Effect of Some Micronutrients on Growth and Yield of Wheat and its Leaves and Grain Content of Iron and Boron

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ABSTRACT

Field studies were carried out during the growing season 2012-13 and 2013-14 at Banat's university of agricultural sciences and veterinary medicine, Timisoara, Romania to study the effect of foliar Fe, B and Fe+B fertilizer at two growth stages on growth, yield and nutrient concentration in flag leaves and grains of wheat. The treatments were laid out in randomized complete block design (RCBD) with three replications. Two years average results show that treatment receiving 333g Fe ha⁻¹+167g B ha⁻¹ at both growth stages ZGS21+ZGS41 produced the highest plant height (86.0 cm), flag leaf area (28.66 cm²), chlorophyll content (58.0 SPAD value) and grain yield (518 gm m⁻²). All micronutrients (Fe, B and Fe+B) sprayed at both stages (ZGS21+ZGS41) significantly improved micronutrients concentration in wheat flag leaf and grains over control treatment.

Keywords: iron, boron, foliar fertilization, wheat.

INTRODUCTION

In Romania, wheat (*Triticum aestivum* L.) is grown on an area of 2.135 million hectares with the total production 7.428 million tones, in average yield of 3.479 tons ha⁻¹. In 2013, considering the area cultivated with wheat crop, Romania taken the 4th place after France, Germany and Poland and, occupying into amount the yield, the 6th place following France, Germany, United Kingdom, Poland and Spain (Sala et al., 2015). Considering the production of wheat, Romania is between the last countries between the Member States (INS, 2014).

Fertilizers are necessary for enhancing productivity in crops especially in wheat, rising use macronutrients and low use micronutrients leading to an imbalance of soil chemical. A staple fertilization program with macronutrients and micronutrients in plant nutrition is very essential

in the high production of yield with good quality products, so there is a need balance use of fertilizers and agronomic procedures are needed to increase yield of this crop. The function of macronutrients and micronutrients is vital in crop nutrition for improved yield and quality (Saeed et. al, 2012).

Micronutrients such as Fe and B have essential roles in plant's life cycle and very essential for normal growth plants (Mengel et al., 2001; Fageria, 2007). Iron is most important for the respiration and photosynthesis processes. Iron is play responsibility in many plant functions. These functions include chlorophyll development, energy transfer, a ingredient of sure enzymes and proteins, and involved in nitrogen fixation. It plays an essential role in nucleic acid metabolism (Pervaiz et al., 2003; Eskandari, 2011; Sala, 2011; Havlin et al., 2014). Boron is a micronutrient

required for all plant nutrition. Boron involves at least 16 functions in plants. These functions include cell wall formation, membrane integrity, cell wall syntheses, carbohydrate metabolism, calcium uptake, flowering, RNA metabolism, respiration, indole acetic acid, (IAA) metabolism, membranes, root growth, pollination and may help in the translocation of sugar (Parr and Loughman, 1983; Bonilla et.al., 2009; Sala 2011; Pandey et al., 2013).

Foliar fertilization (or foliar feeding) is a moderately new and contentious technique of feeding plants by applying liquid fertilizer directly to their leaves (Nasiri et al., 2010).

Current research has discovered that small quantities of micronutrients, especially Fe and B either solitary or association with other micronutrients, applied by foliar spraying significantly enhanced growth and increased yield, yield components and grain quality of wheat crop. Ziaei and Malakouti (2001) found that Fe, Mn, Zn and Cu fertilization significantly increased grain yield, straw yield, 1000-grain weight, and the number of grains per spikelet. Also showed that application of Fe significantly increased the concentration and total uptake of Fe in grain, flag leaves grain protein contents as well. Asad and Rafique (2002) found that application micronutrients increased wheat dry matter, grain yield, and straw yield significantly over an unfertilized control. Foliar application of micronutrients (Fe, Mn, Zn, Cu and B) at different growth stages of wheat increased plants height, grains per spike, 1000-grain weight, biological yield, harvest index, straw and grain yield (Khan et al., 2010). Ali (2012) reported that foliar application of Fe at different growth stages enhanced plant height, spike length, 1000-grain weight, grain weight per spike, grain yield, grain protein content and protein yield of wheat plant in both growing seasons as compared to control. Rawashdeh and Sala (2013) reported that foliar application of Fe and B significantly increased plant height, number of tillers and root depth as compared to control treatment (no Fe and B application). Gomaa et al. (2015) found that the foliar application of mixture nutrients (Zn+Fe) gave the highest grain and yield components and quality of wheat grain. Foliar application of B and Zn had positive effect on yield and yield components of wheat (Ali et al., 2009; Moghadam

et al., 2012). Raza et al. (2014) reported that foliar application of B was significant affected on grain yield, number of grains per spike and 1000-grain weight.

The objectives of the experiment were to study the effect of foliar application of some micronutrients (Fe, B, Fe+B) at two growth stages on growth, yield quantity and quality also to increased concentration of Fe in grain of wheat.

MATERIALS AND METHODS

Two field experiments were conducted at the Didactic Station, Banat's University of Agricultural Sciences and Veterinary Medicine, Timisoara, Romania during growing seasons 2012-13 and 2013-14. Texturally the soil was clay. It contained 6.86 pH, 0.50 EC, 3.35% Humus, 0.19% total N, 12.91 $\mu\text{g g}^{-1}$ available P, 169.37 $\mu\text{g g}^{-1}$ available K, 1.12 $\mu\text{g g}^{-1}$ available Zn, 3.32 $\mu\text{g g}^{-1}$ available Fe and 0.26 $\mu\text{g g}^{-1}$ available B contents. The crop cultivar was Alex. The experiment was arranged in a randomized complete block design with three replications, each plot being 10.0 m long x 3.0 m wide.

Treatments including: T1: control; distilled water spray, T2: 333 g Fe ha^{-1} at ZGS21, T3: 333 g Fe ha^{-1} at ZGS41, T4: 333 g Fe ha^{-1} at ZGS21+ZGS41, T5: 167 g B ha^{-1} at ZGS21, T6: 167 g B ha^{-1} at ZGS41, T7: 167 g B ha^{-1} at ZGS21+ZGS41, T8: 333g Fe ha^{-1} +167g B ha^{-1} at ZGS21, T9: 333g Fe ha^{-1} +167g B ha^{-1} at ZGS41, T10: 333g Fe ha^{-1} +167g B ha^{-1} at ZGS21+ZGS41.

Foliar solutions were sprayed with a hand held spray bottle at the rate of 400 L ha^{-1} on plant foliage according to the Zadok's scale as described by (Zadoks et al., 1974). Nitrogen was applied in two doses. First dose of N was applied at 4 weeks after sowing in the form of complex 15:10:10 N:P:K, respectively and at a rate of 360 kg ha^{-1} . Second dose of N was applied in the form of urea at the stem elongation stage at a rate of 100 kg ha^{-1} . Besides micronutrients (Fe, B and Fe+B), every treatment had received the same dose of NPK fertilizer.

Data on the growth and yield were recorded. Grain and flag leaf samples from every plot were analyzed for Fe, B, Zn, and Cu contents. All data were statistically analyzed using MSTAT-C statistical computer package software version 2.10 for a randomized complete block design (Michigan State University, 1991). Mean comparisons of the

treatments were made by the Least Significant Difference (LSD) test at 0.05 level of probability ($p=0.05$) comparison method (MSTAT-C, 1991).

RESULTS AND DISCUSSION

Plant height

Two years average, data in (Figure 1) showed that the plant height increased significantly ($p=0.05$) due to foliar application of micronutrient (Fe, B, Fe+B) at individual stages (ZGS21 or ZGS41) and at both stages (ZGS21+ZGS41). The highest height plant mean value was obtained in T10 followed by T4 and T8. These treatments (T10, T8 and T4) showed 14.00%, 12.33% and 11.20% increase in plant height over control (T1), respectively. The lowest height plant mean value was achieved from control treatment (T1).

Iron has a structural role in chlorophyll, energy transfer within the plant and enters in root cells and B plays an important role in the physiological process of plants, such as, cell elongation, cell maturation, meristematic tissue development, sugar transportation, IAA, formation, germination and protein synthesis. This in turn, maybe leads to an increase in plant height of wheat. This result is agreement with (Ali, 2012; Bameri et al, 2012; Rehman et al, 2012; Rawashdeh and Sala, 2013) who reported plant height increased due to micronutrient foliar application.

Flag leaf area

The mean data of the two years (2012-2014) showed that flag leaf area increased significantly

Fig. 1. Plant height as affected by application of micronutrients (Fe, B and Fe+B) at different growth stages (Mean of two years); Column means followed by the same letter(s) are not significantly different at 5% probability using LSD test.

($p=0.05$) by employed foliar application of micronutrient (Fe, B and Fe+B) at individual growth stages (ZGS21 or ZGS41) and at both stages of growth (ZGS21+ZGS41). According to (Figure 2) the greatest flag leaf area mean value was obtained in (T10) followed by T4, T7 and T9. These treatments (T10, T4, T7 and T9) showed 39.13%, 27.57%, 22.43% and 19.13% increase in flag leaf area over control (T1) respectively, while the smallest flag leaf area mean value was recorded in control treatment.

Fe is an important nutrient in crops because it is necessary for many important enzymes, as well as cytochrome that is involved in electron transport chain, synthesize chlorophyll, keeps up the structure of chloroplasts, involved in nitrogen fixation and increases enzymes activities (Eskandari, 2011) which lead to higher crop production and leaf area increase (Zayed et al., 2011). Boron application at different growth stages improves the flag leaf area. Accessibility of enough nutrients resulted in higher leaf area, which in turn improved the photosynthetic activity and in the end higher dry matter accumulation. These results are supported by (Nadim et al., 2012) who observed significantly higher leaf area index by the application different micronutrients to wheat.

In general, the application of Fe and B had increased the tissue formation with better plant growth which increases its concentration in leaves and results in higher leaf area.

Chlorophyll content

Fig. 2. Flag leaf area as affected by application of micronutrients (Fe, B and Fe+B) at different growth stages (Mean of two years); Column means followed by the same letter(s) are not significantly different at 5% probability using LSD test.

Average data of two years (2012-2014) showed that flag leaf chlorophyll content increased significantly ($p=0.05$) due to foliar application of micronutrient (Fe, B and Fe+B) at individual growth stages (ZGS21 or ZGS41) and at both stages of growth (ZGS21+ZGS41). The greatest flag leaf chlorophyll content mean amount was obtained in (T10) Followed by T4, T3 and T9. These treatments (T10, T4, T3, and T9) showed 18.96%, 16.22%, 12.40% and 12.07% increase in flag leaf chlorophyll content over control (T1) respectively, while the smallest flag leaf chlorophyll content mean value was recorded in control treatment (Figure 3). It shows that Fe was more effectual on the chlorophyll content than B. These results might be due to the critical role of Fe nutrient in crop growth, involving in chlorophyll formation, photosynthesis, chloroplast development and respiration of plants and other biochemical and physiological activates (Zeidan et al., 2010). These results were agreement with (Kazemi, 2013; Rawashdeh and Sala, 2014 a,b) who demonstrated that adding Fe and B alone or in association with other micronutrients increased chlorophyll content of plants.

Grain yield

Mean of two years (2012-2014) data showed that grain yield increased significantly at 5% probability level ($p=0.05$) due to foliar application of micronutrient (Fe, B and Fe+B) at different growth stages. Figure (4) showed that the greatest grain

yield mean amount (518 gm m^{-2}) was obtained in (T10) when plants received micronutrient (Fe+B) at both growth stages (ZGS21+ZGS41) followed by T7 (498.8 gm m^{-2}), T6 (478 gm m^{-2}) and T9 (475.7 gm m^{-2}) due to B application single at both growth stages (ZGS21+ZGS41), B application single at individual growth stage (ZGS41) and Fe+B application at individual growth stage (ZGS41), respectively. These treatments (T10, T7, T6, and T9) showed 32.55%, 27.64%, 22.31% and 21.72% increase in grain yield over control respectively, while the smallest grain yield mean value (390.8 gm m^{-2}) was recorded in control treatment (T1). These results are in good line with the findings of (Zada and Afzal, 1997; Ali, 2012; Tahir et al., 2009; Khan et al., 2010; Nadim et al 2012; Raza et al., 2014), reported that the grain yield of wheat increased due to the application of Fe and B solitary or association with other micronutrients. This may be due to better crop nutrition through foliar application of Fe and B at individual growth stages and at both stages of growth also due to most important roles of Fe and B in plant growth and development which may result in improved crop growth and increased production.

Micronutrients concentration in Flag leaves and Grains

Mean two years values presented in (Table 1), the results indicated that the highest micronutrients Fe, B, Zn, and Cu $\mu\text{g g}^{-1}$ concentration in flag leaves and grains were recorded when plant

Fig. 3. Chlorophyll content as affected by application of micronutrients (Fe, B and Fe+B) at different growth stages (Mean of two years); Column means followed by the same letter(s) are not significantly different at 5% probability using LSD test.

Fig. 4. Grain yield as affected by application of micronutrients (Fe, B and Fe+B) at different growth stages (Mean of two years); Column means followed by the same letter(s) are not significantly different at 5% probability using LSD test.

Tab. 1. Micronutrients concentration ($\mu\text{g g}^{-1}$) in Flag leaves and grains of wheat (Mean of two years)

Treatments	Flag leaves				Grains			
	Fe	B	Zn	Cu	Fe	B	Zn	Cu
T1	45.34F	0.27C	12.89F	1.67H	42.94G	0.67H	20.03G	4.44I
T2	58.74D	0.31C	15.52CD	1.84G	47.61E	0.83G	21.73E	4.85G
T3	87.87B	0.30C	16.30C	2.14E	49.56D	1.01F	21.54EF	5.26CD
T4	94.92A	0.35C	18.09AB	2.38B	54.74B	1.09F	24.67B	5.41B
T5	49.22EF	0.95B	13.97EF	1.76GH	44.97F	1.26E	20.90F	4.72H
T6	50.23E	1.04B	14.09EF	2.17DE	44.37FG	1.45C	21.97E	5.11EF
T7	53.61E	1.63A	14.93DE	2.26C	46.68E	1.64B	23.84C	5.19DE
T8	59.10D	0.97B	16.84BC	2.04F	50.90CD	1.34DE	24.18BC	5.04F
T9	82.41C	1.24B	16.16CD	2.23CD	52.21C	1.40CD	23.11D	5.30C
T10	98.21A	1.84A	18.42A	2.55A	56.59A	1.76A	26.49A	5.66A
LSD	4.39	0.3583	1.344	0.0905	1.625	0.1045	0.7243	0.0905

Means followed by same letter are not significantly different at 5% probability using LSD test.

treated with micronutrients Fe+B at both growth stages (T10). The lowest of these nutrients were observed in control treatment (T1). These results are agreement with the finding of (Zeidan et al. 2010; Gomaa et al., 2015), who reported that foliar application of micronutrients significantly increased concentration of micronutrients in flag leaves and grains.

CONCLUSION

Current study showed that the foliar application of Fe, B and Fe+B at individual growth stages (ZGS21 or ZGS41) and at both growth stages (ZGS21+ZGS41) of wheat significantly increased chlorophyll content, flag leaf area, grain yield and enhanced micronutrients concentration in flag leaves and grains. Treatment (T10) gave the highest values of all studied parameters. Whilst, the lowest values of all studied parameters were obtained from control treatment.

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