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Yield and Micronutrients Content of Bread Wheat (*Triticum aestivum* L.) under a Multinutrient Fertilizer – Hal-Tonic

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ABSTRACT

We evaluated the response of bread wheat (*Triticum aestivum* L.) to the varying levels of a new multinutrient fertilizer product – Hal-Tonic – integrated with constant rates of N and P. The field experiment was conducted at Soil Fertility Section, Agriculture Research Institute, Tandojam, Sindh, involving four quadruplicated treatments, in a randomized complete block design. Grain and straw yields increased non-significantly from 1.48 to 4.25 and from 1.55 to 3.55 t ha^{-1}, respectively, when 15 kg Hal-Tonic was applied with recommended dose of NP. However, plant analytical data showed that Cu, Fe, Mn and Zn contents of leaf, straw and grain of wheat increased with the application of various levels of Hal-Tonic and mineral fertilizers. The effect was more pronounced where 10 kg ha^{-1} Hal-Tonic was applied with recommended dose of NP fertilizer.

Key Words: Hal-Tonic; Bread wheat (*Triticum aestivum* L.); Grain and straw yield; Micronutrients

INTRODUCTION

In Pakistan, bread wheat (*Triticum aestivum* L.) is produced over eight million hectares, making Pakistan one of the top 10 producers of wheat in the world. However, the average wheat yield in Pakistan (2373 kg ha^{-1}) is still much lower and, in comparison, even its neighbour country China is getting 60% (3860 kg ha^{-1}) more wheat yield (MINFAL, 2005). The efficiency of major nutrients in increasing wheat production has been well documented (Nisar & Rashid, 2003; Rashid, 2003; Jarwar *et al*., 2005; Stewart *et al*., 2005; Panaullah *et al*., 2006; Saleque *et al*., 2006; Timsina *et al*., 2006). The research on micronutrient nutrition of wheat in increasing crop production is limited in Pakistan, however, it is now well established that most soils of Pakistan are facing wide spread deficiencies of some micronutrient, especially in Zn (Rashid, 1998; Nisar & Rashid, 2003). According to an estimate, wheat crop removes 34-50 g Cu, 232-1219 g Fe, 140-330 g Mn and 66-209 g Zn for producing 2 t grain ha^{-1} (Rashid, 1998). Hence, various types of micronutrient products and multinutritional fertilizers are being experimented to fulfill the micronutrient requirements of wheat. Hal-Tonic is a multinutritional fertilizer product to supplement crop nutrition. It contains plant nutrients like P: 3%, K: 5%, Mg: 5.43%, Ca: 2.50%, Cl: 2%, Fe: 0.5%, Zn: 0.25%, Mn: 0.07%, B: 0.05%, S: 0.2%. According to Sial *et al.* (2003), the application of Hal-Tonic increased paddy yield more than 30%. In Sindh, the application of Hal-Tonic remarkably increased (up to ≈ 200%) wheat grain and straw yields by significantly affecting the important yield components. Moreover, soil contents of Fe, Mn and Zn were also increased due to Hal-Tonic application. We evaluated the effect of Hal-Tonic application on micronutrients content of leaf, straw and grain and, in turn, in increasing the wheat yield.

MATERIALS AND METHODS

A field experiment was conducted to evaluate the effect of Hal-Tonic on wheat grain and straw yields, and plant micronutrient contents, involving wheat *cv.* 'Anmol'. The experiment was laid out at Soil Fertility Section, Agriculture Research Institute, Tandojam, Sindh in a randomized complete block design with four quadruplicated treatments. The soil analysis (following Ryan *et al.,* 2001) revealed that the experimental area was heavy in texture (clay), alkaline in nature (pH: 7.8), free from salinity hazards (EC: 1.86 dS m^{-1}), calcareous in reaction ($CaCO_3$: 11.2%), and low in fertility (organic matter: 0.93%). The DTPA extractable Cu, Fe and Mn were adequate (3.67, 5.24 and 2.97 mg kg^{-1}, respectively), whereas Zn was deficient (0.42 mg kg^{-1}). The experiment involved two fertilizer sources, viz. inorganic fertilizer, i.e. nitrogen (N) and P applied as blanket dose at a rate of 170 and 85 kg ha^{-1} to all the treatments, and Hal-Tonic applied at a rate of 10 and 15 kg ha^{-1}. A control was also kept where no fertilizer source was used. After cotton picking, the land was properly prepared and irrigated with a soaking dose. Nitrogen was applied through urea in three splits, i.e., at sowing, first irrigation and second irrigation. Phosphorus was given through diammonium phosphate (DAP) at the time of sowing. The required quantity of Hal-Tonic was mixed with fine soil and broadcasted to the soil surface in two splits, i.e., 1/3rd of the required amount at first irrigation and the remaining quantity at second irrigation. Wheat seed was drilled at the rate of 125 kg ha^{-1}. Irrigation was given according to the requirements of crop. The crop was kept free from weeds throughout the growth period by manual weeding. Wheat was harvested at maturity to record the grain yield.

Leaf samples of wheat were collected at late booting stage and that of grain and straw at harvest and analysed for Cu, Fe, Mn and Zn, following Ryan *et al.* (2001). The micronutrients content were measured on Atomic absorption spectrophotometer (Shimadzu Model AA-670). The data were subjected to statistical analysis using MSTAT-C.

RESULTS AND DISCUSSION

Grain yield. The data (Fig. 1) showed that all the treatments produced higher wheat grain yield over control. The values ranged from 1.48 to 4.25 t ha^{-1} (avg. 3.50 t ha^{-1}). Wheat grain yield increased non-significantly with the increasing application of Hal-Tonic from 10 to 15 kg ha^{-1}. The beneficial effects of Hal-Tonic in increasing wheat yield may be attributed to its micronutrients content, especially zinc (Sial *et al.,* 2003). Pervaiz *et al.* (2003) reported that wheat grain yield significantly increased to Zn application. Earlier, Saif *et al.* (1997) also obtained maximum wheat yield with the application of 10 kg Zn and 100 kg P_2O_5 ha^{-1} with recommended dose of nitrogen. The data collected by National Fertilizer Development Center (NFDC), Islamabad revealed about 13% increased wheat grain yield with the application of 5 kg Zn ha^{-1} coupled with recommended dose of NPK. In most cases, these results were obtained from Zn deficient soils. Moreover, wheat yield increased 7-11% over control when supplemented with 10 kg Fe ha^{-1}, as $FeSO_4$. About 6-23% increase in wheat yield over control was also observed in different experiments conducted at various localities with the application of 5 kg Cu ha^{-1} (Rashid, 1998). The results of 25 field experiments showed that Fe, Mn, Zn, and Cu fertilization significantly increased grain yield, 1000 grain weight, and number of seeds per spikelet with the application of these nutrients (Ziaeian *et al.,* 2001). Earlier researchers also reported alike results (Habbal *et al.,* 1995; Modaihsh, 1997).

Straw yield. The data (Fig. 1) indicated that the application of Hal-Tonic along with NP gradually increased straw yield. The values ranged from 1.55 to 3.55 t ha^{-1} (avg. 2.98 t ha^{-1}). The maximum straw yield (3.55 t ha^{-1}) was recorded in treatment receiving 15 kg Hal-Tonic along with recommended dose of NP, and the minimum (1.55 t ha^{-1}) was obtained under control. The statistical analysis showed that the straw yield increased significantly with the application of Hal-Tonic and NP fertilizer over control. However, the increase in straw yield with the application from 10 to 15 kg Hal-Tonic ha^{-1} was statistically non-significant. These results are in agreement with those reported by Islam *et al.* (1999), Hossain *et al.* (2001), Pervaiz *et al.* (2003) and Sial *et al.* (2003).

Micronutrient contents of flag leaf

Copper. The data (Table I) showed that Cu content varied from 12.82 to 17.80 mg kg^{-1} (avg. 15.65 mg kg^{-1}). The minimum copper content (12.82 mg kg^{-1}) was recorded from control plot. With NP fertilizer application, it increased to 14.30 mg kg^{-1}. Application of Hal-Tonic at 10 and 15 kg ha^{-1} with recommended dose of NP fertilizers increased copper content of flag leaf to 17.7 and 17.8 mg kg^{-1}, respectively. However, there was no any significant statistical difference between both the treatments. According to Jones *et al.* (1991) 3-5 mg kg^{-1} Cu in flag leaf (before heading) is considered low while 5-50 mg kg^{-1} Cu as sufficient for wheat crop. In the present study, the data revealed that Cu content of various treatments was greater than the optimum level. This may be due to the composition of Hal-Tonic.

Iron. The data (Table I) indicated that Fe content of leaf at late booting stage ranged from 122.72 to 173.35 mg kg^{-1} (avg. 150.82 mg kg^{-1}). Maximum iron content (173.35 mg kg^{-1}) was observed in treatment receiving 15 kg Hal-Tonic along with recommended dose of NP, where as the lowest (122.72 mg kg^{-1}) recorded in control plot. Moreover, NP treated plots were considerably high in Fe content (134.10 mg kg^{-1}). The treatments containing 10 and 15 kg Hal-Tonic ha^{-1} were statistically non-significant to each other. However, both these treatments were superior to rest of the treatments. Moreover, all the treatments possessed more Fe content than the critical level and generally no treatment was found deficient, when compared with the critical limit of Fe (120 mg kg^{-1}) proposed by Reuter and Robinson (1997).

Manganese. The data (Table I) showed that Mn content of flag leaf varied from 26.77 to 65.60 mg kg^{-1} (avg. 48.04 mg kg^{-1}). Maximum Mn content was recorded in treatment receiving 15 kg Hal-Tonic + recommended dose of NP while, minimum was obtained in control. Application of Hal-Tonic increased Mn content from 26.77 to 47.4 mg kg^{-1} which is statistically significant. Application of 10 kg Hal-Tonic non-significantly increased Mn content. Further application of Hal-Tonic, i.e., 15 kg recommended dose of NP resulted in further improvement of Mn content in leaf. According to the classification given by Jones et al. (1991), the plant samples containing >15 mg kg^{-1} are sufficient in Mn content. The present results showed much higher quantity of Mn present in the flag leaf than the critical level.

Zinc. The data (Table I) showed that Zinc content of leaf varied from 15.42 to 59.20 mg kg^{-1} with a mean value of 41.36 mg kg^{-1}. Zinc content of leaf was highest (59.20 mg kg^{-1}) at 15 kg Hal-Tonic + recommended dose of NP application and lowest (15.42 mg kg^{-1}) in control plots. Statistical analysis of the results showed that Zn content in leaf increased significantly up to 10 kg Hal-Tonic ha^{-1}. Further increase in Hal-Tonic dose gave non-significant results. According to the classification given by Jones et al. (1991), the Zn content in flag leaf is low (<20 mg kg^{-1}) in

Table I. Micronutrient contents of flag leaf of wheat

Treatment N	P (kg ha^{-1})	HT	Cu	Fe (mg kg^{-1})	Mn	Zn
000	00	00	12.82c	122.72b	26.77c	15.42c
170	85	00	14.30b	134.10b	47.40b	33.97b
170	85	10	17.70a	173.10a	52.40b	56.87a
170	85	15	17.80a	173.35a	65.60a	59.20a
Avg.			15.65	150.82	48.04	41.36
LSD 0.05			0.682	22.49	12.39	5.98

Figures sharing same letters are non-significant at p = 0.05

Table II. Micronutrient contents of wheat grain

Treatments			Micronutrient contents of wheat grain			
			Cu	Fe	Mn	Zn
N	P	HT		(mg kg^{-1})		
000	00	00	10.40c	567.9c	39.01b	11.99d
170	85	00	12.65b	688.9b	44.95b	17.55c
170	85	10	14.72a	722.2ab	57.20a	31.00b
170	85	15	14.82a	766.8a	60.37a	34.80a
Avg.			13.14	686.5	50.38	23.83
LSD 0.05			1.97	49.7	6.52	3.53

Figures sharing same letters are non-significant at p = 0.05

Table III. Micronutrient contents of wheat straw

Treatments			Micronutrient contents of wheat straw			
			Cu	Fe	Mn	Zn
N	P	HT		(mg kg^{-1})		
000	00	00	13.02c	277.3d	55.02a	10.82c
170	85	00	16.03b	317.4c	76.77a	24.25b
170	85	10	18.87a	394.3b	80.25a	29.72a
170	85	15	19.47a	410.3a	82.72a	31.95a
Avg.			16.84	349.8	73.69	24.18
LSD 0.05			2.11	14.4	28.04	6.15

Figures sharing same letters are non-significant at p = 0.05

control plot while adequate where inorganic fertilizer and Hal-Tonic were used.

Micronutrient content of wheat grains

Copper. The data (Table II) depicted that the copper content (mg kg^{-1}) varies from 10.40 to 41.82 mgkg^{-1} with an average of 13.14 mg kg^{-1}. The data followed almost similar trend to that observed in case of copper content in flag leaf.

Iron. The data (Table II) showed that iron content of wheat grains varied from 567.90 to 766.82 mg kg^{-1}. Maximum iron content (766 mg kg^{-1}) was observed in the plot receiving 15 kg Hal-Tonic + Recommended dose of NP, whereas, minimum iron content (567 mg kg^{-1}) was recorded in control. The statistical analysis showed that the treatments receiving 10 and 15 kg Hal-Tonic ha^{-1} with recommended dose of NP were non-significant to each other with regard to Fe content of wheat grain. However, 10 kg Hal-Tonic ha^{-1} applied with recommended dose of NP was the superior treatment and was statistically more significant than control and inorganic fertilizer treatments. The data revealed that Hal-Tonic, applied with NP fertilizer, increased the Fe content of wheat grains. The grain is food of human being and sufficient quantity of iron content in grain surely improves the nutritional values of wheat flour.

Manganese. The data (Table II) reflected that the Mn contents of wheat grain ranged from 39.01 to 60.37 mg kg^{-1} with a mean value of 50.38 mg kg^{-1}. Maximum Mn content (60.37 mg kg^{-1}) was recorded in treatment where 15 kg Hal-Tonic was applied with recommended dose of NP, whereas, the minimum Mn content (39.01 mg kg^{-1}) was found in control plot. The statistical analysis showed that the treatments receiving 10 and 15 kg Hal-Tonic were statistically non-significant to each other. The above results are in agreement with those of Mastoi (1998), who reported that Mn content in grain increased with the application of inorganic fertilizer.

Zinc. The data (Table II) revealed that the Zn content varied from 11.99 to 34.8 mgkg^{-1} (avg. 23.83 mg kg^{-1}). The statistical analysis showed that all the treatments are statistically significant to each other. The data further showed that all the treatments improved Zn content of wheat grain over control. When the inorganic fertilizer was applied singly the Zn content increased from 11.99 to 17.55 mg kg^{-1}. It increased to 31.0 mg kg^{-1} where 10 kg Hal-Tonic ha^{-1} was applied with recommended dose of NP, and reached to its maximum (34.8 mgkg^{-1}) where 15 kg Hal-Tonic was applied with recommended dose of NP. This indicated that Hal-Tonic, due to its micronutrient contents, improved the Zn nutrition of wheat.

Micronutrients Content of wheat straw

Copper. The data (Table III) showed that copper content of wheat straw ranged from 13.02 to 19.47 mg kg^{-1} (avg. 16.84 mg kg^{-1}). Minimum copper content (13.02 mg kg^{-1}) was recorded in control plots, while the maximum (19.47 mg kg^{-1}) was observed where 15 kg Hal-Tonic was applied with recommended dose of NP fertilizer. Hal-Tonic slightly increased copper content of wheat straw over control plots. The effect was more pronounced when 10 kg Hal-Tonic was applied with NP fertilizer. Further increase due to Hal-Tonic application at 15 kg slightly increased the copper content but it was statistically non significant.

Iron. The data (Table III) showed that iron content of wheat straw ranged from 277.30 to 410.35 mg kg^{-1} (avg. 34.83 mg kg^{-1}). Iron content of straw was maximum in treatment containing 15 kg Hal-Tonic + Recommended dose of NP, hereas minimum (277.30 mg kg^{-1}) was recorded in control. Statistically all the treatments were significant to each other.

Manganese. The data (Table III) revealed that manganese content of wheat straw ranged from 55.02 to 82.72 mg kg^{-1} (avg. 73.69 mg kg^{-1}). The maximum Mn content (82.72 mg kg^{-1}) was recorded in 15 kg Hal-Tonic treated plot while, minimum (55.02 mg kg^{-1}) was recorded in control. Examination of the data showed that Hal-Tonic improved the Mn content of straw but it is statistically non-significant.

Zinc. The data (Table III) showed that zinc content of wheat straw ranged from 10.82 to 31.95 mg kg^{-1} (avg. 24.18 mg kg^{-1}). The maximum Zinc content (31.95 mg kg^{-1}) was found in the treatment received 15 kg Hal-Tonic and recommended dose of NP, while minimum value (10.82 mg kg^{-1}) was recorded in control. Statistical analysis showed that zinc content was same in wheat straw as recorded in flag leaf.

DISCUSSION

Bread wheat (*Triticum aestivum* L.) is the most widely grown type of wheat, occupying about 92% of the world's wheat growing land area. Zn deficiency is established as the most widespread micronutrient deficiency in wheat, often resulting 50% yield reduction (Alloway, 2004).

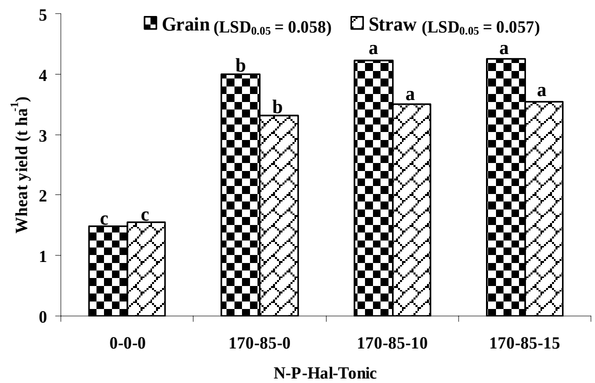
The majority of Pakistani soils are also facing wide spread Zn deficiencies (Rashid, 1998; Nisar & Rashid, 2003). Despite a 32% increase in fertilizer use in Pakistan in the last decade, the corresponding increase in yield was only 15% due to imbalanced use of fertilizers and micronutrient deficiencies, especially of Zn and boron (Kausar *et al.,* 2001).

Sillanpää (1990) conducted field trials in Pakistan and found that all 9 field sites in different parts of the country were deficient in Zn. The major reasons of Zn deficiency include soils of low Zn content, soils with restricted root zone, calcareous soils, soils low in organic matter, low applications of manure, high soil pH, and high phosphate applications (Lindsay, 1972; Rashid, 1998).

Zinc plays a vital role in plant nutrition (Brown *et al.*, 1993; Marschner, 1995; Welch, 1995) by acting as a functional, structural or regulatory co-factor of a large number of enzymes. More than 70 Zn containing metallo-enzymes are found in all of the six classes of enzymes: oxidoreductases, transferases, hydrolases, lyases, isomerases and ligases (Barak & Helmke, 1993). According to Srivastrava and Gupta (1996), Zn plays a critical role in many important enzyme systems including: carbonic anhydrase (transport of CO_2 in photosynthesis), several dehydrogenases (alcohol dehydrogenase, glutamic dehydrogenase, L-lactic dehydrogenase, malic dehydrogenase, D-glyceraldehyde-3-phosphate dehydrogenase, and D-lactate dehydrogenase), aldolase, carboxypeptidase, alkaline phosphatase, superoxide dismutase (converting superoxide radicals to hydrogen peroxide and water), RNA polymerase (protein synthesis), ribulose bi-phosphate carboxylase (important role in starch formation), and phospholipase.

Moreover, Zn also exerts an effect on carbohydrate metabolism through its effects on photosynthesis and sugar transformations. A deficiency of Zn can cause a reduction in net photosynthesis by 50-70% (Graham *et al.*, 1992). Zinc deficiency affects protein synthesis due to a reduction in RNA and the deformation and reduction of ribosomes (Brown *et al.*, 1993). Zinc plays a critical physiological role in the structure and function of biomembranes. Welch *et al.* (1982) found greater leakage of the ^{32}P isotope out of the roots of Zn-deficient wheat. Zinc limits photooxidation as a protective and stabilizing component of biomembranes against activated oxygen species (Brown *et al.*, 1993). Cackmak and Marschner (1998) reported significantly higher K leakage from the roots of Zn-deficient wheat, cotton and tomato plants.

Fig. 1. Wheat yield as effected Hal-Tonic



Zinc is involved in synthesis of auxin and its deficiency may result in most distinctive visible Zn-deficiency symptom, i.e. stunted growth and 'little leaf', due to disturbances in the metabolism of auxin, especially Indole Acetic Acid (IAA). Some evidences are there that Zn is required for the synthesis of tryptophan, the most likely precursor of IAA. An increase in tryptophan content in rice grains is observed after Zn fertilization of plants growing on a calcareous soil. (Alloway, 2004). Flowering and seed production are severely depressed in Zn deficient plants. Wheat has been reported to have developed small anthers and pollen grains, in case of Zn deficiency (Brown *et al.*, 1993).

These data support our results as the soil under study was heavy, alkaline calcareous, poorly fertile and Zn deficient. Moreover, in Pakistan, wheat is heavily fertilized with phosphatic fertilizers and farmers seldom apply the organic manures (Nisar & Rashid, 2003). These all factors could result in crop response to Zn containing fertilizers, like Hal-Tonic. Thus, the increased wheat grain yield and improved micronutrients content of various plant parts may be attributed to the Zn content of the Hal-Tonic, which is in line with the previous research results highlighting the role of Zn in plant growth and crop nutrition.

CONCLUSION

The application of 10 kg Hal-Tonic ha^{-1} increased wheat grain yield and improved micronutrient nutrition of wheat, because of its multinutrient content, especially Zn. Our results advocate micronutrient nutrition of wheat for better yields and quality production and invite intensive researches for micronutrient nutrition of wheat.

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