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Short Communication

Foliar Application of Micronutrients Improves the Wheat Yield and Net Economic Return

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ABSTRACT

A field trial to evaluate the response of exogenously applied commercial micronutrients mixture "Shelter" (Zn = 2%, Fe = 1%, Mn = 2%, Cu = 1%, B = 1%) on growth and yield of wheat was conducted during winter 2007-2008. Shelter was exogenously sprayed at tillering, jointing, booting, earing, tillering and booting, tillering and jointing, jointing and earing, booting and earing, tillering, jointing and booting and tillering, jointing, booting and earing stages of wheat; while control plots were sprayed with distilled water. There was no effect of micronutrient application on number of tillers, fertile tillers and spike length. Exogenous application of Shelter significantly improved the number of grains per spike, 1000-grain weight, grain yield, straw yield, biological yield and harvest index at different growth stages of wheat. An increase in the number of grains per spike, 1000-grain weight, straw yield and biological yield was recorded when Shelter was applied at least at three growth stages. Maximum grain yield, net economic returns were recorded when Shelter was applied at tillering, jointing, booting and earing. In conclusion, foliar application of commercial preparation Shelter may be helpful to improve the wheat yield.

Key Words: Foliar application; Micronutrients; Wheat; Grain yield; Benefit:cost ratio

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important cereal crop, source of staple food and thus the most important crop in food security prospective. Besides its tremendous significance, average yield is far below than developed countries (FAO, 2010), although the genetic potential of local varieties is not less than any country in the region. Major yield limiting factors includes delayed sowing, high weeds infestations, water shortage at critical growth stages and imbalance and non-judicious fertilizers use.

The micronutrients play an important role in increasing crop yield. Micronutrients have prominent affects on dry matter, grain yield and straw yield in wheat (Asad & Rafique, 2000). Iron plays role in biological redox system, enzyme activation and oxygen carrier in nitrogen fixation (Romheld & Marschner, 1991); Mn utilized in enzyme activation, electron transport and in disease resistance (Burnell, 1988); Zinc is important to membrane integrity and phytochrome activities (Shkoinik, 1984); Cu is vital for physiological redox processes, pollen viability and lignifications (Marschner, 1995) and B is required for reproductive plant parts, cell wall formation and stabilization, membrane integrity, carbohydrate utilization, stomatal regulation and pollen tube formation (Marschner, 1995). Therefore, much attention is needed for adequate and balanced use of micronutrients along with macronutrients to enhance the response of wheat to organic fertilizers (Baddaruddin *et al.*, 1999).

Several reports indicate that either soil or foliar application of micronutrients have positive correlation with wheat yield (Rashid & Rafique, 1988; Wisal *et al.*, 1990; Habib, 2009; Wroble, 2009). Foliar spray of micronutrients is more effective to control deficiency problem than soil application (Torun *et al.*, 2001). Foliar application of B at reproductive stage enhanced grain yield of wheat (Wroble, 2009), while its deficiency caused male sterility resulting in grain set failure in wheat (Jamjod & Rerkasem, 1999).

Previously, many reports have evaluated the response of wheat to micronutrients (soil or foliage) application but little information is available regarding combined application of micronutrients. It is surmised that micronutrient application may improve the wheat growth and yield. This experiment was conducted to evaluate the role of mixed application of micronutrients in improving wheat performance.

MATERIALS AND METHODS

Site and soil: This study was conducted at Agronomic

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Research Area, University College of Agriculture, Bahauddin Zakariya University, Multan during 2007-2008. The climate of the region is subtropical to semi-arid. The experimental area is located at 71.43° East longitude, 30.2° North latitude and at an altitude of 122 m above sea level.

Experimental details: The experiment was laid out in randomized complete block design with three replications and a net plot size of 6 m × 4.2 m. Commercially available micronutrients mixture 'Shelter'™ (Zn = 2%, Fe = 1%, Mn = 2%, Cu = 1%, B = 1%) was exogenously applied at four different growth stages of wheat in different combinations viz., tillering, booting, jointing, earing, tillering + booting, tillering + jointing, jointing + earing, earing + booting, (9) tillering + booting + jointing and tillering + booting + jointing + earing; while control plots were sprayed with distilled water.

Prior to seed bed preparation, 10 cm pre-soaking irrigation was applied. After workable moisture level in the field, seed bed was prepared by cultivating the field twice with tractor mounted rotavator, each followed by planking. Wheat variety Abdulstar-2002 was sown on 25th November, 2007 at seed rate of 125 kg ha^{-1}. Fertilizers were applied @ 150 and100 kg N and P_2O_5 ha^{-1}, respectively in the form of urea and DAP. Full dose of P and half of N were applied at sowing and remaining N was applied with first irrigation. Bromoxinil + MCPA @ 1000 g a.i. ha^{-1} was sprayed 30 days after (after first irrigation) in moist soil using a knapsack hand sprayer fitted with T-jet nozzle to keep the crop free from weeds. Other three irrigations were applied at booting, earing and grain formation stage. Crop was harvested manually on 24th April, 2008.

Observations: At harvest, 1 m^2 quadrate was randomly thrown at four places and total number of tillers and fertile tillers were counted and then averaged. Ten plants from each plot were randomly selected at maturity and plant height was measured from base to top of spike and then average was worked out to record plant height. Spikes of 10 randomly selected plants were threshed separately. Total number of grains were counted and averaged to find number of grains per spike. Spike length of 10 randomly selected spikes was recorded separately and average was worked out to calculate spike length. To calculate 1000-grain weight, three samples of 1000 grains were obtained from each plot, weighed by electric balanced and then averaged.

To calculate biological yield, crop was harvested manually when mature. The plants were tied into bundles and left in the respective plots for 3 to 4 days for sun drying, weighed with a spring balance and then converted into kg ha^{-1}. These plants were threshed manually to record straw and grain yield and converted into kg ha^{-1}. Grain yield was adjusted at 10% moisture contents. Harvest index was calculated as ratio between grain yield and biological yield.

Economic analysis: A benefit–cost (BC) analysis was carried out to determine the economic feasibility of micronutrient use. The amount of Shelter once used in the study was 1.23 L ha^{-1}, costing PKR 500 for one time. The production costs included field preparation, seed, sowing, fertilizing, weeding, crop protection measures and harvesting. The gross income was estimated using the prevailing average market price in Pakistan, PKR 24 kg^{-1}. The net income was estimated by subtracting the cost of production from gross income. BC ratio was estimated.

Statistical analysis: The data were statistically analyzed using statistical program MSTAT-C. Analysis of variance 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 differences among treatment means (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Total numbers of tillers, fertile tillers and spike length remained unchanged by the foliar application of Shelter at different growth stages (Table I). This might be due to the reason that up to tillering stage nothing was applied to the experimental units. Similar findings were earlier reported by Asad and Rafique (2000) and Hussian *et al.* (2002) for foliar applications of micronutrients.

Micronutrient application substantially improved the plant height and grain number per spike, which were maximum when 'Shelter' was applied at tillering, booting, jointing and earing stage followed by the plots receiving shelter at tillering, booting and jointing stage (Table I).

Table I: Influence of micronutrient application on plant height and yield related traits in wheat

Treatments	Total tillers (m^{-2})	Fertile tillers (m^{-2})	Plant height (cm)	Spike length (cm)	Grains per spike	1000-grain weight (g)
Control	367	334	65.5 f	9.1	29.9 d	31.4 e
Tiller	368	337	67.6 f	9.6	33.6 cd	32.4 de
Boot	367	338	71.6 e	9.5	34.8 c	32.8 de
Joint	369	338	71.7 e	10.8	36.4 bc	32.6 de
Ear	373	342	72.2 de	10.8	34.5 c	33.3 cde
Tiller + Boot	363	334	72.9 de	9.7	34.3 c	34.5 bcd
Tiller +Joint	368	337	75.9 cd	10.0	37.1 bc	35.3 abc
Joint + Ear	370	337	75.7 cd	11.0	39.2 ab	35.4 abc
Boot + Ear	367	335	78.6 bc	11.0	40.0 ab	34.6 bcd
Tiller + Boot + Joint	368	335	80.0 ab	11.2	41.6 a	36.0 ab
Tiller + Boot + Joint + Ear	368	338	82.7 a	11.8	42.7 a	37.6 a
LSD value at 5% probability	NS	NS	3.7	NS	3.8	2.20

Means not sharing the same letters in a column differ significantly from each other at 5% level of probability

Table II: Influence of micronutrient application on wheat yield and harvest index

Treatments	Biological yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)
Control	7917 f	5287 cd	2629 f	33.2 cd
Tiller	8147 f	5350 cd	2797 ef	34.3 bcd
Boot	7962 f	5133 d	2828 ef	35.5 ab
Joint	8180 ef	5301 cd	2879 def	35.2 abc
Ear	8210 ef	5161 d	3049 cde	37.1 a
Tiller + Boot	9231 cd	5985 bc	3246 bc	35.1 abc
Tiller +Joint	9033 de	5491 cd	3209 bc	35.5 ab
Joint + Ear	9587 bcd	6447 ab	3139 bcd	32.7 d
Boot + Ear	9991 bc	6639 ab	3339 b	33.0 cd
Tiller + Boot + Joint	10088 ab	6790 a	3299 bc	32.6 d
Tiller + Boot + Joint + Ear	10885 a	7010 a	3670 a	35.5 ab
LSD value at 5% probability	857.10	715.70	279.60	2.20

Means not sharing the same letters within a column differ significantly from each other at 5% level of probability

Table III: Influence of micronutrient application on net income and benefit: cost ratio (BCR) of wheat

Treatments	Total benefits (Rs.)	Total expenses (Rs.)	Net income (Rs.)	BCR
Control	63096	27696	35400	2.28
Tiller	67128	28196	38932	2.38
Boot	67872	28196	39676	2.41
Joint	69096	28196	40900	2.45
Ear	73176	28196	44980	2.60
Tiller + Boot	77904	28696	49208	2.71
Tiller +Joint	77016	28696	48320	2.68
Joint + Ear	75336	28696	46640	2.63
Boot + Ear	80136	28696	51440	2.80
Tiller + Boot + Joint	79176	29196	49980	2.71
Tiller + Boot + Joint + Ear	88080	29696	58384	2.97

Increase in plant height due to the foliar spray of Shelter might be due to the involvement of micronutrients in different physiological process like enzyme activation, electron transport, chlorophyll formation and stomatal regulation etc., which ultimately resulted in greater dry matter (Asad & Rafique, 2000; Hussian *et al.,* 2002). Increase in number of grains per spike due to foliar application of Shelter might be due the involvement of B in pollen tube formation and Cu in pollen viability, resulting in more seed set. Deficiency of B at reproductive stage may result in male sterility of wheat (Jamjod & Rerkasem, 1999), leading to shorter anthers and non-fertility of many florets and ultimately poor grain set per ear (Huang *et al*., 2000; Guenis *et al*., 2003; Soleimani, 2006; Chaudry *et al*., 2007).

Shelter sprayed at tillering, jointing, booting and earing stages resulted in maximum 1000-grain weight, followed by its application at tillering, jointing and booting, but also at par with the plots where Shelter was once applied at tillering, jointing, booting or earing stage only (Table I). Increase in this attribute by foliar spray of Shelter might be due to the involvement of the sprayed micronutrients in enzyme activation, membrane integrity, chlorophyll formation, stomatal regulation and starch utilization at early stages, while enhanced accumulation of assimilate in the grains, which result in heavier grains of wheat at later stages. In conformity, Soylu *et al.* (2005), Guenis *et al*. (2003) and Hussian *et al*. (2002) reported significant increase in 1000-grains weight of wheat with foliar application of micronutrients.

Micronutrient application at tillering, jointing, booting and earing stages resulted in maximum biological yield and straw yield followed by its spray at tillering, jointing and booting. Minimum biological and straw yields were recorded in control plots, followed by the plots where Shelter was once applied at tillering, jointing, booting or earing stages only (Table II). These findings might be due the involvement of micronutrients in a variety of physiological and biochemical processes, culminating in more dry matter production (Grewal *et al*., 1997; Torun *et al.,* 2001). More than one foliar spray of micronutrients mixture starting at tillering improved the biological, grain and straw yields.

Foliar application of Shelter at all the four growth stages of wheat increased grain and straw yields compared with control having minimum grain yield followed by those, where Shelter was applied only at tillering, jointing or booting stages (Table II). This increased grain yield is the direct result of improvement in yield components. Grain size and number of grains per spike had positive correlation with grain yield. So highest grain yield might be the direct effect of improvement in grain size and number of grains per spike (Table I). Many reports indicate the positive correlation of foliar spray of micronutrients with grain yield in wheat. Foliar application of iron, zinc and boron at reproductive growth stages increase grain and straw yield significantly in wheat (Korzeniowska, 2008; Habib, 2009; Wroble, 2009).

Maximum harvest index was recorded when Shelter was applied only at earing stage followed by booting, earing, tillering and booting, tillering and jointing and all the various growth stages (Table II). But minimum harvest index was recorded where Shelter was applied at tillering, booting and jointing of wheat (Table II). This might be due to better starch utilization resulting in more better seed set and translocation of assimilates to developing grains, which increase the grain size and number of grains per spike (Table I). This is contrary to Hussain *et al*. (2002) who said that micronutrients did not affect significantly to harvesting index.

Maximum net income and BC ratio was recorded where Shelter was exogenously applied at four growth stages (tillering, booting, jointing & earing) of wheat compared with control (no application), which resulted in minimum net income and BCR (Table III). The increase in BC ratio due to foliar application of Shelter at four growth stages is supposedly due to the enhanced grain yield (Table II).

CONCLUSION

Foliar application of micronutrients mixture Shelter at various growth stages improved plants height, grains per spike, 1000- grain weight, biological yield, harvest index, straw yield and grain yield in wheat. Thus, foliar application of Shelter at tillering, booting, jointing and earing of wheat is suggested to get maximum grain yield and net income.

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