EFFECT OF MICRONUTRIENTS FOLIAR APPLICATION ON YIELD AND QUALITY OF MAIZE

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ABSTRACT:- Micronutrients have globally proven importantance in agriculture. The deficiency of micronutrients is an expected trend among cereal crops which confines yield and nutritional value of grains. A field trial was laid out to evaluate the effect of micronutrients on yield and quality of maize in randomized complete block design (RCBD) at Agronomic Research Area, University of Agriculture, Faisalabad . The treatments comprised of no micronutrient application (control), water spray and foliar application of micronutrients mixture @ 250, 500, 750, 1000, 1250 and 1500 ml ha^{-1} at stem elongation stage of maize. All micronutrients treatments significantly improved plant height, cob length, number of grains rows cob^{-1}, cob weight, 1000-grain weight, grain yield, biological yield, harvest index, grain protein and grain oil contents. However, micronutrients application at stem elongation stage showed non-significant effect on plant papulation and number of cobs plant^{-1}. Therefore, for attaining maximum yield of maize, it is suggested that 250 ml ha^{-1} at stem elongation stage of maize should be used.

Key Words: Maize; Micronutrients; Stem Elongation; Yield; Yield Components; Oil Contents; Pakistan.

INTRODUCTION

Maize (*Zea mays* L.) is the most important and high yielding cereal crop in the world. Regarding production it ranks first worldwide, while in Pakistan, it ranks third after wheat and rice. Maize is cross pollinated annual crop belonging to family Poaceae. Its grain comprises starch (72%), protein (10%), fiber (5.8%), edible oil (4.8%), sugar (3.0%) and several important minerals and vitamins (Farhad et al., 2009). Average yield of maize is about 3.49 t ha^{-1} and average annual grain production is about 3.26 mt in Pakistan. Maize fulfills the demand of rapidly increasing population, in the form of food, feed, fodder and as raw material for industry (Tahir et al., 2009). The yield potential of rice maize system is about 40-65%, and to meet the future food demands, it is necessary to increase the yield potential up to 70-80% (Cassman et al., 2002). It is important to adopt improved package of production technology for better production of maize. Its Micronutrients have globally proven importance in agriculture. Plants require a balanced dose of micronutrients (Fe, Zn, Cu and Mn) at cellular and systematic level for achieving their maximum yield (Puig and Penarruba, 2009). The micronutrients (iron, zinc, copper, molybdenum, boron, manganese and chlorine) are basic ingredients for the growth and development of plants and they are consumed in lower quantity as compared to nitrogen, phosphorus and potassium. The

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micronutrients such as iron, zinc and manganese play an important role in the corn nutrition as compared to other elements (Zarabimafi and Pour, 2014).

Among micronutrients, copper, zinc and boron looked more deficient for the productivity and growth of the plants. Ambak et al. (2015) suggested that micronutrients deficiency dramatically decreased the yield of barley and rice. Wide range of nutrients deficiency occurs in field due to intensive crop rotation and imbalanced fertilizer used (Ghaffari et al., 2011). Micronutrients play an active role in the plant metabolism process starting from cell wall development to respiration, photosynthesis, cholorophyll formation, enzyme activity, nitrogen fixation and reduction (Adihkary et al., 2010). Yield and grain production increased due to proper use of micronutrients (Johnson et al., 2005). Balanced plant nutrition with the application of micronutrients can decrease the expense of costly fungicides and pesticides (Rivera et al., 2003). Micronutrients availability to plants is significantly affected by the soil fertility (Aref, 2012) as soil pH affects the copper, zinc and manganese accessibility. The yield, quality and macronutrients use efficiency was improved up to 50% by supplying plants with micronutrients, either through soil application, foliar application, or seed treatment (Ghaffari et al., 2011). Foliar applied fertilizer is a valuable tool in agric-ulture. Aref et al. (2011) found that the effectiveness of foliar application is 6 to 20 times more as compared to soil application. Recent study has shown that foliar application of micronutrients (Fe, Zn and Mn) significantly increased the yield of crop (Bahrani and Pourreza, 2014). Holloway et al. (2006) reported that Zn and Mn were 40-60% more effective when applied as a separate fluid than coated granules or blended fertilizer when banded.

Therefore, the present study was conducted to evaluate the effect of foliar application of micronutrients on yield and quality of maize under prevailing conditions of Faisalabad, Pakistan.

MATERIALS AND METHOD

A field trial was laid out to evaluate the effect of micronutrients on growth, yield and quality parameters of maize crop at Agronomic Research Area, University of Agric-ulture, Faisalabad (a semi-arid area, 31.26°N latitude 73.06°E longitude, 184.4 m above sea level), Pakistan during spring 2014,. The experiment was done in 6 m × 3 m plot size with three replications arranged in randomized complete block design (RCBD). Soil sampling was done before sowing of crop, according to method used by Chapman and Pratt (1978). The pre sowing physicochemical analysis of the soil was ascertained (Table 1).

Seed bed was prepared for maize by using 3-4 ploughing and 1-2 planking (planking was done to crush the hard clods to smoothen the soil surface and to compact the soil lightly). Soil was leveled by using laser land leveler. Maize was sown during 1st week of March 2014. The maize hybrid Monsanto DK-9108 was used as test crop. Sowing was done by using dibbling method with row to row distance of 75 cm and plant to plant distance 15 cm was maintained. Seed rate used was 25 kg ha^{-1}. Recommended doses of Nitrogen (N), Phosphorus (P) and Potassium (K)

Table 1. Pre-sowing physicochemical analysis of soil

Physical characteristics	Values
Sand	45%
Silt	40%
Clay	15%
Textural class	
Chemical characteristics	
Saturation	32%
Ph	7.75
EC_c	2.25 dS m^{-1}
Organic matter	0.6%
Nitrogen	0.048%
Phosphorus	6.67 ppm
Potassium	184.1 ppm
Zinc	0.54 ppm
Iron	4.1 ppm
Copper	0.18 ppm
Manganese	1.7 ppm
Boron	0.96 ppm
Sulpher	Nil

fertilizers were applied @ 247-171-124 kg ha^{-1} using urea, diamonium phosphate and sulphate of potash as the sources. Half dose of N and whole of P and K were applied at the time of sowing while the remaining nitrogen was applied in splits. Irrigation was applied at critical growth stages; first irrigation after one week of germination, then next irrigation after eight days interval till silking, then three to five days interval till grain formation by keeping it in mind of the rain fall and no moisture stress after silking stage. Weather data (temperature, relative humidity and rainfall) during crop season was also obtained (Figure. 1).

All other agronomic practices were kept normal. Micropower was used as a source of micronutrients. It is solution of micronutrients (Zn 4.7%, B 1.0%, Fe 2%, Mn 2.0% and Cu 0.3%). Different concentrations of micropower were added in 247 l ha^{-1} of water. The experiment comprised the following treatments: T_1 = Control (No spray), T_2 = Water spray, T_3= 250 ml ha^{-1}, T_4 = 500 ml ha^{-1}, T_5= 750 ml ha^{-1}, T_6= 1000 ml ha^{-1}, T_7= 1250 ml ha^{-1}, T_8= 1500 ml ha^{-1}. It was sprayed with the help of hand sprayer at stem elongation stage. Crop was harvested at maturity on June 18, 2014. Twenty plants were selected as a sample to estimate the morphological characters and seed oil and protein contents. Crude oil in seed was determined according to AOAC (1995). Seed protein was determined according to Kjeldhal method (Bremner, 1964). The data was

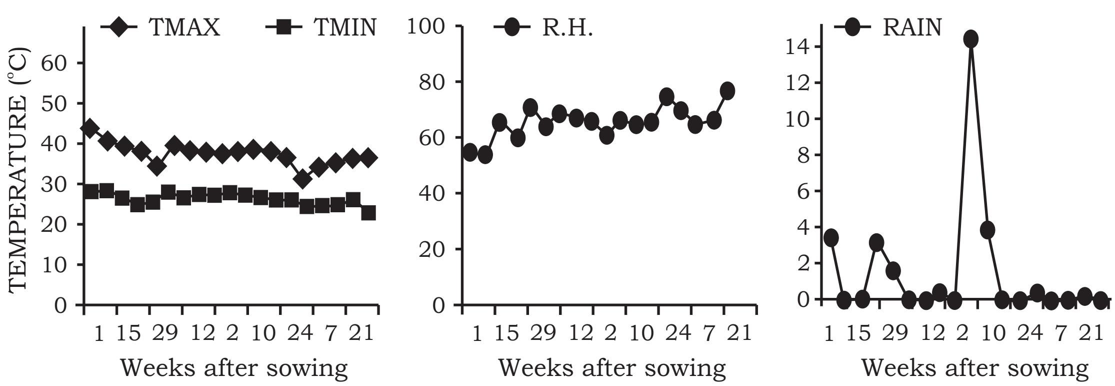

Figure 1. Weekly maximum and minimum temperature, relative humidity and rainfall during crop season

collected on various yield and quality parameters and it was statistically analyzed by using Fisher's analysis of variance technique (Steel et al., 1997) and least significant difference (LSD) test at 5% probability was applied to test significance among treatment's means.

RESULTS AND DISCUSSION

The levels of micronutrients affected significantly the plant height, number of cobs plant^{-1}, number of grain rows cob^{-1}, number of grains cob^{-1}, 1000 grain-weight, biological yield, grain yield. Results showed that foliar application of micronutrients had no significant effect on plant population because thinning and gap filling was practiced to maintain the plant population. Plant height is an indication of growth and development factors, it takes part in grain yield as more green area more will be the photosynthetic activity. Maximum plant height (195 cm) was recorded when micronutrients was sprayed @ 1250 ml ha^{-1} at stem elongation stage (Table.2). It was statistically at par with 1500 ml ha^{-1} of micronutrients application (193 cm). While control showed the minimum plant height of maize (153.67 cm) which was statistically at par with water spray (156 cm). The improvement of plant height might be due to foliar application of micronutrients at right time, right proportion and right method. Ghaffari et al. (2011) reported that foliar application of micronutrients improved the length of the plant.

The foliar application of micronutrients had no effect on number of cobs per plant. Maize genotype is the second yield contributing factor, they concluded that number of cobs per plant were significantly affected by genotypic variation (Barlog and Frckowiak-Pawlak, 2008; Harris et al., 2007).

The number of grain rows per cob is an important yield contributing parameter. The foliar application of micronutrients @ 1250 ml ha^{-1} resulted in maximum number of grain rows (16) which was statistically at par with application@ 1500 ml ha^{-1} producing 15.47rows. The minimum numbers of grain rows were recorded in control and water spray treatment (11.87 and 12.40, respectively). The maximum number of grains (341.33) were recorded when micronutrients sprayed @ 1250 ml ha^{-1}. It was statistically at par with 1500 ml ha^{-1} of micronutrients application (333). While minimum number of grains (224.33 and 232.33, respectively) was recorded in control and water sprayed treatment. Cob length is most important yield component. Greater the length of cob more would be the number of grains as a result higher the grain yield. Highest cob length (16.57 cm) was recorded when micronutrients sprayed @ 1250 ml ha^{-1} which was statistically at par with 1500 ml ha^{-1} of micronutrients application (16cm). While lowest cob length was recorded in control and water sprayed (11.80 cm and 12.07 cm, respectively). The foliar application of micronutrients improved the yield and yield contrib-uting parameters (Ghazvineh and Yousefi, 2012; Ghaffari et al., 2011; Yaseen et al., 2010). Micronu-trients plays an important role in metabolic functions of plants from cell wall development to respiration, photosynthesis, cholorophyll formation, enzyme activity and nitrogen fixation and reduction (Adhikary et al., 2010). The increase in number of grains per cob might be due to foliar application of micronutrients mixture by increasing enzymes activity, disease resistance, pollen.

Results showed that foliar application of micronutrients significantly improved the 1000- grain weight of maize (Table 2). Maximum 1000-grain weight (402.76 g) was recorded when micronutrients sprayed @ 1250 ml ha^{-1}. It was statistically at par with 1500 ml ha^{-1} of micronutrients application (395.33 g). Minimum 100-grain weight was recorded in control and water sprayed (268 g and 274 g, respectively). Data revealed that cob weight per plot and grain pith ratio significantly affected by foliar application of micronutrients (Table 3). The maximum cob weight per plot (1319 g) was recorded when micronutrients sprayed @ 1250 ml ha^{-1}. It was statistically at par with 1500 ml ha^{-1} of micronutrients application (1293 g). Minimum cob weight per plot was recorded in control and water sprayed (911 g and 918 g). The maximum grain pith ratio (3.67) was recorded when micronutrients sprayed @ 1250 ml ha^{-1}. It was statistically at par with 1500 ml ha^{-1} of micronutrients application (3.63). Minimum grain pith ratio was recorded in control and water sprayed (2.68and 2.73, respectively). The increase in cob weight might be due to foliar application of micronutrients because micronutrients are involved in plant growth, biochemical and physiological processes (Salem and El-Ghizawy, 2012). The foliar application of micronutrients improved the grain pith ratio of maize due to combined effect of micronutrients in proper quantity and applied at proper time and method. Which enhanced reprodu-ctive growth and ultimately grain yield.

The maximum grain yield (11.19 t ha^{-1}) when micronutrients sprayed @ 1250 ml ha^{-1} which was statistically at par with 1500 ml ha^{-1} of micronutrients application (10.63 t ha^{-1}). Minimum grain yield was recorded in control and water sprayed (5.76 t ha^{-1} and 5.83 t ha^{-1}, respectively). Maxim-

Table 2. Effect of foliar application of micronutrients levels on yield and yield components of maize

Treatments	Plant Population	Plant height (cm)	Number of cobs $plant^{-1}$	Number of grain rows cob^{-1}	Number of grains cob^{-1}	Cob length (cm)	1000-grain weight (g)
T_1	10.00	153.67^{f}	1.00	11.87^{f}	224.33^{f}	11.80^{f}	268.00^{f}
T_2	10.33	156.00^{f}	1.00	12.40^{f}	232.33^{f}	12.07^{f}	274.00^{f}
T	11.00	168.67^{e}	1.11	13.20^{e}	277.76^{e}	13.65^{e}	333.00^{e}
T_4	10.67	174.33^{d}	1.00	14.00^{d}	294.00^{d}	14.33^{de}	346.00^{d}
T_5	10.00	181.00^{c}	1.11	14.53^{cd}	309.00^{c}	14.90^{cd}	368.00^{c}
T_6	10.33	190.33^{b}	1.22	15.07^{bc}	323.33^{b}	15.43^{bc}	385.76^{b}
T_7	10.00	195.00^{a}	1.33	16.00^{a}	341.33^{a}	16.57^{a}	402.76^{a}
T_8	10.00	193.00^{ab}	1.11	15.47^{ab}	333.00^{ab}	16.00^{ab}	395.33^{ab}
LSD 5%	01.547	002.176	0.3133	00.1582	010.29	00.6092	012.45

Means followed by same letter do not differ significantly at P = 0.05 level

Table 3. Effect of foliar application of micronutrients levels on yield and yield components of maize.

Treatments	Cob weight plot^{-1} (g)	Grain pith ratio	Biological yield t ha^{-1}	Grain yield t ha^{-1}	Harvest index (%)	Grain oil contents (%)	Grain protein contents (%)
T_1	911^{f}	2.68^{f}	15.73^{e}	05.76^{f}	39.55^{e}	4.20^{g}	8.16^{e}
T_2	918^{f}	2.73^{f}	15.80^{e}	05.83^{f}	39.82^{e}	4.25^{g}	8.19^{e}
T_3	1077^{e}	3.19^{e}	18.79^{d}	07.92^{e}	45.40^{d}	4.40^{f}	8.39^{d}
T_4	1144^{d}	3.33^{d}	19.20^{cd}	08.59^{d}	46.87^{cd}	4.45^{e}	8.45^{cd}
T_5	1196^{c}	3.45^{c}	19.57^{c}	09.26^{c}	48.68^{c}	4.52^{d}	8.51^{c}
T_6	1263^{b}	3.55^{bc}	20.19^{b}	10.07^{b}	50.67^{b}	4.59^{c}	8.67^{b}
T_7	1319^{a}	3.67^{a}	21.04^{a}	11.19^{a}	53.82^{a}	4.69^{a}	8.69^{a}
T_8	1293^{ab}	3.63^{ab}	20.63^{ab}	10.63^{ab}	52.30^{ab}	4.64^{b}	8.66^{ab}
LSD 5%	32.19	0.1108	00.4499	00.6599	01.886	0.0303	0.078

Means followed by same letter do not differ significantly at P = 0.05 level

um biological yield (21.04 t ha^{-1}) and harvest index (53.82%) was recorded when micronutrients applied @ 1250 ml ha^{-1} which was statistically at par with 1500 ml ha^{-1} of micronutrients spray (10.63 t ha^{-1}). While minimum biological yield and harvest index was recorded in control and water sprayed (Table 3). This results are in line with the findings of Safyan et al. (2012) who reported that foliar application of iron and zinc increased the carbohydrates, starch, indole acetic acid and protein in grain of maize. This will improve the yield of maize. The application of micronutrients combinations gave the highest biological yield as grain yield was also influenced which might be attributed to the additional availability of nutrients (Ali et al., 2008; Tabrizi et al., 2009). Ghaffari et al. (2011) reported that harvest index was increased by the application of micronutrients.

Grain oil and protein contents are an important quality parameters of maize. These are significantly affected by foliar application of micronutrients (Table 3). Maximum grain oil contents (4.69%) were recorded when micronutrients sprayed @ 1250 ml ha^{-1}. While minimum grain oil contents were recorded in control and water sprayed (4.20% and 4.25%, respectively). Maximum protein contents (8.69%) were recorded when micronutrients sprayed @ 1250 ml ha^{-1} which was statistically at par with 1500 ml ha^{-1} of micronutrients application (8.66%). While minimum grain protein contents were recorded in control and water sprayed (8.16% and 8.19%, respectively). These results are in line with findings of Zarabimafi and Pour (2014) who reported that foliar application of micronutrients increased the seed protein content of maize. Ghaffari et al. (2011) reported that foliar application of micronutrients improved the grain oil contents of maize. The control and water spray treatments statistically showed same results regarding yield, yield contributing parameters and quality related parameters because only water spray might not be beneficial for optimum growth of the plant.

It is therefore, concluded that the foliar application of micronutrients positively affected all the studied characters of maize. However, foliar application of zinc @ 1250 ml ha^{-1} at stem elongation stage of maize is the most suitable and beneficial to increase the production potential of maize under the agro ecological conditions of Faisalabad, Pakistan.

LITERATURE CITED

AOAC. 1995. Association of official analytical chemists. Official methods of analysis, 16th ed. AOAC International, Washington, D. C. USA.

Adhikary, B. H., J. Shrestha and B. R. Baral. 2010. Effects of micronutrients on growth and productivity of maize in acidic soil. Intern. Res. J. Appl. Sci. 1:8-15.

Ali, S., A.R. Khan, G. Mairaj, M. Fida and S. Bibi. 2008. Assessment of different crop nutrient management for yield improvement. Aus. J. Crop Sci. 2:150-157.

Ambak, K. and T. Tadano. 2015. Effect of micronutrient application on the growth and occurance of sterility in barley and rice in a Malaysian deep peat soil. Soil Sci. Plant Nutri. 37:715-724.

Aref, F. 2011. Influence of zinc and boron nutrition on copper, manganese and iron concentrations in maize leaf. Aus. J. Basic and Appl. Sci. 5:52-62.

Arif, F. 2012. Manganese, iron and copper contents in leaves of maize plants (*Zea mays* L.) grown with different boron and zinc micronutrients. Afr. J. Biot. 11:896-903.

Bahrani, A. and J. Pourreza. 2014. Effects of micronutrients on seed yield and oil content of *Brassica napus* L. cv. Talayeh. Bangladesh J. Bot. 43:231-233.

Barlog, P. and Frckowiak-Pawlak. 2008. Effect of mineral fertilization on yield of maize cultivars differing in maturity scale. Acta Sci. Pol. Agricultura 7:5-17.

Bremner, J.M. 1964. Organic forms of nitrogen. In: C.A. Black. et al. (eds.). Methods of soil analysis, Part-2. Amer. Soc. Agron., Inc., madison, Wisconsin. 9:1235-1255.

Cassman, K.G., A. D. Dobermann and D.T. Walters. 2002. N-use efficiency, and N management. J. Human Health . 31:132-140.

Chapman, H.D., and R.F. Pratt. 1978. Methods analysis for soil, plant and water. Univ. of California Div. Agric. Sci .p. 16-38

Farhad, W., M. F. Saleem, M. A. Cheema and H. M. Hammad. 2009. Effect of poultry manures levels on the productivity of spring maize (*Zea mays* L.). J. Animal Plant Sci. 19:122- 125.

Ghaffari, A., A. Ali, M. Tahir, M. Waseem, M. Ayub, A. Iqbal and A.U. Mohsin. 2011. Influence of integrated nutrients on growth, yield and quality of maize (*Zea mays* L.). J. Plant ScI. 2:63-69.

Ghazvineh, S. and M. Yousefi. 2012. Study the effect of micronutrient application on yield and yield components of maize. J. Agric. Environ. Sci. 12:144-147.

Holloway, R., D. Brace, I. Richter, M. McLaughlin, G. Hettiarachchi and R. Armstrong. 2006. Micronutrient availability improved with fluids. Fluid J. 3:15-18.

Hossain, M. B., T. L. Kumar and S. Ahmad. 2001. Effect of zinc, boron and molybdenum application on the yield and nutrient uptake by BRRI Dhan 30. J. Bio. Sci. 1:698-700.

Johnson, S.E., J.G. Lauren, R.M. Welch and J.M. Duxbury. 2005. A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicer arientinum*), lentil (*Lens culinaris*), rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Nepal. Exp. Agric. 41:427-448.

Puig, S., and L. Penerruba. 2009. Placing metal micronutrients in context: transport and distribution in plants. Plant Biol. 12:299-306.

Rivera, J. A., C. Hotz, T.G. Lez-Cossı ´o, L. Neufeld and A. G. Guerra. 2003. The effect of micro-nutrient deficiencies on child growth. Am. Soc. Nutr. Sci. 133:4010-4020.

Safyan, N., M. R. Naderid arbagh shahi and B. Bahari. 2012. The effect of microelements spraying on growth, qualitative and quantitative grain corn in Iran. Intern. Res. J. Appl. Basic Sci. 3:2780-2784.

Salem, H. M and N. K. B. El-Gizawy. 2012. Importance of micronutrients and its application methods for improving maize (*Zea mays* L.) yield grow in clayey soil. American-Eurasian J. Agric. Environ. Sci. 12:954-959.

Steel, R. G. D., J. H. Torrie and D.A. Dickey. 1997. Principles and procedures of statistics a bio-metrical approach. McGraw Hill Book Co., Inc. New York. 3:400-428.

Tabrizi, E. F.M., M. Yarnia, M.B. Khorshidi and V. Ahmadzadeh. 2009. Effects of micro-nutrients and their application method on yield, crop growth rate (CGR) and net assimilation rate (NAR) of corn. J. Food Agri. Environ. 7: 611-615.

Tahir, M., N. Fiaz, M. A. Nadeem, F. Khalid and M. Ali. 2009. Effect of different chelated zinc sources on growth and yield of maize (*Zea mays* L.). Soil and Environ. 28:179-183.

Yaseen, A. A., E. A. A. bou El-Nour and S. Shedeed. 2010. Response of wheat to foliar spray with urea and micro-nutrients. J. Amer. Sci. 6:14-22.

Zarabimafi, F. and O. S. Pour. 2014. Effects of micro-nutrients foliar application on physiological traits and grain yield of sweet corn under water stress conditions. J. Acad. Appl. Stud. 4:40-55.

AUTHORSHIP AND CONTRIBUTION DECLARATION

S.No	Author Name	Contribution to the paper
1.	Dr. Muhammad Tahir	Concived the idea, Overall management of the article Technical input at every step
2.	NeelamYasin	Wrote Abstract, Methodology, Did SPSS Analysis, Data Collection, Result and Discussion, Introduction References

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