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EFFICIENCY OF SOME FOLIAR FERTILIZERS IN WINTER WHEAT

S. KOSTADINOVA[1], St. KALINOVA[1], A. HRISTOSKOV[1] and A. SAMODOVA[2]
[1]*Agricultural University, BG - 4000 Plovdiv, Bulgaria*
[2]*Experimental Station of Irrigation Agriculture, BG – 4400 Pazardzik, Bulgaria*

Abstract

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A field trial was carried out during 2007-2010 in the Experimental Station of Irrigation Agriculture – Pazardzik. The effect of new foliar products on the wheat grain yield and efficiency of nitrogen was investigated. Biostimulant Amalgerol containing extract of algae, herbs and plant oils, and five foliar fertilizes (Cereal mix, Foliar extra, Vertex HI-N 34, Potassium thiosulfate, Hi-Phos) were studied. The experimental design consisted of fully randomized block design with four replications. The studied treatments were: 1. Control (Untreated and unfertilized); 2. Background (Acurate 60WG – 10 g.ha^{-1} and Imact 25SC - 500 ml.ha^{-1}) 3. Amalgerol; 4. Amalgerol+Cereal mix; 5. Cereal mix; 6. Foliar extra; 7. Vertex HI-N; 8. KTS; 9. Hi-Phos. It was established that the foliar products Amalgerol+Cereal mix, Foliar extra and KTS were the most effective for grain yield of wheat - the increasing of yield compared to untreated control was by 39.3, 38.1 and 36.2%, respectively. Foliar fertilizer Hi-Phos showed higher positive effect on the wheat productivity under unfavorable meteorological conditions. The studied foliar products Amalgerol, Cereal mix, Foliar extra, Vertex HI-N 34, KTS and Hi-Phos had a positive effect on the values of PFPN and AEN. The integration of soil fertilization 120 kg N.ha^{-1} with foliar top dressing in phase end of tillering - beginning of stem elongation with Amalgerol+Cereal mix, Foliar extra and KTS leaded to productivity of 1 kg nitrogen 46-50 kg wheat grain and nearly twice as high agronomic efficiency of nitrogen 12-16 kg.kg^{-1}.

Key words: wheat, foliar fertilizers, nitrogen efficiency

Abreviations: GY - grain yield (t.ha^{-1}); PFP_N – partial factor productivity; AE_N – agronomic nitrogen use efficiency

Introduction

In modern nutritional programs of wheat soil fertilization may be optimized and reduced by means of additional application of foliar biologically active products as foliar fertilizers and biostimulants (Bruulsema et al., 2008; Chien et al., 2009). Recently a great amount of attention has been paid to enhanced efficiency of soil fertilizers. In this connections the modern technologies for wheat production in Bulgaria and worldwide a greater emphasis is placed on using mineral and complex foliar fertilizers (Delchev and Panayotova, 2010; Panayotova, 2007). The reduction of the negative effect of chemical fertilizers on the soil properties or eliminating their consequences is an issue of pressing interest for the modern agriculture; it is related to protecting the environment by obtaining ecologically clean plant products (Fageria et al., 2008; Foulkes and Hawkesfo, 2009). Foliar fertilization ensures better efficiency of the applied products as the nutrient and the biologically active substances are completely absorbed by the plants without the soil medium where secondary processes of immobilization of the nutrient element may occur or it may be washed outside the root- system soil layer (Hirschi, 2009). The use of foliar fertilizers, independently or together with pesticides, creates an opportunity to increase the economic effect of mineral fertilization, to reduce the environment pollution by reducing the fertilizer rates and their use to the best advantage (Baligar et al., 2001).

The aim of this investigation was to establish the efficiency of the new foliar fertilizers on the grain productivity of Bulgarian wheat cultivar Sadovo 1, and on the partial factor productivity and agronomical efficiency of nitrogen.

E-mail: svetlak@au-plovdiv.bg

Materials and Methods

The study was carried out in the experimental field of Experimental Station of Irrigation Agriculture – Pazardzik during three years 2010 – 2012. The effect of new foliar products on the wheat grain yield and efficiency of nitrogen was investigated. Biostimulant Amalgerol containing extract of algae, herbs and plant oils, and five foliar fertilizes (Cereal mix, Foliar extra, Vertex HI-N 34, Potassium thiosulfate, Hi-Phos) were studied. Cereal mix contains micronutrients for cereals (g/L): Mn – 330, Cu – 110, Zn – 84. Foliar extra contains macro and micronutrients (g/L): N - 121, P_2O_5 – 81, K_2O – 60, MgO – 25, B – 0.4, Cu – 0.07, Fe – 0.25, Mn – 2.3, Mo – 0.01, Zn – 0.07. Vertex HI-N 34 has high nitrogen (% w/w): N - 34%, Mg - 2.1%, Mn - 0.9%, Cu - 0.5%. Potassium thiosulfate (KTS) 0-0-25-17 (S) is a chlorine-free, clear liquid solution. Hi-Phos contents (% w/w): P_2O_5 - 30%.5, K_2O - 5.1%, MgO – 5.5%.

The experimental design consisted of fully randomized block design with four replications. The harvested size of the plots was 25 m^2. The treatments were as follows: 1. Control (Untreated and unfertilized); 2. Background (Acurate 60WG – 10 $g.ha^{-1}$ and Imact 25SC - 500 $ml.ha^{-1}$) 3. Amalgerol; 4. Amalgerol+Cereal mix; 5. Cereal mix; 6. Foliar extra; 7. Vertex HI-N; 8. KTS; 9. Hi-Phos.

Herbicide Acurate 60WG (60% metsulfuron-methyl) is selective, systemic, post-emergence sulfonylurea herbicide, and the fungicide Imact 25SC (25% flutriafol systemic triazole) is fungicide with protective, curative and eradicant action. The foliar fertilizers and biostimulator Amalgerol were applied together with herbicide Acurate 60WG and fungicide Imact 25SC at the end of tillering – beginning of stem elongation (Zadoks et al., 1974). The following quantities in $ml.ha^{-1}$ were used: 3000 ml Amalgerol; 1000 ml Cereal mix; 2500 ml Foliar extra; 3000 ml Vertex HI-N; 4500 ml KTS; 5000 ml Hi-Phos.

Nitrogen fertilization in the form of NH_4NO_3 was done before sowing (1/3 of the rate) and at early spring (2/3 of the rate). The phosphorus fertilization (P_{70}) was done before sowing in the form of triple superphosphate. The precursor crop was soy-bean fertilized by N_{80}.

The soil type of experimental field was Chromic luvisols (FAO, 2002). It has a 75–120 cm humus horizon. The mean humus content ant total nitrogen in layer 0-40 cm was 1.42% and 0.8%, respectively. The pH in the arable layer was 5.7. Content of available nutrients before beginning of the experiment was 35 mg $Nmin.kg^{-1}$; 128 mg $P_2O_5.kg^{-1}$; 180 mg $K_2O.kg^{-1}$.

Meteorological conditions during wheat vegetation period were recorded daily in the experimental area and are given in Figure 1, together with the 70-year average of temperature and precipitations. Experimental data for three years differ in meteorological terms. Unfavorable to the development of wheat was the last vegetation period. During the autumn of 2011 and the spring of 2012 a prolonged drought followed by significant rainfall in May 2012, exceeding twice the average rate of rainfall this month, was recorded. Simultaneously the winter months December 2011 and January and February 2012 were characterized by lower temperatures than the average for the region.

The obtained data were subjected to analysis of variance (ANOVA) for determination of the treatment effects. Duncan's multiple comparison range test procedure was employed to denote significant differences between the treatments using the SPSS package.

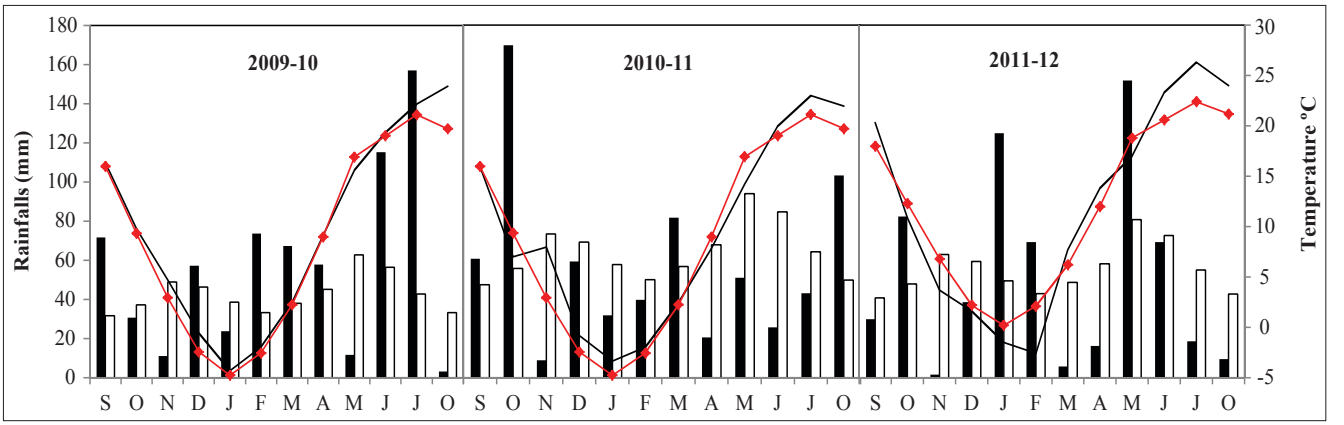

Fig. 1. Air temperature and rainfalls: white bars and lines with bars denote mean values of previous period of 70 years

Results and Discussion

The average yield of wheat grain from all studied variants reflected the climatic conditions of the year and the highest 5.117 t.ha^{-1} was in 2011 and the lowest 3.998 t.ha^{-1} was in 2012. It was found for all three experimental years that the productivity of wheat in background variant with plant protection products and the variants with used the product for foliar application is proven higher compared to the untreated control (Table 1, Figure 2).

The obtained GY from variety Sadovo 1 in the control variant average for the period was 3.774 t.ha^{-1}. Similar to the average productivity of all tested variants, it was lower during unfavorable meteorological 2012 without use of pesticides and foliar fertilizer products were obtained 0.780 t.ha^{-1} lower wheat yield compared to the harvest 2011. The results for GY in 2010 and 2011 indicated that the most effective for productivity of wheat were fertilizers Amalgerol+Cereal mix, foliar extra and KTS. During stressful climatic conditions - prolonged drought in the autumn of 2011 and the spring of 2012, also twice as large amounts of rainfall in May of 2012, the highest yields were obtained at the applying of biostimulator Amalgerol+Cereal mix, followed by leaf spraying with Hi-Phos, Amalgerol, KTS and Foliar extra. In 2012 differences were not proved between these five foliar fertilizers. The positive influence of Amalgerol+Cereal mix, Hi-Phos, Amalgerol, KTS and Foliar extra over grain yield was close and average increase of yield was 28.1%, compared to the control variant. Our data indicate that in conditions of soil drought and difficulty entrance on mobile phosphate from the roots, foliar fertilizer Hi-Phos was highly effective.

Average for the period 2010-2012 had tendency to increase GY at variety Sadovo 1 as a result of foliar application with five studied products Amalgerol, Cereal mix, Foliar extra, Vertex HI-N 34, KTS and Hi-Phos. Proven effect compared to untreated control was established when used Amalgerol+Cereal mix, Foliar extra and KTS, increased with 39.3, 38.1 and 36.2%, respectively. The results of average GY were higher and exceed 5.140 t.ha^{-1}. Independently nourish with biostimulator Amalgerol and foliar fertilizers Cereal mix and Hi-Phos increased grain yield at variety Sadovo 1 average with 21-22%. Under the conditions of this study less effect on GY was observed when use Vertex HI-N 34 (Table 1, Figure 2).

Test weight of seeds average for the period varies in a close range from 78.9 kg to 81.9 kg (data not shown). In con-

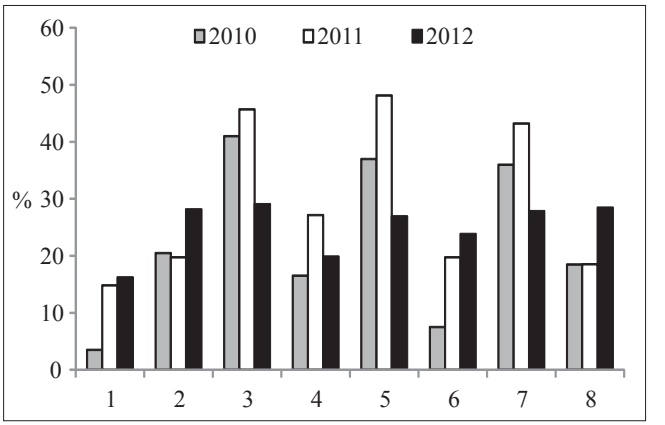

Fig. 2. Grain yield increasing of wheat (% to the control) at applying foliar products: 1 – Background; 2 – Amalgerol; 3 - Amalgerol + Cereal mix; 4. Cereal mix; 5 - Foliar extra; 6 - Vertex HI-N; 7 – KTS; 8 - Hi-Phos

Table 1
Grain yields of wheat at applying foliar products

Year	2010	2011	2012	Average	%
Treatment	t/ha				
1. Control	4.001 e	4.050 f	3.270 e	3.774 b	100.0
2. Background	4.140 de	4.651 e	3.800 d	4.197 ab	111.2
3. Amalgerol	4.820 c	4.852 d	4.191 ab	4.621 ab	122.5
4. Amalgerol + Cereal mix	5.641 a	5.903 ab	4.223 a	5.256 a	139.3
5. Cereal mix	4.662 c	5.150 c	3.921 cd	4.578 ab	121.3
6. Foliar extra	5.480 ab	6.002 a	4.150 ab	5.211 a	138.1
7. Vertex HI-N	4.300 d	4.851 d	4.050 bc	4.400 ab	116.6
8. KTS	5.440 b	5.800 b	4.182 ab	5.141 a	136.2
9. Hi-Phos	4.741 c	4.802 de	4.201 ab	4.581 ab	121.4
$LSD_{0.05}$	0.263	0.264	0.219		

trol variant it was 79.4 kg. Smaller differences between the experimental variants and control variant for this indicator may explained by the fact that the size of the seed is genetically determined and less affected by climate conditions and the technology of cultivation.

The efficiency of fertilization is characterized by the main indicators of the crop practice - partial factor productivity of nitrogen and agronomical nitrogen use efficiency (Delogua et al., 1998; Craswell and Gowdin, 1984). PFP_N represents the kg of grain harvested per kg of N fertilizer applied. It can be used as an index of total economic outputs relative to the use of all N sources - soil N and applied fertilizer (Weih et al., 2011). AE_N represents the kg of yield increase per kg of N fertilizer applied. The quantity of grain which was produced for one kilogram nitrogen fertilizer average from variants with fertilization varied depended on the conditions of the year (Figure 3). It as lower (34.1 $kg.kg^{-1}$) in 2012 under the influence of abiotic stress factors during the vegetation period of wheat. The values of PFP_N during the other two experimental years were similar and 40.9 and 43.8 $kg.kg^{-1}$, respectively. The AE_N varied slightly by years and its average values were within 6.8 - 10.0 $kg.kg^{-1}$ (Figure 4). The effect of foliar products Amalgerol, Cereal mix, Foliar extra, Vertex HI-N 34, KTS and Hi-Phos over the values of PEP_N and AE_N at the wheat corresponded with those on grain yield (Figures 3 and 4). All five products had a positive effect on the PFP_N and AE_N, compared with the background variant. The application of Amalgerol+Cereal mix, Foliar extra and KTS showed the best effect over increase of the efficiency indexes PEP_N, and especially AE_N average for the period and under climatic conditions similar to the multiannual rate for the region - in 2010 and 2011 harvest years. The integration of soil fertilization 120 kg $N.ha^{-1}$ with foliar top dressing in phase end of tillering - beginning of stem elongation with Amalgerol+Cereal mix, Foliar extra and KTS leaded to productivity of 1 kg nitrogen 46-50 kg wheat grain and nearly twice as high agronomic efficiency of nitrogen 12-16 $kg.kg^{-1}$.

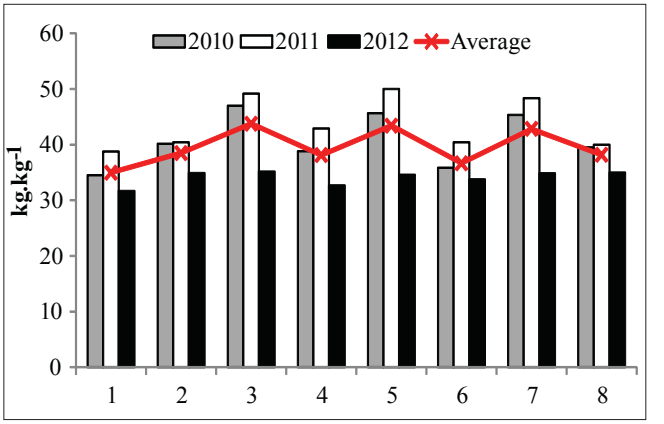

Fig. 3. Partial factor productivity of nitrogen (PFP_N) in wheat at applying foliar products:
1 – Background; 2 – Amalgerol; 3 - Amalgerol+Cereal mix; 4. Cereal mix; 5 - Foliar extra; 6 - Vertex HI-N; 7 – KTS; 8 - Hi-Phos

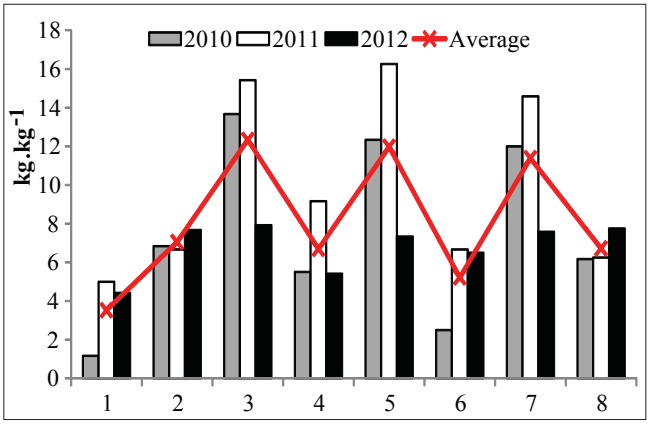

Fig. 4. Agronomical nitrogen use efficiency (AE_N) in wheat at applying foliar products:
1 – Background; 2 – Amalgerol; 3 - Amalgerol+Cereal mix; 4. Cereal mix; 5 - Foliar extra; 6 - Vertex HI-N; 7 – KTS; 8 - Hi-Phos

Conclusions

The foliar products Amalgerol+Cereal mix, Foliar extra and KTS were the most effective for grain yield of wheat - the increasing of yield compared to untreated control was by 39.3, 38.1 and 36.2%, respectively. The foliar fertilizer Hi-Phos showed higher positive effect on the wheat productivity under unfavorable meteorological conditions. The studied foliar products Amalgerol, Cereal mix, Foliar extra, Vertex HI-N 34, KTS and Hi-Phos had a positive effect on the values of PFPN and AEN. The integration of soil fertilization 120 kg $N.ha^{-1}$ with foliar top dressing in phase end of tillering - beginning of stem elongation with Amalgerol+Cereal mix, Foliar extra and KTS leaded to productivity of 1 kg nitrogen 46-50 kg wheat grain and nearly twice as high agronomic efficiency of nitrogen 12-16 $kg.kg^{-1}$.

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