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Effect of Foliar Application of Plant Micronutrient Mixture on Growth and Yield of Wheat (*Triticum aestivum* L.)

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Abstract: A field experiment was conducted to study the effect of nutrient mixture Plant Care sprayed on foliage at different physiological growth stages of wheat. The composition of the nutrient mixture Plant Care was N 200 g, P_2O_5 200 g, K_2O 200 g, Zn 750 mg, Iron 1500 g, Copper 750 mg, Boron 300 mg, Manganese 750 mg, Magnesium 375 mg and Molybdenum 8 mg. The results indicated that there were non-significant differences in number of plants m^{-2}, total number of tillers per plant and number of fertile tillers per plant. A significant improvement in number of grains per spike and 1000 grain weight was found when the nutrient mixture was sprayed on wheat foliage at three growth stages i.e. at tillering, booting and milking. Spraying micronutrients at tillering and/or booting and milking growth stage(s) increased the grain yield of wheat. The foliar spray of micronutrients at the same stages also gave maximum biological and straw yields. The values of harvest index were non-significant with each other. The maximum net profit was gathered in foliar spray of micronutrients at tillering+booting+milking growth stages of wheat. The booting stage appeared the most suitable physiological stage for foliar application of micronutrients. The other stage for the application of micronutrients might be tillering.

Key words: Wheat (*Triticum aestivum* L.), physiological growth stages, micronutrient mixture, foliar spray

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop of Pakistan. Average yield of wheat in Pakistan is lower than that of developed countries. In most wheat growing areas inadequate supply of essential elements at improper developmental stages limit yield potential of wheat. In Pakistan, the use of sub optimal and imbalanced level of plant nutrients limit production potential of soils thus better plant nutrient management is, therefore, necessary for achieving self reliance in agriculture[1].

The application of only two or three plant essential elements (nitrogen and phosphorous with and without potassium) is not adequate to achieve potential yields of crops. Deficiency of one or more plant essential elements results reduction in yields and quality and makes the plants susceptible to many fungal and bacterial diseases. Adequate nutrient management is among the most important factors in obtaining good yields of crops. It has been estimated that at least 30 to 50% of crop yield is attributable to commercial fertiliser nutrient inputs[2].

The importance of balance application of plant essential elements is well recognized throughout the world. Nitrogen and phosphorous deficiency is common in wheat production in Pakistan; use of potassium in potassium deficient parts of the country and against stresses is also important to increase grain yield. Micronutrient-deficient soils are widespread throughout the world and cause reduction in yield and quality. Use of micronutrients with nitrogen, phosphorus and potassium enhanced response of wheat to organic fertiliser[3]. Modaihsh[4] reported that application of micronutrient combinations either in chelated or non-chelated forms gave greater biological and grain yields than individual applications of the micronutrients.

The critical growth stage for nutrient application is one of the determinants of nutrient use efficiency. Weisz *et al.*[5] found that manipulating the timing of nitrogen application can optimize early tillering and yield component formation. Negm and Zahran[6] concluded that the booting stage is the most suitable stage to apply micronutrients for wheat plants with another spray at tillering.

Various nutrient solutions are available in the market with different names. In this study nutrient solution Plant Care(N 200 g, P_2O_5 200 g, K_2O 200 g, Zn 750 mg, Iron 1500 g, Copper 750 mg, Boron 300 mg, Manganese 750 mg,

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Magnesium 375 mg and Molybdenum 8 mg) was sprayed on wheat foliage at different growth stages. The aims of the study were I) to determine the adequate amount of plant essential elements and ii) to identify the best suitable growth stage(s) for mineral nutrient sprays.

MATERIALS AND METHODS

Wheat variety Inqalab-91 was sown on 2nd November 2004 on a well-prepared seedbed in rows 22.5 cm apart using the seed rate 150 kg ha^{-1}. Randomized Complete Block Design with four replications was laid out to study the effect of nutrient mixture Plant Care sprayed at different growth stages of wheat. The composition of the nutrient mixture Plant Care was N 200 g, P_2O_5 200 g, K_2O 200 g, Zn 750 mg, Iron 1500 g, Copper 750 mg, Boron 300 mg, Manganese 750 mg, Magnesium 375 mg and Molybdenum 8 mg. Plant nutrient mixture was sprayed at tillering, booting, milking, tillering+booting, tillering+ milking, booting+milking and tillering+booting+milking. A control treatment was also included for the comparison.

Data on number of plants, total number of tillers and number of fertile tillers were recorded from an area of one square meter. Averages plant height at maturity and spike length of 10 plants randomly selected from each plot were taken to record data on plant height at maturity and spike length whereas average grains of 10 spikes from each experimental unit recorded data on grains per spike.

At harvesting maturity, wheat crop in each experimental unit was harvested separately and tied up in bundles. The tied bundles were left in the field for ten days before threshing. Just before threshing biological yield was recorded. The threshed wheat grains of each experimental unit were weighed to note economic yield. Three samples of 1000 grains were taken from the seed lot of each plot to record the data on 1000 grains weight. The ratio between economic and biological yields was taken as harvest index. Total cost that vary was subtracted from the total value of economic and straw yields for economic analysis.

RESULTS AND DISCUSSION

The results indicated that there were no significant differences in number of plants m^{-2}, total number of tillers per plant and number of fertile tillers per plant among experimental units (Table 1). However, number of plants m^{-2}, total number of tillers per plant and number of fertile tillers per plant ranged between 183.3 to 190.6, 358.6 to 371.0 and 332.3 to 348.3, respectively (Table 1). Up to the tillering stage no treatment was applied to the experimental units. Foliar spray of nutrient mixture was started at the tillering stage of wheat. Number of plants m^{-2} and total number of tillers per plant were the performance of wheat plants of the same cultivar Inqalab-91 treated equally thus indicated non-significant differences among the experimental units. Fertile tillers were differentiated from the total number of tillers after foliar application of nutrient solution so they appeared genetically controlled character hardly to be influenced by the application of nutrients. In this study wheat plants were not given any treatment up to the tillering stage, therefore the results did not differ significantly. Applications of different levels of nutrients at the sowing time and/or at the 2-3 leaf stage i.e. before tiller initiation may influence the plant population of wheat. The inferences are supported by the findings of Asad and Rafique[7], who stated that total number of tillers of wheat plants per unit area did not differ by the applications of micronutrients (Zarzameen). Spike length was measured after completion of nutrient treatments sprayed at different growth stages but it was not influenced by foliar application of plant essential elements at different growth stages of wheat indicating inherent potential of wheat cultivars (Table 1).

Table 1: Effect of foliar application of micro nutrient mixture on growth and yield of wheat (*Triticum aestivum* L.)

Plant characters	Control	Tillering	Booting	Milking	Tillering + booting	Tillering + milking	Booting + Milking	Tillering + booting + milking	LSD (0.05)
Number of plants m^{-1}	190.60	188.30	186.60	187.60	189.60	183.60	186.30	183.30	NS
Total tillers m^{-1}	360.30	370.30	363.00	369.60	363.00	370.00	358.60	371.00	NS
Fertile tillers m^{-1}	335.30	344.00	332.30	334.60	348.30	339.30	332.30	343.00	NS
Plant height (cm)	72.20cd	73.37cd	76.73bc	70.87d	82.37a	80.00ab	81.27ab	84.93a	5.76
Spike length (cm)	10.00	11.00	11.30	11.10	12.10	12.50	12.10	13.00	NS
Number of grains $spike^{-1}$	48.67e	51.21d	52.00d	51.12d	52.99cd	54.82bc	56.51b	59.98a	2.97
1000-grain weight (g)	31.54e	33.43de	34.62cd	33.27de	36.04bc	34.79cd	36.88b	38.83a	1.89
Biological yield (kg ha^{-1})	8998d	9567c	10000c	9543cd	11000b	11000b	11040b	12010a	489.15
Grain yield (kg ha^{-1})	3235f	3672de	3835cd	3467ef	4225b	4105bc	4281ab	4582a	303.26
Straw yield (kg ha^{-1})	5763c	5895c	6168c	6076c	6971ab	6897b	6759b	7431a	441.23
Harvest index (%)	35.96	38.34	38.33	36.37	36.62	37.32	38.78	38.14	NS
Net profit (Rs. ha^{-1})	4569	8070	9769	4920	11604	12405	13072	15555	

Means not sharing similar letter(s) differ significantly at 0.05 level of probability

Plant Care = N 200 g, P_2O_5 200 g, K_2O 200 g, Zn 750 mg, Iron 1500 g, Copper 750 mg, Boron 300 mg, Manganese 750 mg, Magnesium 375 mg and Molybdenum 8 mg, NS = Non-significant

When nutrient solution was sprayed thrice at tillering, booting and milking, maximum plant height of 84.93 cm was recorded which was statistically at par with the plant heights of 82.37, 80.00 and 81.27 cm obtained by foliar application of nutrient mixture at tillering+booting, tillering+booting and booting+milking, respectively (Table 1). The results showed that foliar application of nutrient mixture starting from tillering or booting up to the milking stage significantly improved the plan height. Earlier Asad and Rafique[7] also reported significant increase in wheat plant height by the applications of micronutrients (Zarzameen).

Significantly higher number of grains per spike and heavier seeds were produced by wheat plants by the foliar spray of nutrient mixture at tiilering+booting+milking. Number of grains and 1000 grains weight varied from 48.67 to 59.98 per spike and 31.54 to 38.83 g, respectively (Table 1). Number of grains per spike and 1000 grains weight are important yield component along with number of fertile tillers per unit area. Spraying the nutrient mixture at any growth stage did not influence number of fertile tillers per unit area (Table 1) but a significant improvement in number of grains per spike and 1000 grains weight was noted when the nutrient mixture was sprayed on wheat foliage at three growth stages i.e. tillering, booting and milking (Table 1). Increased individual grain by the application of micronutrients might be good strategy to narrow the gap between actual and potential yields. Calderini and Monasterio[8] suggested that it will be more effective to select genotypes for higher grain yield by increasing individual grain yield rather than grain number. Logically maximum grain yield (4582 kg ha^{-1}) was observed in the same treatment followed by foliar spray at booting + milking (Table 1). This indicated that critical stages for significant increase in grains per spike and 1000 grains weight by foliar application of micronutrient solution are booting and milking. Spraying micronutrients at booting and/or milking growth stage (s) may increase the grain yield of wheat. Table 1 also indicated that when nutrient solution was sprayed only at milking stages, the grain yield was at par with that of control. This indicated that the critical growth for foliar spray of micronutrients in wheat is booting rather than milking. Asad and Rafique[9] reported that the application of micronutrients (Zarzameen) increased grain yield and yield components of wheat and over unfertilised control. Muhammad and Khan *et al.*[10] also reported that grain yield of maize was increased with combined application of Fe, Mn and Zn showing thereby synergetic relationship with each other. Negm and Zahran[6] concluded that the booting stage is the most suitable stage to apply micronutrients for wheat plants with another spray at tillering.

Biological yield and straw yield ranged between 8998 and 12010 kg ha^{-1} and 5763 and 7431 kg ha^{-1}, respectively (Table 1). The maximum biological yield (12010 kg ha^{-1}) and straw yield (7431 kg ha^{-1}) was observed in wheat plants sprayed nutrient mixture at tillering+booting+ milking. The same micro nutrient treatment also gave the maximum grain yield and straw yield of wheat (Table 1). More than one foliar spray of mixture of micronutrients starting at tillering improved the biological, grain and straw yields. Asad and Rafique[9] reported that the fertiliser treatments (macro and micro nutrients) increased wheat dry matter, grain and straw yields significantly over an unfertilised control. The results indicated that higher value of biological yield in wheat plants receiving foliar spray at tillering+booting+milking were due to increased straw yield and increased grain yield. Increased biological yield by increasing the rates of foliar application of micronutrients resulted in increase in grain yield at the same magnitude under the prevailing conditions. Application of micronutrient combinations either in chelated or non-chelated forms gave greater biological and grain yields of wheat than individual applications of the micronutrients[4]. That is why the values of harvest index of wheat plants receiving different amount of micronutrients were non-significant with each other. The values of harvest index varied from 35.96 to 38.78 (Table 1). Muhammad and Khan[10] reported that Hall tonic (a fertiliser containing micronutrients) showed no significant effect on harvest index wheat crop.

Maximum net profit (Rs. 15555/- ha^{-1}) was gained in foliar spray of micronutrients at tillering + booting + milking growth stages of wheat by spending extra money of Rs. 1365/- ha^{-1} than control whereas minimum net profit (Rs. 4569/- ha^{-1}) was gathered in control (Table 1). So net profit increased by more than ten times by investing extra one rupee on foliar application of micronutrients at the physiological stage booting with other applications at tillering and milking. Spray only at milking stage resulted net profit of Rs. 4920/- ha^{-1}, which was very close to net profit of Rs. 4569/- ha^{-1} obtained from control treatment.

It is concluded that the booting stage is the most suitable physiological stage for foliar application of micronutrients in terms improvement in number of grains per spike and 1000 grain weight hence grain yield. The other stage for the application of micronutrients might be tillering. It was also confirmed by economic analysis that omission of foliar application of nutrient solution at booting stage resulted a substantial decrease in net profit. Another foliar application of nutrient solution at tillering enhanced the net profit.

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