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Effect of soil and foliar application of zinc and iron on productivity and quality of wheat

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Abstract: A field experiment was carried out during *rabi* season of 2015-16 to study the 'effect of of zinc (Zn) and iron(Fe) application on productivity and quality of wheat' at Main Agricultural Research Station, Dharwad. The experiment was laid out in a Randomized Complete Block Design (RCBD) having fifteen treatments and replicated thrice. A common dose of 100 N: 75 P_2O_5: 50 K_2O kg ha^{-1} was applied to all the plots. Along with recommended dose of fertilizer $ZnSO_4$ and $FeSO_4$ were applied to soil at the rate of 20 kg ha^{-1}. Two foliar application of $ZnSO_4$ and $FeSO_4$ each @ 0.5 % were made at heading stage and at milking stage. Wheat crop (Var. UAS-428) responded significantly to the soil and foliar application of Zn and Fe. The higher number of productive tillers m^{-2} (273.3), weight of grain per ear head (1.47 g), 1000 grain weight (43g), ear head length (6.79 cm), number of filled grains (281), number of chaffy grains (10.7), spikelet fertility (86.1 %), grain yield ((38. q ha^{-1}) and biomass yield (100.7 q ha^{-1}) were recorded with soil (20 kg ha^{-1}) and foliar application (0.5 %) of Zn at heading and milking stage. Quality parameter like protein (14.2 %), sedimentation value (37.67 ml) was significantly higher due to soil and foliar application of zinc at heading and milking stage as compared to other treatments and found on par with soil and foliar application of iron at heading and milking stage, soil and foliar application of zinc at milking stage and soil and foliar application of iron at milking stage.

Key words : Bio-fortification, Quality, Wheat, Yield

Introduction

Wheat (*Triticum* spp.) crop is the first important and strategic cereal crop for the majority of world's population. Wheat which triggered green revolution is the second most important food crop next to rice and contributing nearly 35% to the national food basket.Wheat contributes 70-90% of calories and 66-90% of protein consumed in developing countries (Agha *et al.,* 2016) Area under wheat is 31 mha with an annual production of about 95.91mt and productivity of about 3.09 t/ ha (Anon., 2015). Micronutrient malnutrition i.e. inadequate dietary intake of iron (Fe), zinc (Zn), vitamin A and iodine (the "big four"), threatens more than 2 billion people, predominantly in developing countries (Stein, 2010).

It is estimated that, of the world's 6 billion people, 60-80 % are Fe deficient, more than 30 % are Zn deficient, 30 % are iodine (I) deficient and about 15 % are selenium (Se) deficient (Kennedy, 2003). Among the micro nutrients, Zn and Fe deficiencies are occurring in both crops and humans.

Thus, increasing micro nutrient concentration of food crop plants, resulting in better crop production and improved human and animal health, is an important global challenge. To alleviate Fe and Zn deficiency, it is required to increase their concentration in the endosperm to 8 and 30 mg kg^{-1}, respectively through different tools. According to (Anon., 2015), bio-fortification is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding or modern biotechnology. Agronomic biofortifiction is required for, keeping sufficient amount of available Zn and Fe in soil solution, maintaining adequate Zn transport to the seeds during reproductive growth stage. Therefore, agronomy related approaches offer short-term and complementary solutions to the Zn and Fe deficiency in crop production and human health. Hence, the agronomic biofortification of Zn and Fe can be done through seed treatment, soil application and foliar applications (Cakmak, 2008).

Material and methods

A field experiment was conducted during *rabi* 2015-16, at All India Co-ordinated Wheat and Barley Improvement Project (AICW&BIP), Main Agricultural Research Station, UAS, Dharwad (Karnataka) on deep black soil having 248.5, 35.6 and 329.4 kg ha^{-1} of available N, P_2O_5 and K_2O, respectively and 3.56 and 0.56 ppm DTPA- extractable Fe and Zn, respectively with a soil pH of 7.8 and organic carbon content of 0.44%. The treatments included T_1 : Soil application of $FeSO_4.7H_2O$ @ 20 kg ha^{-1}, T_2 : Foliar application of $FeSO_4.7H_2O$ @ 0.5 per cent during heading stage, T_3 : Foliar application of $FeSO_4.7H_2O$ @ 0.5 per cent during milking stage, T_4 : Foliar application of $FeSO_4.7H_2O$ @ 0.5 per cent during heading and milking stage, T_5 : Soil and foliar application of $FeSO_4.7H_2O$ @ 20 kg ha^{-1} and @ 0.5 per cent, respectively during heading stage, T_6 : Soil and foliar application of $FeSO_4.7H_2O$ @ 20 kg ha^{-1} and @ 0.5 per cent, respectively during milking stage, T_7 : Soil and foliar application of $FeSO_4.7H_2O$ @ 20 kg ha^{-1} and @ 0.5 per cent, respectively during heading and milking stage, T_8 : Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}, T_9 : Foliar application of $ZnSO_4.7H_2O$ @ 0.5 per cent during heading stage, T_{10} : Foliar application of $ZnSO_4.7H_2O$ @ 0.5 per cent during milking stage, T_{11} : Foliar application of $ZnSO_4.7H_2O$ @ 0.5 per cent during heading and milking stage, T_{12} : Soil and foliar application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} and @ 0.5 per cent, respectively during heading stage, T_{13} : Soil and foliar application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} and @ 0.5 per cent, respectively

Table 1. Effect of Zinc and Iron nutrition on yield parameters, yield , quality and micro nutrient uptake by wheat

Treatments	No. of productive tillers/m^2	Grain weight (g)/spike	1,000 grain weight (g)	Earhead length (cm)	No. of Filled grains/spike	No. of chaffy grains/spike	Spikelet fertility (%)	Grain yield (q ha^{-1})	Biomass yield (q ha^{-1})	Protein (%)	Sedimentation value (ml)	Zinc uptake (g ha^{-1})	Iron uptake (g ha^{-1})
T_1	259.0	1.3	41.9	6.0	229.0	19.0	74.7	34.4	93.2	13.4	34.0	125.2	1363.0
T_2	244.7	1.1	40.2	5.7	197.0	24.6	71.1	32.8	90.3	13.1	33.2	126.0	1401.4
T_3	250.0	1.2	40.1	5.9	211.3	23.6	72.5	33.3	91.8	13.2	33.7	128.1	1409.2
T_4	253.7	1.3	41.8	6.0	228.0	20.0	73.2	33.9	92.3	13.3	33.9	131.8	1474.1
T_5	264.3	1.3	42.0	6.1	233.6	17.0	75.8	35.3	94.6	13.5	34.5	136.2	1521.8
T_6	267.0	1.4	42.7	6.3	247.6	11.6	78.0	36.2	95.5	13.8	35.3	138.7	1541.7
T_7	270.7	1.4	43.3	6.6	258.3	11.0	81.1	37.6	98.3	14.0	37.3	142.6	1577.0
T_8	262.7	1.3	41.9	6.1	233.3	17.3	74.7	34.6	93.8	13.5	34.4	137.8	1311.0
T_9	247.3	1.2	40.4	5.8	206.0	24.0	71.5	33.1	91.1	13.2	33.3	140.1	1314.9
T_{10}	252.0	1.2	41.2	5.9	225.3	20.6	72.7	33.6	92.1	13.2	33.7	141.8	1320.4
T_{11}	257.3	1.3	41.8	6.0	228.3	19.3	73.8	34.0	92.9	13.3	34.0	146.9	1329.1
T_{12}	266.0	1.3	42.3	6.1	234.0	13.6	76.8	35.6	94.8	13.6	34.5	154.1	1338.7
T_{13}	269.3	1.4	43.1	6.5	251.3	11.3	78.5	36.7	97.1	13.9	36.7	159.8	1457.1
T_{14}	273.3	1.5	44.0	6.8	281.0	10.6	86.0	38.0	100.6	14.2	37.7	165.3	1361.0
T_{15}	238.7	1.1	37.2	5.6	194.0	27.0	70.3	32.3	88.8	12.9	33.1	117.6	1299.6
S.Em ±	1.4	0.0	1.8	0.2	11.7	0.9	2.9	0.8	2.0	0.2	0.9	3.2	35.6
C.D. at 5 %	4.1	0.1	NS	0.7	33.8	2.7	8.3	2.3	5.7	0.6	2.6	9.2	103.2

Treatments

T_1 Soil application of $FeSO_4.7H_2O$ @ 20 kg ha^{-1}.
T_2 Foliar application of $FeSO_4.7H_2O$ @ 0.5 % during heading stage.
T_3 Foliar application of $FeSO_4.7H_2O$ @ 0.5 % during milky stage.
T_4 Foliar application of $FeSO_4.7H_2O$ @ 0.5 % during heading & milky stage.
T_5 Soil & foliar application of $FeSO_4.7H_2O$ @ 20 kg ha^{-1} & @ 0.5 %, respectively during heading stage
T_6 Soil & foliar application of $FeSO_4.7H_2O$ @ 20 kg ha^{-1} & @ 0.5 %, respectively during milky stage.
T_7 Soil & foliar application of $FeSO_4.7H_2O$ @ 20 kg ha^{-1} & @ 0.5 %, respectively during heading & milky stage.
T_8 Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}.
T_9 Foliar application of $ZnSO_4.7H_2O$ @ 0.5 % during heading stage.
T_{10} Foliar application of $ZnSO_4.7H_2O$ @ 0.5 % during milky stage.
T_{11} Foliar application of $ZnSO_4.7H_2O$ @ 0.5 % during heading & milky stage.
T_{12} Soil & foliar application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} & @ 0.5 %, respectively during heading stage.
T_{13} Soil & foliar application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} & @ 0.5 %, respectively during milky stage.
T_{14} Soil & foliar application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} & @ 0.5 %, respectively during heading & milky stage.
T_{15} RDF (water spray)

during milking stage, T_{14} : Soil and foliar application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} and @ 0.5 per cent, respectively during heading and milking stage, T_{15} : RDF (water spray). The experiment was laid out in a Randomized Complete Block Design (RCBD) having fifteen treatments and replicated thrice. A common dose of 100 N: 75 P_2O_5: 50 K_2O kg ha^{-1} was applied to all the plots. Along with recommended dose of fertilizer $ZnSO_4$ and $FeSO_4$ were applied to soil at the rate of 20 kg ha^{-1} as per the treatment specification. Two foliar application of $ZnSO_4$ and $FeSO_4$ each @ 0.5 % were made at heading stage and at milking stage as per the treatments. The crop was sown on 20 November 2015 with a plot size of 3.2 m X 5 m. The variety used was UAS-428 and was sown with row spacing of 20 cm. The crop was harvested as per the treatments. All the growth and yield components were recorded and statistically analysed as per the procedures described by Gomez and Gomez (1984). Irrigation at an interval of 15-20 days was provided till the crop reached physiological maturity.

Results and discussion

Soil and foliar application of zinc and iron each @ 20 kg ha^{-1} and @ 0.5 per cent, respectively at heading and milking stages of the crop significantly influenced the yield contributing traits, yield, quality and micronutrient uptake by wheat crop.

Significantly higher number of productive tillers m^{-2} (273.3),weight of grain per ear head (1.47 g), 1000 grain weight (44 g), ear head length (6.79 cm), number of filled grains (281), number of chaffy grains (10.7), spikelet fertility (86.1%), grain yield (38.1 q ha^{-1}) and biomass yield (100. 7 q ha^{-1}) were recorded with combined soil and foliar application of zinc at both the stages, which was on par with soil and foliar application of iron at both stages, soil and foliar application of zinc at milking stage, soil and foliar application of iron at milking stage and recorded significantly higher over control (Table 1). The most probable reason of these results might be due to the role of Zn in chlorophyll biosynthesis, maintenance of photosynthetic activity and biosynthesis of auxin, which regulated the remobilization of carbohydrates to the grain and for achieving these improvements was the increase in leaf area index, providing an improved resource generating base for the crop i.e. an improved carbohydrate source. The consequence of this improved source was the improvement in overall biomass and consequently improvements in yield components of the crop. Chowdhury *et al.* (2008) revealed that application of micronutrients (soil + foliar) was the best method to increase grain yield of wheat. Wroble (2009) stated that both soil and foliar application of micronutrients were positively correlated with wheat grain yield.

Soil and foliar application of zinc at both stages recorded significantly higher protein content (14.2 %), sedimentation value (37.67 ml) recorded significantly higher over control (Table 1). Micronutrients has enhanced the accumulation of assimilates in the grains (during the grain filling stage) and the resultant seeds had greater protein content which caused the higher development of gluten and consequently in the improvement in sedimentation value. These results are in accordance with Goswami (2007) where soil application of zinc at 15 kg ha^{-1} + foliar spray of Zn at 900 g ha^{-1} exhibited highest protein content (18.7 %) along with grain Zn about 67.2 mg g^{-1} and Fe content of 39.63 mg g^{-1}.

Soil and foliar application of zinc at both stages recorded higher uptake of zinc by wheat crop (165.3 g ha^{-1}) while lower uptake was recorded in control (117.6 g ha^{-1}). Soil and foliar application of iron at both stage significantly recorded higher uptake of iron (1,576.96 g ha^{-1}) while lower uptake was recorded in control (1,299.6 g ha^{-1}). This is attributed to a positive frequently close, relationship between the grain concentrations of protein, Zn and Fe has been found in wheat (Peterson *et al.,* 1986). This indicates that protein represent a great sink for Zn and Fe (Table 3).

Conclusion

From the study, it was be inferred that soil (20 kg ha^{-1}) and foliar application of zinc (0.5 %) at heading and milking stage is the best agronomic practice in order to obtain higher grain yield and quality of the crop.

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