PLANT GROWTH REGULATORS IN WINTER WHEAT UNDER LITHUANIAN CONDITIONS

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The aim of investigation was to evaluate the influence of different PGR on plant height of winter wheat, grain yield and protein content in grain of two winter wheat varieties under Lithuanian conditions.

The stands of winter wheat varieties 'Ada' and 'Zentos' were sprayed with the gibberellin biosynthesis inhibitors chlormequat chloride (CCC), trinexapac - ethyl (TE) or with ethylene releasing mepiquatchloride + ethephon (MQEH) and ethephon (ETH) four times at BBCH 27-29, BBCH 32-33, BBCH 37-39, and BBCH 39-45.

The effect of plant growth regulators (PGR) on grain formation of winter wheat was ambiguous and depended on year and varieties of winter wheat.

Highest decrease in plant height of winter wheat were obtained in treatments, wherein for the first time of application CCC at rate of 1 L ha^{-1} and for the second - Modus 0.4 L ha^{-1}, Terpal C 0.7 L ha^{-1}, or Cerone 0.5 L ha^{-1} at BBCH 39 – 45 were used.

***Key words**: PGR, winter wheat, grain yield, grain quality.*

Nitrogen fertilizer and high precipitation favour stem elongation and increase risk of cereal lodging [5]. In high input agriculture application of plant growth regulators (PGR) has become common practice to prevent lodging. They are used to shorten straw of cereals and thereby increase lodging resistance [6, 10]. PGR are chemical compounds that regulate stem elongation through inhibiting biosynthesis of gibberellins or release ethylene. Anti-gibberellic plant growth regulators (CCC, trinexapac-ethyl) used for shortening cereal stems inhibits gibberellin biosynthesis at different stages of the metabolic pathway [1, 11].

Many research papers suggest that plant growth regulators have potential to modify cereal growth additional to their primary target of stem elongation [9]. Banevičienė et al. [4] proposed that CCC influenced winter wheat growth: in the plots treated with CCC grain number per ear increased, and grain yield was higher than in the untreated even in those cases when winter wheat had not lodged. In the PGR - treated plots a trend of grain yield increase was recorded, as well as greater chlorophyll content in leaves [2, 3]. PGR initiate more heads per plant and direct improvement in grain yield [7, 8].

The aim of investigation was to evaluate the influence of different PGR on plant height, grain yield and protein content in the grain of two winter wheat varieties.

MATERIAL AND METHOD

Field trials were conducted at the Lithuanian Institute of Agriculture's Department of Soil and Plant Management in the two winter wheat varieties: 'Ada' and 'Zentos' in 2005 - 2006. The soil of the experimental site is drained soddy gleyic, light loam. The seed rate was 4 million viable seed per hectare, $N_{180}P_{80}$ K_{80} fertilization was applied. Conventional soil tillage technology - deep ploughing was employed. The winter wheat stands were sprayed with the gibberellin biosynthesis inhibitors CCC (chlormequat chloride CCC), Modus (trinexapac - ethyl) or with ethylene releasing Terpal C, and Cerone four times at BBCH 25-29 (tillering) - CCC; BBCH 32-33 (stem elongation) CCC, Moddus, BBCH 37-39 (flag leaf stage) - Terpal C, Cerone and BBCH 39-45 (early boot stage) - Cerone. Date about used PGR in winter wheat are showed in *table 1*.

Table 1

Plant growth regulators (PGR) used in winter wheat crops

PGR	Active ingredient, amount
Cycocel (CCC) 750 (water solution)	Chlormequatchloride 750 g L^{-1}
Modus 250EC (concentrated emulsion)	Trinexapac – ethyl 250 g L^{-1}
Terpal C 460 (water solution)	Mepiquatchloride +ethephone 305 + 155 g L^{-1}
Cerone 480 (water solution)	Ethephone 480 g L^{-1}

The trial design was a randomized block with four replicates. The plot size was 25 m^{-2}.

PGR were sprayed with a compressed nitrogen gas sprayer using a 2.5 m wide boom, at a pressure of 250 kPa, nozzle type 4110-12, spraying speed 1ms^{-1} and a volume rate of 200 l ha^{-1}. Before harvest 20 plants were collected at random from each plot for morphological measurements: stem, ear and internodes length and number of grains per ear. The yield was taken with a small plot combiner (Sampo), protein content was determined by method of Kjeldahl with a coefficient for protein in wheat grain 5.7.

The experimental data were compared by using an analysis of variance (ANOVA) and, where the F-ratio was significant, the least significant difference (LSD) was calculated for $P<0.05$.

RESULTS AND DISCUSSIONS

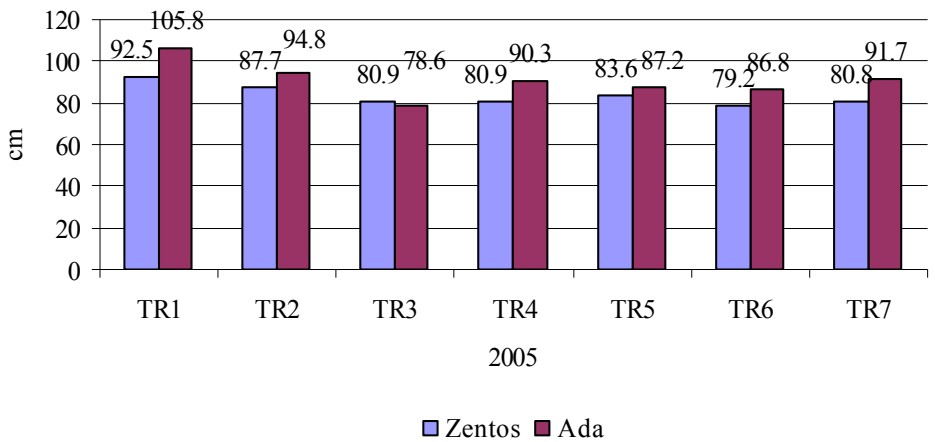
The grain yield of winter wheat differed between years. The grain yield of winter wheat in 2005 was in average of 7.78t ha^{-1} by var. Zentos, and 8.09t ha^{-1} by var. Ada. The grain of winter wheat for both varieties in 2006 was lower – 5.39 t ha^{-1} for Ada and 5.81t ha^{-1} for Zentos. The influence of PGR on grain yield of winter wheat was little and in most cases insignificant (*tab.2*). Nonetheless some differences were found between years and varieties. In the treatment where winter wheat var. 'Ada' was applied with CCC twice in 2005 increase in grain yield was significant, while the grain yield of winter wheat var. 'Zentos' in PGR treated plots tended to decrease. Significant decrease in grain yield was obtained in 2006 in plots treated with CCC at BBCH 29 – 30 for the first time and modus 0.4 l ha^{-1} at BBCH 32 – 33 for the second time.

Table 2

The effect of different PGR on the grain yield changes of two winter wheat varieties

Treatment	Rate L ha^{-1}	Growth stage of winter wheat BBCH	Changes in grain yield t ha^{-1}			
			2005		2006	
			Zentos	Ada	Zentos	Ada
1.Control (untreated)			0	0	0	0
2. CCC	1.5	29 - 30	-0.33	+0.22	-0.21	-0.11
3. CCC Modus	1.0 0.4	29 - 30 32 - 33	-0.54	+0.28	-0.79	-0.15
4. CCC Terpal C	1.0 0.7	29 – 30 37 - 39	-0.31	+0.16	-0.27	-0.02
5. CCC Cerone	1.0 0.5	29 – 30 37 - 39	0.21	+0.31	-0.44	0.01
6.CCC Cerone	1.0 0.5	29 – 30 39 - 45	-0.05	+0.25	-0.39	-0.03
7.CCC CCC	1.0 0.5	29 – 30 32 - 33	-0.18	+0.71	-0.34	-0.03
LSD 05			0.749	0.662	0.588	0.557

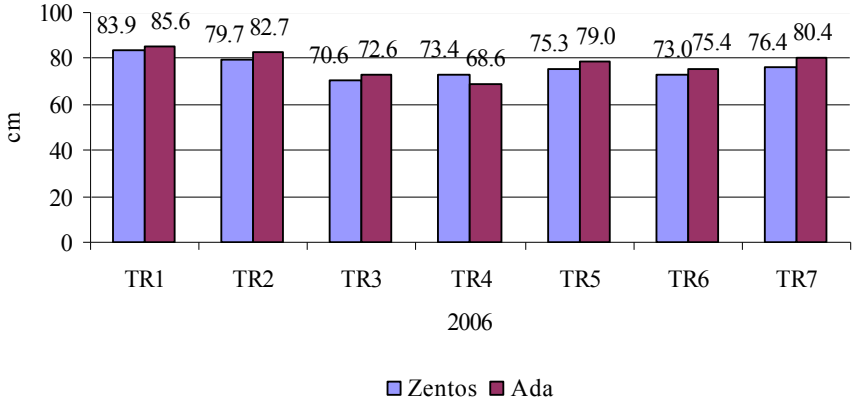
Higher differences between PGR treatments and varieties were obtained in plant height of winter wheat. Plants of winter wheat var. 'Ada' in untreated with PGR plots were significantly higher, than winter wheat plants of 'Zentos', especially in 2005 (*fig.1*).



TR1- Untreated; TR2 - CCC 1.5 L ha^{-1} 25-29 DK (T1); TR3 - T1 and TE 0.4 L ha^{-1} 32-33; TR 4 - T1 and MQET 0.7 L ha^{-1} 37-39; TR5 - T1 and ETH 0.5 L ha^{-1} 37-39; TR6 - T1 and ETH 0.5 L ha^{-1} 39-45; TR7 -T1 and CCC 0.5 L ha^{-1} 32-33

Figure 1 **The plant height of winter wheat at 2005**

There were obtained differences in plant height not only between varieties, also between years – winter wheat plants in 2006 were lower (*fig. 2*).



TR1- Untreated; TR2 - CCC 1.5 L ha^{-1} 25-29 DK (T1); TR3 - T1 and TE 0.4 L ha^{-1} 32-33; TR 4 - T1 and MQET 0.7 L ha^{-1} 37-39; TR5 - T1 and ETH 0.5 L ha^{-1} 37-39; TR6 - T1 and ETH 0.5 L ha^{-1} 39-45; TR7 -T1 and CCC 0.5 L ha^{-1} 32-33

Figure 2 **The plant height of winter wheat at 2006**

Decrease in plant height of winter wheat plants of var. 'Ada' in 2005 was higher, than in 'Zentos' (*tab. 3*).

Table 3

The effect of different PGR on the grain yield changes of two winter wheat varieties

Treatment	Rate L ha^{-1}	Growth stage of winter wheat BBCH	Changes in plant height cm			
			2005		2006	
			Zentos	Ada	Zentos	Ada
1.Control (untreated)			0	0	0	0
2. CCC	1.5	29 – 30	-4.80	-10.93	-4.18	-2,92
3. CCC Modus	1.0 0.4	29 – 30 32 – 33	-11.58	-27.18	-13.28	-13,03
4. CCC Terpal C	1.0 0.7	29 – 30 37 – 39	-11.55	-15.48	-10.56	-17.00
5. CCC Cerone	1.0 0.5	29 – 30 37 – 39	-8.83	-18.60	-8.63	-6,6
6.CCC Cerone	1.0 0.5	29 – 30 39 – 45	-13.28	-18.95	-10.88	-10,15
7.CCC CCC	1.0 0.5	29 – 30 32 – 33	-11.65	-14.03	-7.51	-5,17
LSD 05			2.307	3.863	3.513	3.454

Differences between winter wheat varieties in plant height through effect of PGR in 2006 were lower – only in treatment 4 (CCC for the first time and Terpal C for the second) decrease in plant height of winter wheat var. 'Ada' was more higher, than var. 'Zentos'. In the other treatments effect of PGR on plant height was similar for both varieties of winter wheat. Highest decrease in plant height of winter wheat were obtained in treatments, wherein for the second time of

application Modus 0.4 L ha^{-1} (TR3), Terpal C 0.7 L ha^{-1} (TR 4), and Cerone 0.5 L ha^{-1} at BBCH 39 – 45 (TR6) were used, respectively: 11.58 – 27.18, 10.56 – 17.00, and 10.15 – 18.95 cm in comparison to untreated. Some differences were found in amount of protein content in grain of winter wheat (*tab.4*).

Table 4

The effect of different PGR on the protein content in the grain of winter wheat

Treatment	Rate L ha^{-1}	Growth stage of winter wheat BBCH	Protein content %			
			2005		2006	
			Zentos	Ada	Zentos	Ada
1.Control (untreated)			14.4	14.0	16.6	15.1
2. CCC	1.5	29 – 30	14.4	14.0	15.9	15.7
3. CCC Modus	1.0 0.4	29 – 30 32 – 33	14.0	13.5	17.1	15.8
4. CCC Terpal C	1.0 0.7	29 – 30 37 – 39	13.8	14.0	15.7	15.6
5. CCC Cerone	1.0 0.5	29 – 30 37 – 39	13.9	13.9	16.7	15.8
6.CCC Cerone	1.0 0.5	29 – 30 39 – 45	13.6	14.1	16.8	15.2
7.CCC CCC	1.0 0.5	29 – 30 32 – 33	14.2	12,9	16.4	15.4
LSD 05			0.54	1.08	0.31	0.40

The influence of PGR on protein conten in winter wheat grain differed between years: 2005 in treated with PGR plots protein content has a tendency to decrease. In grain of winter wheat var. ‚Zentos' significant decrease in protein content obtained in treatment, where for the second application Cerone at BBCH 39 – 45 (TR6), and in var. ‚Ada' significant decrease in TR7 (for the second application – CCC). Protein content in treated with PGR winter wheat grain in 2006 has a tendency to increase in both varieties. Significant differences were obtained in both varieties in treatment 3 – where for the second application Modus 0.4 L ha^{-1} was used.

CONCLUSIONS

The effect of plant growth regulators (PGR) on grain formation of winter wheat was ambiguous and depended on year and varieties of winter wheat. The grain yield of winter wheat var. 'Ada' tended to increase under the influence of PGR. In the treatment where winter wheat was applied with CCC twice in 2005 increase in grain yield was significant, while the grain yield of winter wheat var. 'Zentos' in PGR treated plots tended to decrease. Significant decrease in grain yield was obtained in 2006 in plots treated with CCC at BBCH 29 – 30 for the first time and modus 0.4 l ha^{-1} at BBCH 32 – 33 for the second time.

1. The influence of PGR on plant height of winter wheat depended on varieties of winter wheat nonetheless PGR have had an influence. Highest decrease

in plant height of winter wheat were obtained in treatments, wherein for the second time of application Modus 0.4 L ha^{-1} ,Terpal C 0.7 L ha^{-1}, and Cerone 0.5 L ha^{-1} at BBCH 39 – 45 were used, respectively: 11.58 – 27.18 cm , 10.56 – 17.00, and 10.15 – 18.95 cm in comparison to untreated plots.

2. The content of protein in winter wheat grain depended on use of PGR, but in different years was unequal. In treated with PGR plots in 2005 protein content has a tendency to decrease. Significant differences obtained in winter wheat var. ‚Zentos' plots for the second application treated with Cerone at BBCH 39 – 45, and in var. ‚Ada' plots for the second application treated with CCC 0.5 L ha^{-1}. Increase in content of protein in winter wheat grain was found in 2006 in both varieties in treatment 3 – Modus 0.4 L ha^{-1} for the second application.

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