Zinc Application Method Impacts Winter Triticale in Western Siberia

By Igor A. Bobrenko, Natalya V. Goman and Elena Yu. Pavlova

Field experiments revealed that winter triticale responds significantly to Zn fertilizer applied to soil low in available Zn. Both yield and quality of grain were improved with Zn application. Soil application of Zn was generally more effective compared to seed treatment. The optimum Zn rates for soil application and seed treatment were found to be 8 kg Zn/ha and 100 g $ZnSO_4$/100 kg seed, respectively.

Nowadays, studies on new foodgrain resources and technologies to enhance crop productivity have a great practical significance. Improving grain quality of cereals and increasing production of plant protein are considered as the most important goals for Russian agriculture. Mineral fertilizers play a key role in achieving these goals including micronutrient fertilizers that are effective in increasing both grain yield and quality of cereals according to numerous research studies (Bobrenko et al., 2011a; 2011b). Micronutrients need to be applied at lower rates compared to macronutrients, but have higher requirements regarding their uniformity of application.

Zinc fertilizer has a significant effect on both grain yield and quality of winter triticale grown on meadow-chernozem soil.

Winter triticale is a very promising cereal crop for Russia. Triticale grain has higher level of lysine than winter wheat. Lysine is an essential amino acid in human nutrition and plant proteins usually have insufficient levels of lysine. Baking properties of triticale are not as good as soft wheat, but its characteristics may be successfully used for baking of so-called "white rye" bread and pastries made from unleavened dough—when gluten quality is less important than nutritional value (Sechnyak and Sulima, 1984).

Omsk Oblast is a second largest agricultural region in Western Siberia, after Altai Krai. Arable soils in Omsk Oblast are very often deficient in available Zn according to soil fertility surveys. A low level of available Zn was revealed in 2.9 million ha, or 99% of the arable land comprised by the regional soil survey. Meadow-chernozem soils (Gleyic Chernozems) generally have insufficient levels of available P; however, high rates of P fertilizers may contribute to Zn deficiency if soil available Zn is low. A balanced application of Zn fertilizers to cereal crops is of high importance to optimize plant nutrition and, hence, to obtain higher yield and quality of grain (Krasnitskiy, 2002). Developing strategies to increase the effectiveness of Zn fertilizer use to winter triticale may be considered as a significant goal to enhance crop productivity in the Southern forest-steppe zone of Western Siberia (Krasnitskiy, 1999; Orlova, 2007).

The purpose of this study was to develop the most effective methods and rates of Zn fertilizer application to winter triticale in Omsk Oblast (Southern forest-steppe). This region is characterized by average annual rainfalls of 135 mm during the growth period. Research experiments were conducted during 2007-2011 in experimental fields of the Siberian Research Institute of Agriculture. The region's meadow-chernozem was a clay loam with medium OM content (6 to 9%). Average initial contents of nitrate-N (NO_3-N) and available P (0 to 30 cm soil layer) were medium at 8.0 ppm NO_3-N and 4.0 ppm P, respectively. The average level of available K was 49 ppm, which falls within the "high" interpretation class. Nitrate, available P and K were extracted with 2% acetic acid (CH_3COOH) solution (Ermokhin, 1995). It is important to indicate that available soil Zn extracted with ammonium acetate buffer solution (pH 4.8) was only 0.6 ppm Zn, which falls within the "low" category. Plots were 16 m^2 and were replicated three times. Winter triticale (variety Sibirskiy) was preceded by bare fallow. Fertilizer applications included basal rates of N and K applied as ammonium nitrate and potassium chloride before tillage and a seed-placed P fertilizer as triple superphosphate.

Abbreviations and notes: N = nitrogen, P = phosphorus, K = potassium, Zn = zinc, OM = organic matter; ppm = parts per million.

Table 1. Effect of basal Zn application on grain yield and quality of winter triticale grown on meadow-chernozem soil.

Treatment, kg/ha		Grain yield, t/ha					Yield increase		Test weight, g/l	Glassiness, %	Protein, %	Falling No., sec.
P_2O_5	Zn	2008	2009	2010	2011	Average	t/ha	%				
0	0	2.58	1.30	2.03	3.15	2.27	-	-	604	50	16.3	63
0	4	2.71	1.47	2.41	3.75	2.59	0.32	14	637	50	16.5	63
0	8	2.79	1.37	2.70	3.86	2.68	0.41	18	639	50	16.9	63
60	0	2.94	2.29	2.13	4.28	2.91	-	-	635	50	16.4	64
60	4	3.23	2.38	2.59	4.33	3.13	0.22	8	638	50	16.6	63
60	8	3.05	2.87	2.93	4.33	3.30	0.39	13	641	49	16.8	63
$LSD_{0.05}$		0.16	0.13	0.13	0.11							

Note: Four-year averages are given for grain quality parameters. All treatments received 30 kg N/ha.

We studied two methods of zinc sulfate ($ZnSO_4$) fertilizer application: 1) basal application before tillage and 2) powdered seed treatment.

Results

During four experimental years, grain yield of winter triticale varied from 1.30 to 3.15 t/ha (2.27 t/ha average) in the treatment receiving N fertilizer only (N_{30}) (**Table 1**). The effect of Zn fertilizer on grain yield was most dependent upon annual weather conditions and Zn rates used. Soil applied Zn rates in addition to N fertilizer improved crop productivity and a significant yield increase was revealed during all experimental years. An average yield increase due to basal Zn application at rates of 4 and 8 kg Zn/ha was 0.32 and 0.41 t/ha or 14 and 18%, respectively.

Improved P nutrition resulted in a significant yield increase of winter triticale because soil at the site had a medium soil test P. Phosphorus application at 60 kg P_2O_5/ha gave an average yield increase of 0.64 t/ha or 28% compared to N fertilizer alone. During the 2008-2009 vegetative season that had both excessive rainfall and cool weather, P application was most effective and generated a considerable yield increase of 0.99 t/ha or 76%. Basal application of Zn fertilizer at rates of 4 and 8 kg Zn/ha in treatments receiving both N and P increased the average grain yield by 0.22 and 0.39 t/ha or by 8 and 13%, respectively. In our experiments, the highest average grain yield of 3.30 t/ha was obtained in the treatment receiving $N_{30}P_{60}Zn_8$. Therefore, the highest grain productivity of winter triticale under these environments can be achieved only through balanced application of N, P and Zn.

During the last two years of study, two more treatments were added to combine a higher basal Zn rate of 12 kg Zn/ha with both N_{30} and $N_{30}P_{60}$. However, these failed to increase grain yield beyond that achieved with 8 kg Zn/ha (data not shown). Hence, the optimum rate for basal Zn application to winter triticale grown on meadow-chernozem soil may be recommended as 8 kg Zn/ha.

Soil applied Zn fertilizer in addition to N_{30} had the highest positive effect on grain quality of winter triticale (**Table 1**). Grain test weight increased from 604 to 639 g/l and grain protein content increased from 16.3 to 16.9% (four-year average) due to basal Zn application at a rate of 8 kg Zn/ha. Improving P nutrition lessened the effect of basal Zn application on grain quality. Low Falling Numbers (63-64 sec.) for winter triticale variety Sibirskiy generally indicate the high activity of α-amylase enzyme and the accumulation of starch breakdown products in grain that makes bread sticky.

Seed treatment with $ZnSO_4$ powder at rates of 50 and 100 g $ZnSO_4$/100 kg seed was generally less effective compared to soil application of Zn. Seeds covered with $ZnSO_4$ within the $N_{30}P_{60}$ and $N_{30}P_{60}K_{60}$ treatments generated average yield increases of 2 to 9% and 6 to 8%, respectively (**Table 2**). A high effectiveness of seed treatment was found in the 2008-2009 growing season with prevailing cool weather and excessive rainfall. For example, $N_{30}P_{60}K_{60}$ combined with 50 and 100 g $ZnSO_4$/100 kg seed resulted in 0.38 and 0.55 t/ha or 16 and

Table 2. Effect of Zn seed treatment on grain yield and quality of winter triticale grown on meadow-chernozem soil.

Treatment		Grain yield, t/ha					Yield increase		Test weight, g/l	Glassiness, %	Protein, %	Falling No., sec.
K_2O	Zn	2008	2009	2010	2011	Average	t/ha	%				
0	0	2.94	2.29	2.13	4.28	2.91	-	-	635	50	16.6	64
0	50	2.99	2.48	2.19	4.26	2.98	0.07	2	640	49	16.6	63
0	100	3.64	2.60	2.31	4.10	3.16	0.25	9	641	50	17.0	63
60	0	3.04	2.33	2.04	4.30	2.93	-	-	638	50	16.7	63
60	50	3.14	2.71	2.25	4.32	3.11	0.18	6	640	50	16.7	63
60	100	2.94	2.88	2.47	4.36	3.16	0.23	8	641	50	17.1	63
$LSD_{0.05}$		0.14	0.13	0.11	0.13							

Note: Four-year averages are given for grain quality parameters. All treatments received 30 kg N/ha and 60 kg P_2O_5/ha.
Rates for K_2O are kg/ha while rates for Zn are g $ZnSO_4$/100 kg seed.

24% yield gains, respectively.

During the last two years we included an increased Zn rate of 150 g $ZnSO_4$/100 kg seed into the study for both the $N_{30}P_{60}$ and $N_{30}P_{60}K_{60}$ treatments; however, no further yield increase was found with this high Zn rate (data not shown). The optimal Zn rate for seed dressing, therefore, may be recommended as 100 g $ZnSO_4$/100 kg seed.

Comparing the average yields in treatments receiving $N_{30}P_{60}$ and $N_{30}P_{60}K_{60}$ it can be concluded that K fertilizer has practically no any effect when applied to winter triticale. A positive effect of K fertilizer on grain yield was, nevertheless, revealed in the 2007-2008 season that was characterized by a low snowfall in winter and inadequate precipitation during several months.

Seed dressing with $ZnSO_4$ powder in treatments receiving $N_{30}P_{60}$ and $N_{30}P_{60}K_{60}$ had a small positive effect on grain quality of winter triticale (**Table 2**). Nevertheless, the maximum grain protein (17.1%) was formed in the $N_{30}P_{60}K_{60}$ treatment with Zn seed covering at a rate of 100 g $ZnSO_4$/100 kg seed.

Summary

In conclusion, our results indicate that Zn fertilizer has a significant positive effect on both grain yield and quality of winter triticale grown on meadow-chernozem soil in the Southern forest-steppe zone of Western Siberia. It was revealed that soil applied Zn fertilizer under these environments generally is more effective in increasing grain yield compared to seed treatment. The optimum Zn rates for soil application and seed treatment were found to be 8 kg Zn/ha and 100 g $ZnSO_4$/100 kg seed, respectively. BC

Dr. Bobrenko is Dean, Faculty of Agrochemistry, Soil Science and Ecology; e-mail: bobrenko67@mail.ru. Dr. Goman is Head, Department of Agrochemistry; e-mail: mera@mail.ru. Ms. Pavlova is M.Sc. student, Department of Agrochemistry; e-mail: www.elena.ru.09@mail.ru.

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References

Bobrenko, I.A., N.V. Goman, V.I. Popova and E.P. Boldysheva. 2011a. Omsk Science Herald, 1 (104): 246-250. (In Russian).

Bobrenko, I.A., V.M. Krasnitskiy, N.V. Goman and V.I. Popova. 2011b. Soil Fertility, 4: 18-19. (In Russian).

Sechnyak, L.K. and Yu.G. Sulima. 1984. Triticale. Moscow, Kolos. 317 p. (In Russian).

Krasnitskiy, V.M. 2002. Agrochemical and ecological characteristics of soil of Western Siberia. Omsk, Omsk State University Printing House. 144 p. (In Russian).

Krasnitskiy, V.M. 1999. Agrochemical characteristics and fertility of soils of Omsk Oblast. Omsk, Omsk Printing House. 51 p. (In Russian).

Orlova, E.D. 2007. Microelements in soils and plants of Omsk Oblast and use of microfertilizers. Omsk, Omsk State University Printing House. 76 p. (In Russian).

Ermokhin, Yu.I. 1995. Diagnostics of plant nutrition. Omsk, Omsk Agrarian University Printing House. 208 p. (In Russian).

InfoAg Conference Update

Interest in the implementation of precision ag technologies was highly evident at the 2013 edition of The InfoAg Conference, which drew a record number of 1,100 participants this past July 16-18, in Springfield, Illinois.

The International Plant Nutrition Institute (IPNI) partnered with Crop Life Media Group and PAQ Interactive to provide the "premier precision ag event of the year" designed to share expertise amongst practitioners, vendors, and researchers, and showcase new developments within the precision ag industry.

"InfoAg was designed to be a leading edge source for information on technology in crop production, data management, and communication and it continues to deliver," said Dr. Terry Roberts, IPNI President. "I was impressed with the enthusiasm and excitement of the audience and the quality of the presentations."

In his opening address to the plenary session titled "Connecting the Dots", Dr. Steve Phillips, IPNI Southeast U.S. Region Director, and InfoAg Conference Co-Chair summarized, "You can see how this conference has grown and the depth of the relationships and the partnerships that we're able to form by bringing all levels of precision agriculture together at this one event." He also emphasized the increasing role of precision ag in 4R Nutrient Stewardship (i.e., using the right nutrient source at the right rate, right time, and right place) throughout the world, in both developed and developing countries. "It's going to take all of us working together, and it's going to be the precision ag industry that's going to move 4R Nutrient Stewardship forward."

As a reflection of the growth of the conference and a desire to build on the momentum generated from the event, InfoAg is moving from its traditional biennial schedule to become an annual event. The event will take place on July 29-31 at Union Station, St. Louis, Missouri in 2014. BC

Additional links: InfoAg Conference Newsletter: http://infoag.org/subscribe; InfoAg on Twitter: @InfoAg