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COMPARISON OF DIFFERENT SIDE-DRESSINGS ON WINTER WHEAT YIELD

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Abstract: The trial with different side-dressing fertilizations for winter wheat has been conducted at Vetovo site, Croatia, in vegetation seasons 2007/08 and 2008/09. The five side-dressing fertilizations has been tested (Control – no side-dressing, KAN – 100 kg KAN ha^{-1} in tillering and jointing stages; M1 – 8 l of foliar NPK fertilizer "Profert Mara" ha^{-1}; M2 – 16 l ha^{-1} of foliar fertilizer, and; M3 – 24 ha^{-1} of foliar fertilizer) at four winter wheat cultivars (Anika, Fiesta, Gabi and Rapsodija), with previously applied 400 kg NPK 7:20:30 ha^{-1} for all treatments. Results showed that all foliar side-dressing treatments gave winter wheat grain yield higher than the control, and that M1 treatment showed equal in comparison with KAN side-dressing. Treatments M2 and M3 had, in comparison with the control, KAN and M1 treatments, higher yields which leads toward conclusion that foliar treatments can be recommended for side-dressing for given agroecological conditions.

Key words: winter wheat, foliar fertilizer, yield, hectoliter mass, 1000 grains mass.

Introduction

The modern agriculture of high yields has been based not only on modern cultivars, but also on agro techniques, where fertilizers are contributing much as 50% to high modern crops grain yields. But, pollution due to over-fertilization in the modern crop production, especially with the nitrogen, has been recognized both as environmental and human health threat for a while (Bohlool *et al.*,1992).

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The nitrogen looses from applied N-containing fertilizers has been estimated, for different crops, from 5 to even 60% (Ayoub *et al*.,1995), and the nitrogen which cannot be taken by crops is either temporarily fixed in the soil by soil microbiota (60%), or lost by denitrification (30%) or migration in deeper soil (20%), mostly as nitrate-N (Parker, 1972). These processes, especially soil nutrient looses by water flush, can be even more emphasized in the future, due to extreme weather conditions (torrential rains, droughts), induced by global warming processes (IPCC, 2007).

Proper fertilization application strategy, where part of the fertilizers has been added prior to the primary soil tillage and rest of fertilization has been added by side-dressings, can alleviate nutrient looses, but, even this kind of fertilizers application can record up to 50% nutrient's lose (Lopez-Bellido *et al*., 2006).

The foliar fertilizers application is one of the potential solution of environmental pollution from unused N leached from the agriculture, since the total amount of the nutrients in the foliar fertilizers is substantially lower, with better efficiency than granular fertilizers, which has been confirmed by research of Smith *et al*. (1991) and Gooding and Davies (1992), who tested nitrogen uptake and efficiency of crop usage from N from urea solution applied in side-dressing. Certain problems with the foliar fertilizers is the choice of the suitable solution, nutrient content, concentration and an issue of potential crop-tissue damages, as had been observed by Woolfolk *et al*. (2002).

Combined NPK foliar fertilizers, enriched with other micro- and macro-nutrients, became also available for cereal crops, but, not always with clear advantage in comparison with other fertilizers (Haq and Mallarino, 2000; Sexton *et al*.,1998), so there is the need for further scientific elaboration on proper use and efficiency.

Therefore, the main goal of this research was to evaluate efficiency of foliar NPK fertilizer in different dosages in comparison with conventional side-dressing by granular fertilizer at different winter wheat cultivars in agroecological condition of North-eastern Croatia.

Material and Methods

The experimental site with different side-dressing fertilization systems has been established on the land of "Kutjevo" agricultural enterprise, near Vetovo, Požeško-slavonska County, Croatia. The experiment has been conducted on the slope-pseudogley soil type, with very good nutrient content (P_2O_5=19 and K_2O=22 mg 100 g^{-1} of soil, respectively, after AL method) and slightly acid soil reaction (pH (H_2O)=6.2, pH (KCl)=5.6) and moderate soil humus content (1.8%).

The experimental design was split-plot in four repetitions, with main factor "Cultivar", and sub-factor "Side-dressing", and basic experimental plot size of 7.8m^2.

The main factor "Cultivar" had four levels (cultivars): Anika, Fiesta, Gabi and Rapsodija, all creations of seed company "Agrigenetics" d.o.o., Osijek, Croatia.

The sub-factor "Side-dressing" had five levels, as follows: 1) Control – no side-dressings; 2) KAN – two side-dressings, at the beginning of the tillering vegetative stage and at the end of jointing, just before the heading stage, by 100 kg KAN ha^{-1} each; 3) M1 – two side-dressing by foliar fertilizer "Profert Mara", produced by "Vitaflora" d.o.o., Čačinci, Croatia, in recommended dose of 8 l ha^{-1} of "Profert Mara" , dissolved in 400 l of water, in both applications; 4) M2 – two applications with double dose of "Profert Mara" in each application (16 l ha^{-1} each); and 5) M3 - two applications with triple dose of "Profert Mara" in each application (24 l ha^{-1} each). The "Profert Mara" content is 5.7-1.4-2.4% NPK, 1.5% Ca, 0.2% Mg, 0.6% S, and <0,01% of Fe, Cu, Mg, B and Zn. The NPK granular fertilizer has been applied manually, whereas "Profert Mara" foliar fertilizer has been applied by pressure-controlled back-back sprayer.

In both seasons the previous crop was the maize, which stalks were incorporated by moulboard plough at 30 cm depth, together with 400 kg NPK 7:20:30. After seedbed preparation, the winter wheat was sown on 18th October 2007 and on 15th October 2008, in recommended seeding rate for each cultivar. The used crop protection was uniform for a whole experiment, with the herbicides "Tena" (a.i. *triasufuron (0,75%) + klortoluron (79%)*, 2 kg ha^{-1} pre-emergence), and "Dikocid" (a.i. *2,4 D*, 1,0 l ha^{-1} at the end of tillering stage), insecticide "Pirel D" (a.i. *klorpirilfos-etil (500 g l^{-1})+ cipermetrin (50 g l^{-1})*, 1.5 l ha^{-1} after tillering) and fungicide "Porto" (a.t. *tebukonazol (167 g l^{-1}) + karbendazim (133 g l^{-1})*, two application at 1.5 l ha^{-1} each, at the end of tillering and before heading stages).

The harvests were accomplished by small-plot harvester, on 28. June 2008 and 6. July 2009. The whole grain mass has been weighted by portable digital scale (max. 25 kg, d=0.5 g), and 2 subsamples had been collected from each plot for the grain moisture, hectoliter weight and 1000 grains mass laboratory determination. The winter wheat grain weight has been recalculated on 14% of grain moisture.

The statistical analysis of variance (ANOVA) for split-split-plot analysis was performed by SAS statistic package (V 9.1, SAS Institute, Cary, NC, USA, 1999) with the "Season" as the main factor, "Cultivar" as the sub-factor and "Side-dressing" as the sub-sub-factor. The Fisher protected LSD means comparisons were performed for P=0.05 significance levels.

Results and Discussion

The winter wheat grain yields are presented in the Table 1, where is visible significant difference between two seasons, 2007/08 and 2008/09.

The first season, 2007/08 had weather pattern more favorable for the winter wheat production at the beginning of the vegetation, with mild and moist winter

and warm but rainy spring, with very hot end, which forced early winter wheat maturity, but without drought stresses which followed after winter wheat harvest.

Tab. 1. - The effects of side-dressing by granular (*KAN*) and foliar (*Profert Mara*) fertilizers at winter wheat grain yield (t ha^{-1}), experimental site Vetovo, Croatia, average across seasons 2007/08 and 2008/09.

	Anika	Fiesta	Gabi	Rapsodija	Mean
Control	8.023 a[†]	7.695 a	7.875 a	8.188 a	7.945 A[‡]
KAN	8.265 ab	8.070 ab	8.297 ab	8.649 ab	8.320 B
M1	8.376 ab	8.259 abc	8.652 bc	8.787 b	8.519 B
M2	8.561 b	8.509 bc	9.089 c	9.158 bc	8.829 C
M3	9.202 c	8.937 c	10.334 d	9.639 c	9.528 D
Mean	8.485 A	8.294 A	8.849 AB	8.884 B	8.628
Season means:					
2007/08 = 10.878 B					
2008/09 = 6.379 A					

[†] The means labeled with the same letter within the same sort, sort average or fertilizer average are not significantly different according to Fisher protected LSD test for significance level $P<0.05$.

Opposite, the second season 2008/09, in spite of promising beginning, brought hot and droughty spring, without any considerable precipitation. Even worse, spring ended with more than two weeks rains at the end of July 2009, followed by low temperatures, which delayed winter wheat harvest and contributed toward low quality of grain yield components (Table 2 and 3, respectively, observe significantly higher hectoliter weight and lower 1000 grains mass for season means).

In comparison with the Control, the KAN treatment resulted with statistically insignificant differences for all four cultivars, ranging from 242 (Anika) to 461 (Rapsodija) kg ha^{-1}.

The main reason of low KAN efficiency in season 2007/08 is in the fact that the previous year 2007 was extremely droughty, and most of the applied fertilizers were not mineralized during that year (even 200 mm of precipitation lower in comparison with the long-term average). The soil reserves and freshly added fertilizers provided enough nutrients for rather high winter wheat yield (Control treatment mean of 10.160 t ha^{-1}), so KAN side-dressing probably wasn't fully utilized by crop, but partially flushed into the deeper soil layers by frequent rains.

In contrast, during the season 2008/09, weather pattern without rain events resulted to poor breakdown of KAN granules, so, nitrogen from the granular side-dressing KAN barely entered winter wheat crop via root system.

Treatment M1, foliar fertilizer "Profert Mara", in recommended dosage of 8 l ha^{-1} in each application, showed statistically higher winter wheat grain yield than

Control treatment for Gabi and Rapsodija cultivars. Differences were more visible in the first season, where all four cultivars had higher yield at M1 treatment (Anika +3,77%; Fiesta +4,77%; Gabi +9,92%; and Rapsodija +8,12%).

Tab. 2. - The effects of side-dressing by granular (*KAN*) and foliar (*Profert Mara*) fertilizers at winter wheat hectoliter weight (kg), experimental site Vetovo, Croatia, average across seasons 2007/08 and 2008/09.

	Anika	Fiesta	Gabi	Rapsodija	Means
Control	74.7 a[†]	77.3 a	72.9 a	73.6 a	74.6 A
KAN	74.7 a	77.7 a	74.6 b	76.3 b	75.9 B
M1	75.1 ab	77.7 a	74.6 b	76.3 b	75.9 B
M2	75.6 ab	77.3 a	74.7 b	76.1 b	75.9 C
M3	76.0 b	78.8 a	75.5 b	76.5 b	76.7 C
Means	75.2 A	77.7 B	74.4 A	75.8 B	75.8
Season means: 2007/08 = 74.2 A 2008/09 = 77.6 B					

[†] The means labeled with the same letter within the same sort, sort average or fertilizer average are not significantly different according to Fisher protected LSD test for significance level P<0.05.

Tab. 3. - The effects of side-dressing by granular (*KAN*) and foliar (*Profert Mara*) fertilizers at winter wheat 1000 grains mass (g), experimental site Vetovo, Croatia, average across seasons 2007/08 and 2008/09.

	Anika	Fiesta	Gabi	Rapsodija	Means
Control	42.3 a	43.9 a	42.8 a	44.1 a	43.2 A
KAN	41.6 a	44.3 ab	44.8 ab	44.8 a	43.9 A
M1	42.6 ab	44.5 b	44.9 b	45.9 a	44.2 AB
M2	42.5 ab	45.0 b	44.7 b	45.9 a	44.1 AB
M3	43.5 b	45.3 b	45.4 b	46.9 a	44.8 B
Means	42.5 A	44.6 B	44.5 AB	44.5 AB	44.0
Season means: 2007/08 = 44.8 B 2008/09 = 43.3 A					

[†] The means labeled with the same letter within the same sort, sort average or fertilizer average are not significantly different according to Fisher protected LSD test for significance level P<0.05.

Treatment M2 had statistically significant differences in comparison with the Control for all four cultivars, in the average across all cultivars for 884 kg ha^{-1} (11.1% higher grain yield). This treatment recorded also significantly higher grain yield in comparison with KAN for cultivar Gabi (+792 kg ha^{-1}).

Treatment M3 recorded also significantly higher grain yields in comparison with the Control (range from +428 kg ha^{-1} for Fiesta, to +1245 kg ha^{-1} for Gabi)

and in comparison with KAN treatment (range from +867 kg ha^{-1} for Fiesta, to +2036 kg ha^{-1} for Gabi). In comparison with M1, treatment M3 was significant for three out of four cultivars (only non significant difference was for Fiesta). Regarding treatment M2, in comparison with M3 this treatment was significantly lower for Anika (-641 kg ha^{-1}) and Gabi (-1245 kg ha^{-1}).

The observed yield quality parameters, the hectoliter weight (Table 2) and 1000 grains mass (Table 3) showed in most cases significantly higher masses of all side-dressing treatments in comparison with the Control. But, in all cases, these differences were not different from usual values for given cultivars, especially if given into account two very different weather patterns in both seasons.

C o n c l u s i o n

According to presented results of the research of different side-dressings for winter wheat at Vetovo experimental site during the seasons 2007/08 and 2008/09, following conclusions can be stated:

1) use of the foliar fertilizer "Profert Mara" for winter wheat side-dressing in recommended dosage of 8 l ha^{-1} in each of two applications showed equal in comparison with granular fertilizer KAN;

2) the double dose of the same foliar fertilizer (16 l ha^{-1} in each of two applications) gave in average significantly higher winter wheat grain yield than both KAN and single dose of "Profert Mara";

3) the triple dose of "Profert Mara" (24 l ha^{-1} in each of two applications) had significantly the highest winter wheat grain yields, which leads toward conclusion that this treatment can be recommended as the best for the highest grain yield for given cultivars.

4) this research should be continued in order to evaluate given treatments with higher confidence for different weather patterns in North-eastern Croatia.

REFERENCES

1. Ayoub, M., MacKenzie A., Smith, D. L. (1995): Evaluation of N fertilizer rate and timing and wheat cultivars on soil residual nitrates. J. Agronomy and Crop Sci. 175. 87-97.
2. Bohlool, B. B., Ladha, J. K., Garrity, D. P., George, T. (1992): Biological nitrogen fixation for sustainable agriculture: A perspective Plant and Soil 141: 1-11.
3. Gooding, M. J., Davies, W. P. (1992): Foliar urea fertilization of cereals: A review. Fert. Res. 32:209–222.
4. Haq, M. U., Mallarino, A. P. (2000): Soybean yield and nutrient composition as affected by early season foliar fertilization. Agron. J. 92:16–24.
5. IPCC (2007): Climate Change 2007: Impacts. Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment-Report of the Intergovernmental. Panel on Climate Change. Editors: Parry, M. L,. Canziani, O. F., Palutikof, J. P., Van der Linden, P. J., Hanson, C. E. Cambridge University Press. Cambridge. UK. pp 976.
6. Lopez-Bellido, L., Lopez-Bellido, R. J., Lopez-Bellido, F. J. (2006): Fertilizer Nitrogen Efficiency in Durum Wheat under Rainfed Mediterranean Conditions: Effect of Split Application. Agron. J. 98:55–62.
7. Parker, J. H. (1972): How fertilizer moves and reacts in soil. Crops and Soils 25: 7-11.
8. Sexton, P. J., Paek, N. C. and Shibles, R. (1998): Soybean sulfur and nitrogen balance under varying levels of available sulfur. Crop Sci. 38:975–982.
9. Smith, C. J., Frency, J. R., Sherlock, R. R., Galbally, I. E. (1991): The fate of urea nitrogen applied in a foliar spray to wheat at heading. Fert. Res. 28:129–138.
10. Woolfolk, C. W., Raun, W. R., Johnson, G.V., Thomason, W. E., Mullen, R. W., Wynn, K. J., Freeman, K. W. (2002): Influence of late-season foliar nitrogen applications on yield and grain nitrogen in winter wheat. Agron. J. 94: 429–434.

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USPOREDBA PRIHRANE RAZLIČITIM NAČINIMA NA UROD OZIME PŠENICE

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R e z i m e

Istraživanje sa različitim načinima prihrane ozime pšenice sproveden je u vegetacijskim sezonama 2007/08. i 2008/09. na lokalitetu Vetovo, Hrvatska. Testirano je pet tretmana prihrane (Kontrola – bez prihrane; KAN – po 100 kg KAN ha^{-1} u busanju i vlatanju; M1 – 8 l folijarnog NPK gnojiva "Profert Mara" ha^{-1}; M2 – 16 l ha^{-1} folijarnog gnojiva. te; M3 – 24 ha^{-1} folijarnog gnojiva) na četiri sorte ozime pšenice (Anika, Fiesta, Gabi i Rapsodija) uz prethodnu osnovnu gnojidbu za sve varijante od 400 kg NPK 7:20:30 ha^{-1}. Pokus je pokazao da su svi tretmani folijarne prihrane dali urod viši od kontrolnog tretmana, te da se tretman M1 pokazao ravnopravnim u odnosu na prihranu KAN-om. Tretmanom M2 i M3, u odnosu na tretmane Kontrola, KAN i M1, signifikantno su povećani prinosi ozime pšenice, iz čega proizlazi da se folijarni tretmani mogu preporučiti u danim agroekološkim uslovima.

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