JOURNAL OF PLANT PROTECTION RESEARCH
Vol. 46, No. 2 (2006)

INFLUENCE OF TRINEXAPAC-ETHYL ON GROWTH AND DEVELOPMENT OF WINTER WHEAT

Kinga Matysiak

Institute of Plant Protection
Miczurina 20, 60-318 Poznań, Poland
e-mail: k.matysiak@ior.poznan.pl

Accepted: June 13, 2006

Abstract: Trinexapac-ethyl is one of the newest growth regulators used in agriculture and horticulture. As a most growth retardants it acts by inhibiting gibberellin (GA) biosynthesis. A field study was conducted to determine the effects of trinexapac-ethyl on growth of winter wheat. Trinexapac ethyl was used alone (75 g a.i./ha and 125 g a.i./ha) and in the mixture with chlorocholine chloride (50 g a.i./ha + 675 g a.i./ha) at the 2nd node stage. Trinexapac-ethyl and its mixture with CCC activity was weather dependent. Their influence on the crop was strictly related to the temperature and rainfall during an individual year of trials. Plant growth regulators much more influenced winter wheat plants in abundant rainfall and higher temperature conditions. Lodging was not observed during the experiment.

Key words: plant growth regulator, trinexapac-ethyl, winter wheat, weather, chlorophyll content, internode length, ear length, wall thickness

INTRODUCTION

Plant growth retardants are applied in agronomic and horticultural crops to reduce unwanted longitudinal shoot growth without lowering plant productivity. In intensively grown cereals, growth regulators have become an integral part of the cereal production system. Trinexapac-ethyl (Moddus 250 EC*) represents a new chemical class of plant growth regulators belonging to cyclohexandione group. As the most growth retardants trinexapac-ethyl acts by inhibiting gibberelin (GA) biosynthesis, but it inhibits gibberelin production much later in the biosynthetic pathway than chloromequat or triazole compounds (Rademacher 2000; Hafner 2001). This inhibition results in a reduction in the length of those internodes that elongate after application, and therefore a shorter more sturdy plant (Kerber et al. 1989; Adams et al. 1991; Adams et al. 1992).

* Syngenta Crop Protection

Moddus 250 EC prevents lodging not only by reducing the crop height, but also by strengthening of the stem and crown root structures. In comparison to growth regulators belonging to other chemical groups, trinexapac-ethyl (TE) is highly selective flexible in timing of application and has much longer persistence (Hafner 2001). It appears to have also little action on photosynthesis, root growth and development (Henderson et al. 1998). TE also decreases dry matter production and internode length, but increases stem diameter, number of spikes/m^2 and grain yield (Zagonel et al. 2002).

The objective of the experiment was to determine the effect of trinexapac-ethyl and its mixture with chlorocholine chloride on plant stand structure, grain yield and grain quality of winter wheat.

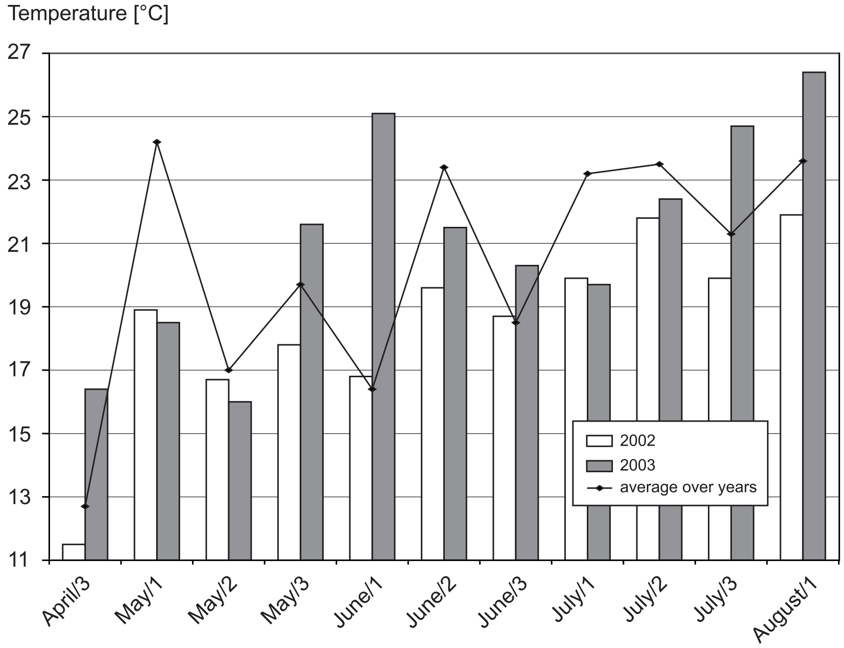
MATERIALS AND METHODS

The trials were carried out in the years 2002–2003 in the Experimental Station in Winna Góra. The tested crop was wheat cv. Korweta. Korweta is a tall wheat cultivar (102 cm) with medium lodging susceptibility (6.8 degrees in 1–9 scale) (COBORU 2000). Winter wheat was sown at the beginning of October with the seeding rate respectively 225 kg/ha and 200 kg/ha. The experiments were of a completely randomized block design with four replications on luvisoil soil of pH 6.0. Size of every plot was 16.5 m^2 with a row spacing of 0.25 m. Soil tillage, fertilization and all agricultural measures were conformable with recommendations for this crop.

The experiments consisted of 4 treatments: trinexapac ethyl used at the dose 75 g a.i./ha, trinexapac-ethyl used at the dose 125 g a.i./ha, trinexapac ethyl + chlorocholine chloride used at the dose 50 g a.i./ha + 675 g a.i./ha and untreated. Trinexapac-ethyl was used as a comercial product Moddus 250 EC and chlorocholine chloride as Antywylegacz płynny 675 SL product.

Growth regulators were applied at the 2nd node stage (32 BBCH) of winter wheat. Temperatures during applications were approximated in each year of trials. In the 1st year it amounted to 19.5°C and 22.2°C in the 2nd year of experiment. The treatments were performed using plot sprayer Gloria, nozzle type R 110-03, spray volume 230 l/ha, and working pressure 200 kPa. Programmes for fertilizer application and disease, pest and weed control were appropriate with regard to soil type, variety, and good agricultural practice.

After spraying the following observations and measurements were done: lodging, height of plants (4 weeks after application), and chlorophyll content using SPAD method (4 weeks after application). Before harvest 25 spikes of winter wheat were taken from each plot and more detailed assessment including length of ears, length of the 3rd internodes, the 3rd internode diameter, thickness of the 3rd internode wall were done. The grain was harvested with a plot combine, and in the laboratory weight of 1000 grains and number of grains in ear were evaluated. Furthermore protein content, gluten content, and sedimentation value were calculated. For thise purpose Analyser Informatic 8100 Parten Co. acting on the basis of near infrared radiation refraction with wavelength 1400–2500 nm was used. All data was subjected to the analysis of variance and treatment means were separated with least significant difference test at 5% probability (LSD 0.05).



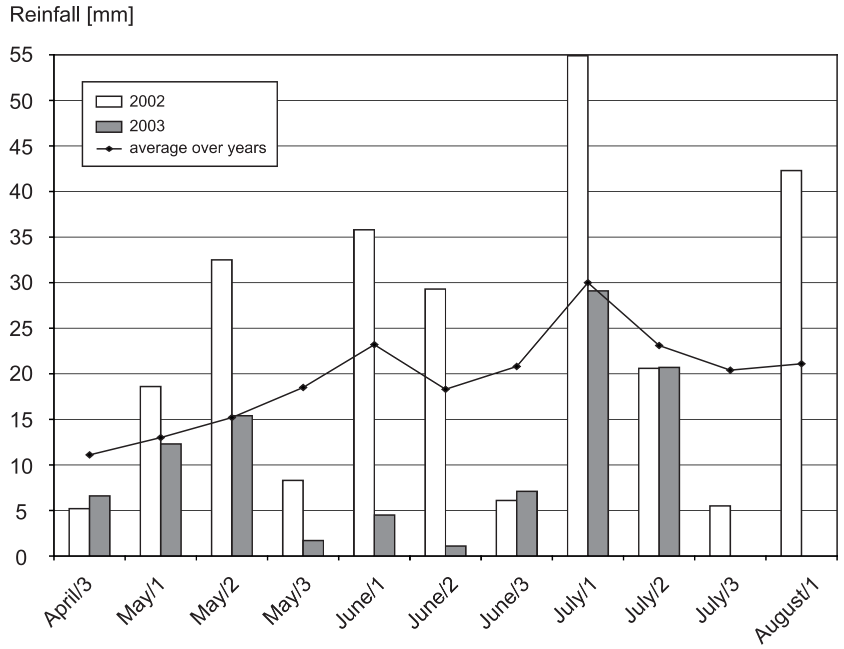


Fig. 1. Weather conditions during the experiments – decade data

Weather conditions during of two years' experiment were different. Generally, the year 2003 was warmer and with more rainfall than 2002. Precipitation in 2003 was much below average over years. In the 3rd decade of May and in June (whole month) there was a critical time. Precipitation in this period was only about 1–7 mm. At the same time but in the previous year precipitation was about 6–36 mm depending on the decade. In the 1st and the 2nd decade of June it was much higher than the average over years. Average rainfall in the period of intensive crop growth (May–June) was about 22 mm in the year 2002 and 7 mm in the year 2003.

Air temperatures in the year 2002 were lower than in the year 2003. During the first two decades of May the temperature was similar in both experimental years. In the 3rd decade of May 2003 and the 1st decade of June 2003 the temperature was much higher than average over years. In this period the temperature was 22–25°C whereas in the previous year it was about 17–18°C. From the middle of June until August the temperature was similar in the both years of experiment. Differences were about 2–3°C.

RESULTS AND DISCUSSION

Lodging was not observed during the experiment but winter wheat responded differently to trinexapac-ethyl and its mixture with chlorocholine chloride, and depended on the year of experiment. It was associated with weather conditions during the crop vegetation. The main weather factor seems to be precipitation especially in months of intensive growth and development of winter wheat. Plant height was reduced by trinexapac-ethyl (TE) in each of the two years but in the first year of trials a greater reduction was observed. A height reduction was observed to be also dose-dependent in that year. In the year 2002 the shortest plants appeared following mixture (TE+CCC) application (Fig. 2).

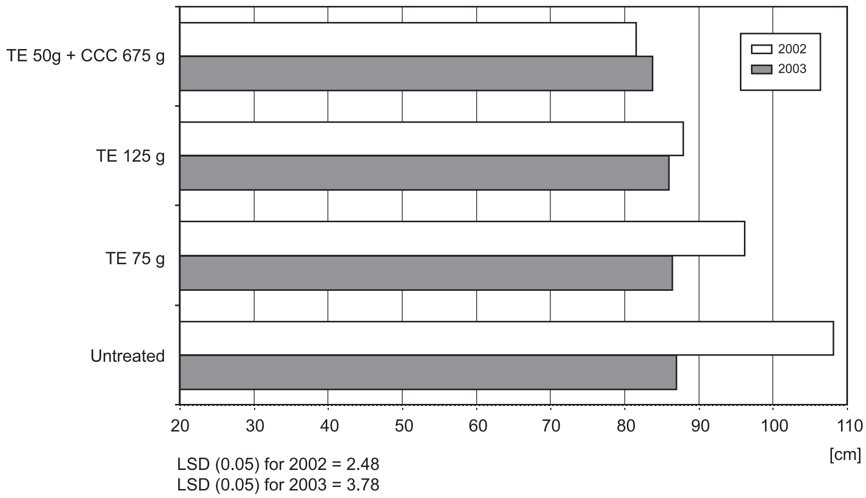


Fig. 2. Influence of trinexapac-ethyl on plant height (4 weeks after application)

Plants were about 26.6% lower than on untreated plots. Łęgowiak and Wysmułek (2000) announced that the application of TE at the dose 100 g a.i/ha resulted in the reduction of plant height by 12–18.5%. Rajala and Peltonen-Sainio (2001) obtained more than 20% lower wheat plants following the application of TE at the dose 75 g a.i./ha.

Our own studies show that growth suppression under TE treatments depended on retardant dose and amounted to 20.3% for TE 125g a.i./ha and 10.7% for TE 75 g a.i./ha comparing to untreated. In the second year of experiment (2003) significant difference in plant height appeared only following TE +CCC treatment but height reduction was much smaller than in the previous year. Winter wheat plants were about 5.5% shorter than on untreated plots.

Some influence of TE and its mixture with CCC on length of ears was noted but only in the year 2003. Growth regulators promoted ear elongation. The best results were obtained when TE was used at the dose of 75 g of a.i. per hectar. In this treatment TE promoted ear elongation by 9.6%. On the other hand the retardant mixture TE+CCC gave also statistically significant increase of ear length. In these treatments ears were longer about 6% than those collected from untreated plots (Fig. 3). Ear elongation after TE application was obtained by Łęgowiak and Wysmułek (2000). A favourable influence of retardants on this trait proved also Woźnica (1981) and Dziamba (1987).

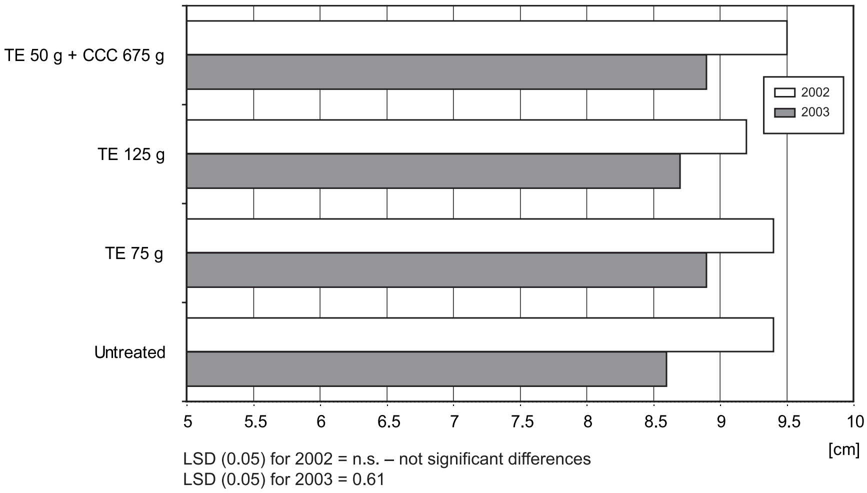


Fig. 3. Influence of trinexapac-ethyl on ear lenght

Obtained data shows that the highest degree of III internode reduction was observed following the application of TE (125 g a.i./ha) and TE +CCC in 2002 and TE (125 g a.i./ha) in 2003. Values of internode reduction for those treatments were respectively 19.4%, 22.4% and 16.3% (Fig. 4). Many authors obtained a similar 17–18% reduction of lower internode lenght following of retardants the application – (Zagonel et al. 2002; Gładysiak 1973).

The chlorophyll content was not affected by used retardants. There was no significant difference in chlorophyll content irrespective of experimental year. However Kerber et al. (1989) mention that TE does not limit photosyntetic activity of plants. Retardants enhanced chlorophyll content especially in drought conditions (Woźnica 1981). The effect of growth regulators on III internode diameter and III internode wall thickness was similar independently on the experimental year. No differences for these traits were observed (Table 1).

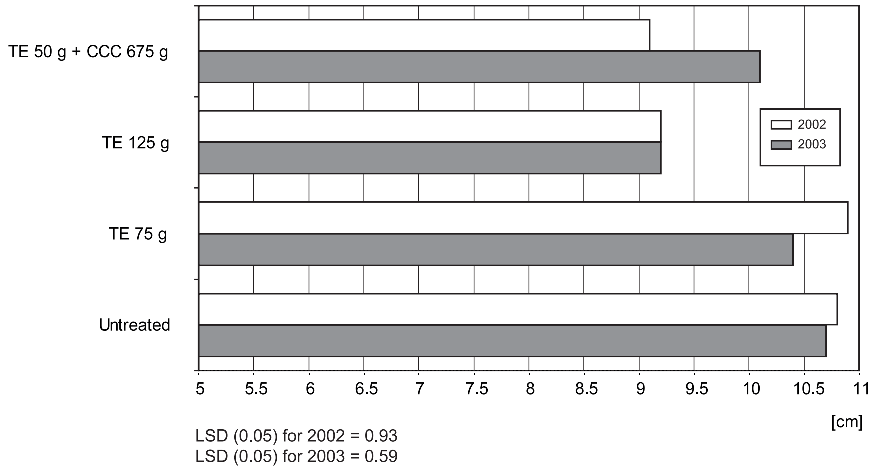


Fig. 4. Influence of trinexapac-ethyl on III internode lenght

Table 1. Influence of trinexapac-ethyl on winter wheat chlorophyll content (SPAD), III internode diameter and wall thickness

Treatment	Dose [g a.i./ ha]	SPAD (4 weeks after treatment)		III internode diameter [mm]		III internode wall thickness [mm]	
		2001/2002	2002/2003	2001/2002	2002/2003	2001/2002	2002/2003
Check	–	676	688	3.38	3.37	0.327	0.325
trinexapac-ethyl	75	672	709	3.24	3.41	0.342	0.305
trinexapac-ethyl	125	683	692	3.21	3.25	0.347	0.278
trinexapac-ethyl +CCC	50 +675	681	696	3.39	3.34	0.345	0.358
LSD (0.05)		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

n.s. – not significant difference

All retardant treatments gave significant higher yield comparing to the yield obtained from untreated plots. Similar grain yield was obtained following TE (125 g a.i./ha) and TE +CCC application. The increase of yield in these treatments reached respectively almost 8% and 8.5%. TE used at the lower dose (75 g a.i./ha) appeared less effective and caused the increase of grain yield by 6.5% in this treatment (Table 2). Rajala and Peltonen-Sanio (2001) announce that CCC and TE do not have any influence on grain yield. However Dziamba (1987) and Rozbicki et al. (1997) obtained higher yield in retardant treatments.

There was dose-response increase of number of grains in ear but only in the year 2002. The lower dose of TE gave 4.4% increase and the retardant used in higher dose gave 4.7% statistically significant increase of number of grains in ear comparing to results obtained from untreated plots. In the year 2003 there were no significant differences in the number of grains in ear under all applied treatments.

Table 2. Influence of trinexapac-ethyl on winter wheat yield and yield components

Treatment	Dose [g a.i./ ha]	Number of grains per ear		Weight of 1000 grains [g]		Yield [t/ha]	
		2001/2002	2002/2003	2001/2002	2002/2003	2001/2002	2002/2003
Check	–	40.4	40.8	43.8	41.9	6.97	6.51
trinexapac-ethyl	75	42.6	41.1	44.7	42.1	7.47	6.64
trinexapac-ethyl	125	42.2	42.5	44.0	39.7	7.56	6.66
trinexapac-ethyl +CCC	50 +675	42.5	41.6	43.3	39.2	7.58	6.64
LSD (0.05)		1.79	n.s.	n.s.	n.s.	0,243	n.s.

n.s. – not significant difference

During the two years' experiment growth regulators applied in the trials did not affect weight of 1000 grains. Some changes were noted for the yield but only in the year 2002 (Table 2). Adamczewski and Bubniewicz (1990) in their studies state a tendency of retardants to increase weight of 1000 grains but they emphasise that the influence is highly weather dependent.

Grain harvested from treated plots in the year 2002 was observed to have higher protein and gluten content and higher sedimentation value than grain harvested in 2003 (Figs. 5, 6, 7). In the year 2002 protein level was significantly greater after using of TE at the higher dose (125g a.i./ha) and TE +CCC. The increase of protein content was 5.6% in both treatments. Lower dose of TE (75g a.i./ha) caused 2.1% increase of protein level.

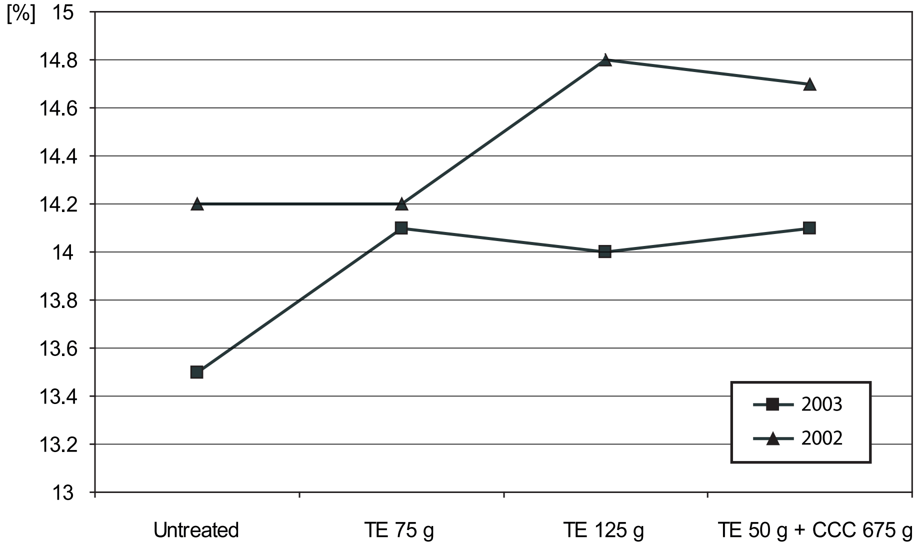
Some authors proved a positive influence of retardants on protein content Pawłowska and Dietrych-Szóstak (1994) but others show an opposite action of retardants on this trait (Romek and Dzienia 1992; Romek et al. 1994; Woźnica 1988).

Gluten content significantly increased following the application of TE (125g a.i./ha) and TE +CCC. Although TE +CCC appears little more active in this respect, and gluten content in winter wheat grain was about 6.6% higher than in grain from untreated plots. Slightly lower increase of gluten content was recorded under TE (125g a.i./ha) treatment. There was some difference of gluten content under TE (75g a.i./ha) treatment (2% more than in untreated).

Results show some changes in sedimentation value between treatments. The sedimentation value increased after TE +CCC and TE (125g a.i./ha) application and it was respectively about 8.4% and 7.6% higher comparing with results obtained from untreated plots. TE used at the lower dose (75 g.a.i./ha) had some effect on this value and in consequence 2.1% increase of sedimentation value was obtained.

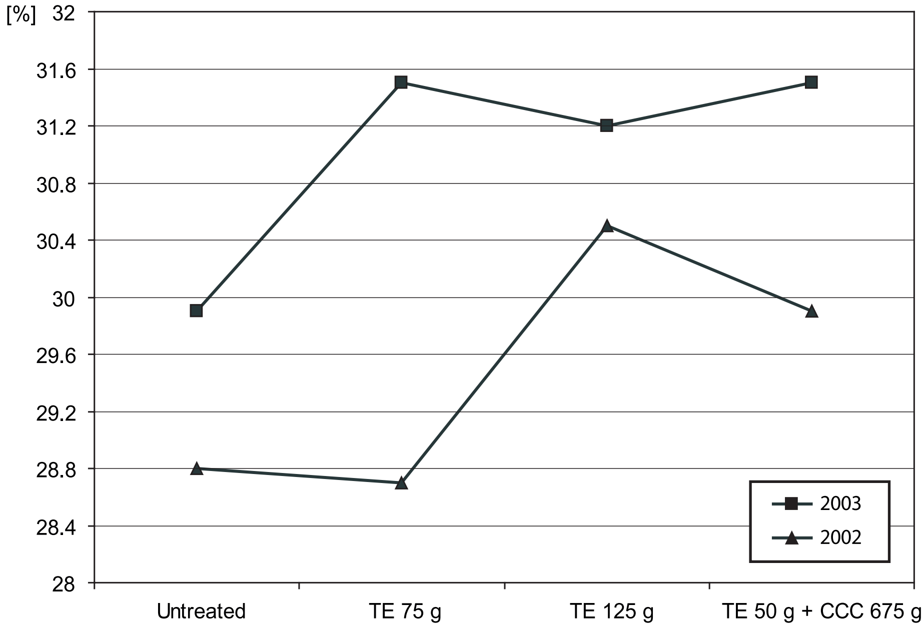
No significant difference between treatments for protein and gluten content and sedimentation value was observed in the year 2003.

The results show a great significance of weather conditions during the crop vegetation after application of retardants, different activity and modification of their action in different traits. Besides, in view of a few papers concerning trinexapac-ethyl it seems to be necessary to continue the research on retardant and moreover the research on interactions of the growth regulator and weather conditions.



LSD (0.05) for 2002 = 0.141
LSD (0.05) for 2003 = n.s. – not significant differences

Fig. 5. Influence of trinexapac-ethyl on protein content



LSD (0.05) for 2002 = 0.166
LSD (0.05) for 2003 = n.s. – not significant differences

Fig. 6. Influence of trinexapac-ethyl on gluten content

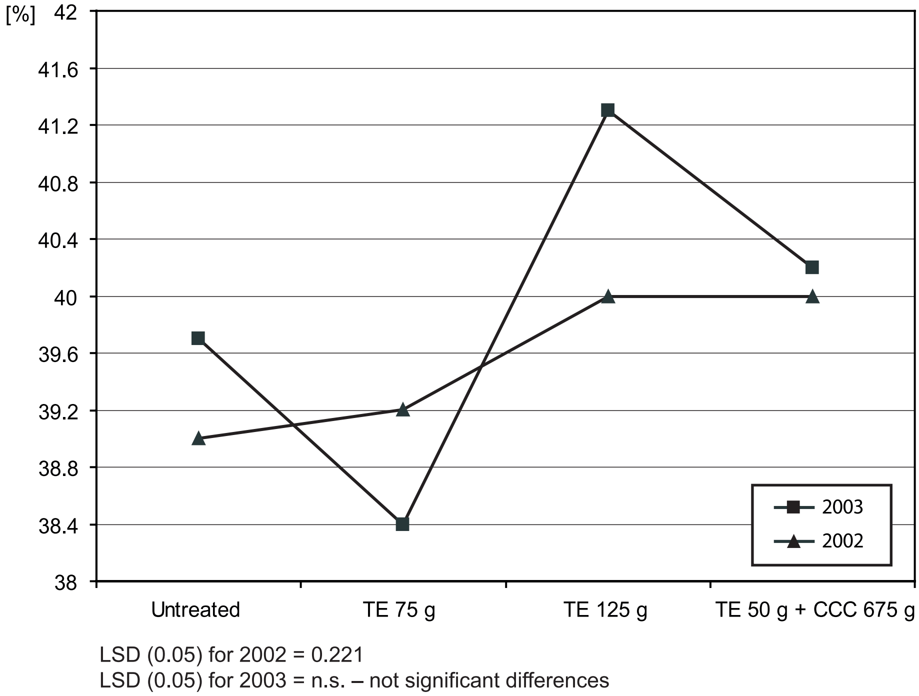


Fig. 7. Influence of trinexapac-ethyl on sedimentation value

CONCLUSIONS

1. The influence of trinexapac-ethyl on winter wheat was dose-dependent. The highest dose of plant growth regulator was much more effective than lower one for such traits as plant height, III internode length, and protein content. For such traits like sedimentation value there were no differences between the highest dose of TE and retardant mixture TE +CCC.
2. In the two years' trials the highest reduction of plant height was obtained from these treatments were mixture of retardants (TE +CCC) was applied. The mixture gave also the best shortening of III internode but only in the year with high amount of rainfall.
3. Response of winter wheat on growth regulators' application was associated with weather conditions during the crop vegetation. The main weather factor seems to be precipitation.
4. Such traits of the crop like gluten content, sedimentation value and protein content were much more significantly influenced by retardants in the year with high amount of rainfall.
5. Chlorophyll content, III internode diameter, III internode wall thickness, number of grains in ear, weight of 1000 grains were not affected by tested growth regulators independently of the experimental year.
6. Statistically proved influence of growth regulators on winter wheat grain yield appeared only in one experimental year. Significant increase of plant yielding was obtained after TE (125 g a.i./ha) and TE +CCC application.

REFERENCES

Adamczewski K., Bubniewicz P. 1990. Ocena działania regulatorów wzrostu w odmianach Triticale. Materiały 30. Sesji Nauk. Inst. Ochr. Roślin, cz. 2: 209–212.

Adams R., Kerber E., Pfister K., Weiler E.W. 1992. Studies on the action of the new growth retardant CGA 163'935 (Cimectacarb). Plant Growth Regulation. 14th Inter. Conf. Plant Growth Substances: 818–827.

Adams R., Weiler E.W., Kerber E., Pfister K., Schar H.P. 1991. Studies on the action of the new growth retardant CGA 163'935. The BCPC Conference – Weeds 2: 1133–1138.

COBORU 2000. Lista opisowa odmian 2000 – Rośliny rolnicze. Słupia Wielka (1): 23–32

Dziamba Sz. 1987. Wpływ Antywylegacza (CCC) i nawożenia na plonowanie, elementy struktury plonu oraz zawartość białka i lizyny w ziarnie pszenżyta, żyta i pszenicy. Biul. Inst. Hod. Aklim. Rośl. 161: 105–112.

Gładysiak S. 1973. Wpływ chlorku chlorocholiny (CCC) w warunkach zróżnicowanego nawożenia azotowego na plon i cechy morfologiczne kilku odmian pszenicy ozimej. Rocz. AR Pozn., 63: 19–28.

Hafner V. 2001. Moddus – universal product for lodging prevention in cereals. 2001. 5th Slovenian Conference on Plant Protection, Catez ob Savi, Slovenia, 6–8 March 2001: 167–172.

Henderson E.J.C., Maurer W., Cornes D.W., Ryan P.J. 1998. Beneficial effects of the plant growth regulator CGA 163'935 in oilseed rape under UK conditions. The BCPC Conference – Weeds 2: 203–210.

Kerber E., Leypoldt G., Seiler A. 1989. CGA 163'935, a new plant growth regulator for small grain cereals, rape and turf. The BCPC Conference – Weeds 1: 83–88.

Łęgowiak Z., Wysmułek A., 2000. Stosowanie regulatorów wzrostu w zbożach. Prog. Plant Protection./Post. Ochr. Roślin 40: 932–934.

Pawłowska J., Dietrych-Szóstak D. 1994. Efekt zastosowania regulatorów wzrostu w pszenżycie jarym. Materiały 34 Sesji Instyt. Ochr. Roślin: 102–105.

Rademacher W. 2000. Growth retardants: effects on gibberelin biosynthesis and other metabolic pathways. An. Rev. Plant Phisiol. Plant Mol. Biol. 51: 501–577.

Rajala A., Peltonen-Sainio P. 2001. Plant growth regulator effects on spring cereal root and shoot growth. Agron. J. 93: 936–943.

Romek B., Dzienia S.1992. Wpływ retardantów na plon i jakość plonów pszenżyta ozimego. Materiały 32. Sesji Nauk. Instyt. Ochr. Roślin cz. 2: 140–144.

Romek B., Dzienia S., Ciążko D. 1994. Wpływ retardantów wzrostu i nawożenia mineralnego na plon i jakość białka ziarna pszenżyta ozimego. Zesz. Nauk Akad. AR Szczecin, Roln. 58: 213–216.

Rozbicki J., Kozdój J., Mądry W. 1997b. Rozwój kłosa pędu głównego oraz udział kłosów z pędów głównych i bocznych w plonie ziarna pszenżyta ozimego (X Triticosecale Wittmack) na tle wybranych czynników agrotechnicznych III. Retardant wzrostu. Biul. Inst. Hod. Aklim. Rośl. 203: 97–103.

Woźnica Z. 1981. Wpływ Camposanu (etefon) na niektóre cechy morfologiczne, wyleganie i plon żyta ozimego. Rocz. AR Pozn., Rozpr. Nauk. 114: 14–28.

Woźnica Z. 1988. Wpływ Flordimexu TH na wyleganie i plony żyta przy zróżnicowanych dawkach azotu i gęstościach siewu. Rocz. Nauk Roln. Seria A 107: 39–51.

Zagonel J., Venancio W.S. Kunz R.P. 2002. Effect of growth regulator on wheat crop under different nitrogen rates and plant densities. Planta Daninha 20: 471–476.

POLISH SUMMARY

WPŁYW DZIAŁANIA TRINEKSAPAKU ETYLU NA WZROST I ROZWÓJ PSZENICY OZIMEJ

W latach 2002–2003 prowadzono w Instytucie Ochrony Roślin w Poznaniu badania, których celem było określenie wpływu trineksapaku etylu na wzrost, rozwój i plonowanie pszenicy ozimej. Ścisłe doświadczenia polowe założono w Pracowni Doświadczalnictwa Polowego w Winnej Górze. Badano dwie dawki trineksapaku etylu (75 g s.a./ha oraz 125 g s.a./ha oraz jego mieszaninę z chlorkiem chloromekwatu (50 g s.a./ha TE +675 g. s.a./ha CCC). Trineksapak etylu zastosowano jako preparat Moddus 250 EC, natomiast chlorek chloromekwatu jako preparat Antywylegacz płynny 675 SL. Zabiegi wykonywano nalistnie w fazie 2 kolanka rośliny uprawnej (32 BBCH). W czasie intensywnego wzrostu pszenicy ozimej dokonano pomiaru wysokości roślin, zawartości chlorofilu w liściach (metoda SPAD), oceny wylegania roślin. Po zbiorze roślin zmierzono długość kłosów, długość III międzywęźla, średnicę III międzywęźla, grubość ścianki III międzywęźla oraz dokonano analizy jakościowej i ilościowej plonu rośliny uprawnej (zawartość białka, zawartość glutenu, współczynnik sedymentacji, liczba ziaren w kłosie masa 1000 ziaren i plon).

Wyniki doświadczeń wykazały, że działanie trineksapaku etylu w bardzo dużym stopniu uzależnione jest od czynników pogodowych w czasie wegetacji roślin, w tym głownie od ilości opadów. Silniejszy wpływ badanej substancji trineksapak etylu oraz jej mieszaniny z chlorkiem chloromekwatu na rośliny pszenicy ozimej wystąpił w roku charakteryzującym się większą ilością opadów w okresie maj–sierpień.