<td>10.367 ab</td>
<td>15.667 a</td>
<td>49.00 a</td>
</tr>
<tr>
<td>T9</td>
<td>92.150 abc</td>
<td>9.400 bcd</td>
<td>15.00 ab</td>
<td>44.667 bcd</td>
</tr>
</tbody>
</table>

LSD (p ≤ 0.05) = 4.93, 1.21, 1.20, 3.47

Values sharing a letter in common do not differ significantly (p ≤ 0.05). T1 = No spray; T2 = Spraying plants with tube well water (control); T3 = Spraying plants with 1.6 kg FeSO4/100 L water/acre; T4 = Spraying plants with 3 kg ZnSO4 (21%)/100 L water/acre; T5 = Spraying plants with 1 kg MnSO4/100 L water/acre; T6 = Spraying plants with FeSO4 + MnSO4; T7 = Spraying plants with FeSO4 + ZnSO4; T8 = Spraying plants with ZnSO4 + MnSO4; T9 = Spraying plants with FeSO4 + ZnSO4 + MnSO4.
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$_4$). 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 T₈ treatment (ZnSO₄ + MnSO₄) which was statistically similar with T₁ treatment (No spray), while Minimum number of grains (36.33) were produced by T₃ treatment (1.6 kg FeSO₄) which were considerably similar to T₄ treatment (3 kg ZnSO₄) (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 T₆ treatment (FeSO₄ + MnSO₄) which was statistically similar with T₉ treatment (FeSO₄ + ZnSO₄ + MnSO₄), T₈ treatment (ZnSO₄ + MnSO₄) and T₅ treatment (1 kg MnSO₄) whereas minimum yield was observed in T₁ 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 T₈ treatment (ZnSO₄ + MnSO₄) followed by T₁ treatment (No spray) and T₇ treatment (FeSO₄ + ZnSO₄). However, T₂ (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 T₉ (FeSO₄ + ZnSO₄ + MnSO₄) treatment which was statistically at par with T₆ treatment (FeSO₄ + MnSO₄). Moreover, minimum harvest index was counted in T₁ treatment (No spray) followed by T₃ treatment (1.6 kg FeSO₄) and T₇ treatment (FeSO₄ + ZnSO₄) (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 (ZnSO₄, FeSO₄ and MnSO₄) exogenously.

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