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Effect of bio-stimulant Asahi SL in winter rapeseed depending on pluviothermic conditions

Efekty działania biostymulatora Asahi SL w uprawie rzepaku ozimego w zależności od warunków pluwiotermicznych

Keywords: winter oilseed rape, bio-stimulant, pluviothermic conditions, seed yield

The influence of Asahi SL on the growth, development and yielding of winter rapeseed cultivars (Californium, Lisek, Libomir and Kaszub) depending on weather was determined in this study. Asahi SL was applied at a dose of 0.6 $dm^3 \cdot ha^{-1}$ (together with a pesticide: in spring — protecting against ceuthorrhynchid beetles, and afterwards — against rapeseed blossom beetle). The application was performed twice: in spring when vegetation started, at the beginning of budding, and jointly in both periods. Investigations were conducted at University of Technology and Agriculture in Bydgoszcz in the two growing seasons 2003/2004 and 2004/2005 of differentiated temperatures and precipitations during the vegetation period. In the season 2004/2005, a large-area experiment in a production field was also conducted, aimed at the evaluation of the effect of the bio-stimulant Asahi SL on winter rapeseed structure and yielding, with a low plant density.

The winter rapeseed cultivars investigated in 2003/2004 were not exposed to the stress of low temperatures or moisture deficiency during the vegetation period and they showed no reaction to Asahi SL. The inclusion of Asahi SL to the winter rapeseed production technology over 2004/2005, when there was a strong frost in the budding period and precipitation shortage, influenced an increase in seed yield up to 11% in comparison with the yield obtained without a bio-stimulant.

In the large-area experiment carried out in the season 2004/2005, applying the bio-stimulant resulted in a significant increase in seed yield (from 9 to 19%), a number of lateral shoots (by 46%), a number of siliques per plant (by 57%), seed number (by 14%) and thousand seed weight (by 18%).

A reaction of winter rapeseed to the time of Asahi SL application was not explicit.

Słowa kluczowe: rzepak ozimy, biostymulator, warunki pluwiotermiczne, plon nasion

Celem badań było określenie wpływu biostymulatora Asahi SL na rozwój i plonowanie odmian rzepaku ozimego (Californium, Lisek, Libomir i Kaszub) w zależności od przebiegu pogody. Asahi SL stosowano w dawce 0,6 $dm^3 \cdot ha^{-1}$ (łączono Asahi z pestycydem — wiosną dla ochrony przed chowaczami, a następnie przed słodyszkiem) w dwóch terminach, wiosną po ruszeniu wegetacji i w fazie początku pąkowania rzepaku oraz łącznie w tych dwóch terminach. Badania wykonano w Akademii Techniczno-Rolniczej w Bydgoszczy, w dwóch sezonach uprawy rzepaku 2003/2004 i 2004/2005 o zróżnicowanej temperaturze i opadach w okresie wegetacji. W sezonie 2004/2005 wykonano również doświadczenie łanowe na polu produkcyjnym, którego celem było określenie wpływu biostymulatora Asahi SL przy niskim zagęszczeniu łanu rzepaku ozimego na jego strukturę oraz plonowanie.

Badane odmiany rzepaku ozimego w sezonie 2003/2004 nie były narażone na stres niskich temperatur lub niedobór wilgoci w okresie wegetacji i nie wykazały reakcji na zastosowany biostymulator Asahi SL. Włączenie biostymulatora Asahi SL do technologii produkcji rzepaku ozimego w sezonie 2004/2005, kiedy wystąpił silny przymrozek w fazie pąkowania i niedobory opadów po wznowieniu wegetacji, jak i w okresie nalewania nasion, wpłynęło na wzrost plonów nasion do 11% w stosunku do plonów uzyskanych bez biostymulatora.

W doświadczeniu łanowym przeprowadzonym w sezonie 2004/2005 zastosowanie biostymulatora wpłynęło na istotny wzrost plonów nasion (od 9 do 19%), liczby rozgałęzień bocznych (o 46%), liczby łuszczyn na roślinie (o 57%), liczby nasion (o 14%) oraz masy tysiąca nasion (o 18%).

Reakcja rzepaku ozimego na termin zastosowania Asahi SL była niejednoznaczna.

Introduction

Winter rapeseed cultivation in accordance with the latest production technology allows high yields to be achieved. The pluviothermic conditions, however, being variable and beyond the control of a farmer, constitute a significant obstacle to regular high yielding. Wintering conditions as well as the volume and distribution of precipitation during spring and summer vegetation period are factors that significantly modify rapeseed seed yield (Wójtowicz 2005). Agricultural technicians are looking for new technological solutions in order to provide plants with the most favourable growth conditions and to reduce their negative reaction to stress factors, the effect of which is supposed to be the highest possible yield. Minimizing environmental stress results is possible by incorporating bio-stimulants into agricultural practices (cultivation technology).

Asahi SL is a growth and yield stimulant in the form of liquid for dilution with water, made in Japan by the Asahi Chemical MFG Co. Ltd. The active substance of the preparation is the mixture of the sodium salts of 5-nitroguaiacol as well as ortho- and paranitrophenols. Plants contain small amounts of these compounds, as they are substrates of oxidoreductive enzymatic systems (Stutte, Clark 1990). Applied externally, they strengthen plant cell walls, enhance the effect of auxins, participate in nitrogen metabolism and cytoplasm transportation, stimulate blooming, increase plant resistance to water and thermal stress, improve plant ability to reconstruct mechanical damage and protect themselves against pathogenic infections. They allow plants to adapt faster to changeable environmental conditions and reduce the growth of some pathogenic fungi. Consequently, they contribute to the increase in plant productivity (Mikos-Bielak, Kukiełka 2000, Saniewska 2000, Cerny et al. 2002, Czeczko, Mikos-Bielak 2004).

The aim of the study was to estimate the influence of the bio-stimulant Asahi SL applied in different development phases on winter rapeseed growth and yield depending on pluviothermic conditions.

Material and methods

The tests were carried out on the basis of the strict field experiment and the large-scale experiment.

Strict experiment

The experiment was conducted in an experimental field of the ATR Research Station in Mochełek in two vegetation seasons: 2003/2004 and 2004/2005. The subjects of the study were the following cultivars of winter rapeseed: Californium, Lisek and Libomir in the season 2004/2005, and Californium, Lisek and Kaszub in the season 2004/2005. A two-factor strict field experiment was conducted in a complete randomized block design in four replications.

The factors of the experiment were as follows:

A — dates of application of the biostimulant Asahi SL in a dose of 0.6 $dm^3 \cdot ha^{-1}$ each time:
- — Control — without the bio-stimulant,
- — Asahi SL biostimulant was applied at the beginning of spring growth (together with plant protection against ceuthorrhynchid beetle using Nurelle 550 EC at a dose of 0.6 $dm^3 \cdot ha^{-1}$),
- — Asahi SL bio-stimulant was applied at budding (together with plant protection against rapeseed blossom beetle using Cyperkill Super 25 EC preparation at a dose of 0.1 $dm^3 \cdot ha^{-1}$ each time),
- — Asahi SL bio-stimulant was applied both at the beginning of spring growth and at budding (together with plant protection against ceuthorrhynchid beetle and rapeseed blossom beetle — see above);

B — Winter rapeseed cultivars:
- — Californium (population cultivar),
- — Lisek (population cultivar),
- — Libomir (population cultivar),
- — Kaszub (hybrid-complex cultivar).

The experiment was set up after spring barley on a typical grey-brown podsolic soil, qualified as a very good rye complex, quality class IVa. Pre-sowingly, 80 $kg \cdot ha^{-1}$ P_2O_5 and 120 $kg \cdot ha^{-1}$ K_2O was applied. The sowing was done on 1 September in 2003 and 3 September in 2004 at a rate of 60–80 plants per 1 m^2 depending on the cultivar. In autumn, Butisan Super was used against dicotyledonous weeds and Fusilade SL was applied against self-sown crops. Spring fertilization with ammonia in an amount of 200 $kg \cdot ha^{-1}$ in the form of Lubofoska and ammonium nitrate was made in the following rapeseed development phases: directly before the beginning of vegetation, in the course of the intensive reconstruction of leaf rosette, at the beginning of stem elongation and at the beginning of plant blooming. Rapeseed was harvested once with a combine-harvester on 20 July 2004 and 15 July 2005.

Seed yield and its components (number of plants per area unit, number of siliques per plant, seed weight per plant, thousand seed weight) and selected morphological features (height of plants, number of primary branches) from 20 randomly sampled plants from each plot. The yield was analysed at 13% water content.

The results obtained were verified statistically using the analysis of variance. The significance of differences was defined with the use of the Tukey test at $\alpha = 0.05$.

A large-area experiment

A single-factor large-area experiment with winter rapeseed was conducted on a private farm in Witoldowo — Kujawsko-Pomorskie province, Koronowo commune — located 7 km north of the Research Station of the University of Technology and Agriculture, and 32 km from Bydgoszcz, in the vegetation season 2004/2005. The farm where the experiment was conducted is among the key ones in this region in production of commodity plants — not only rapeseed, but also sugar beet and spring barley.

The subject of the study was the winter rapeseed cultivar Kaszub cultivated after malting barley.

The date of application of Asahi SL bio-stimulant was the experimental factor:

— Control — without a bio-stimulant,
— Asahi SL bio-stimulant was applied after re-start of spring vegetation – at a dose of 0.6 $dm^3 \cdot ha^{-1}$ (together with plant protection against pests),
— Asahi SL bio-stimulant after re-start of spring vegetation and at budding at a dose of 0.6 $dm^3 \cdot ha^{-1}$ each time (together with plant protection against pests).

Plant protection against Ceuthorrhynchus and rapeseed blossom beetle was conducted on all the objects with Alphaquard 10 EC, Nurelle Nurelle 550 EC Cyperkill super 25 EC pesticides at the doses recommended by the Institute of Plants Protection in Poznań.

The area of the experimental field with rapeseed amounted to over 8 ha. After the exclusion of the field margin from the experiment, the individual objects covered about 2.5 ha each. Due to a remarkably big cropping area, the measurements were made in 4 replications at each object.

Pre-sowingly under rapeseed was applied 300 $kg \cdot ha^{-1}$ of multicomponent fertilizer Polifoska (N — 8%, P_2O_5 — 24% and K_2O — 24%). The winter rapeseed was sown on 27 and 28 August, 2004 in an amount of 3 $kg \cdot ha^{-1}$ at the assumed stock 40–45 plants per 1 m^2. After sowing herbicides were applied: Butisan Start to control dicotyledonous weeds and Targa to control monocotyledonous weeds. Nitrogen fertilization in spring in an amount of 500 $kg \cdot ha^{-1}$ ammonia nitrate was conducted in two equal doses at the moment of vegetation start-up and 10 days later.

20 plants in 4 replications were sampled before harvesting in the area of each object in order to make biometrical measurements. One-phased rapeseed harvesting

was made on 30 July, 2005 after earlier plantation desiccation with Roundup preparation at an amount of 5 l·ha^{-1}.

The results were statistically analysed for a single-factor experiment in the complete random design. Differences for averages were evaluated with the use of the Tukey test at the level $\alpha = 0.05$.

Results

Strict experiment

The analysed vegetation seasons differed considerably in terms of weather conditions. Precipitation volume from the moment of winter rapeseed sowing till the end of January was twice lower in the season 2003/2004 than at the same time in 2004/2005 (Table 1). Plant growth before their transition to winter dormancy (rest) in both seasons proceeded in conditions of high temperatures and long autumn. In both seasons of rapeseed vegetation below zero temperatures occurred at the end of December and remained at intervals over January and February. Winter rapeseed crops were covered with snow and there were no plants found killed by frost after the winter period. In spring 2004 vegetation started 10 days earlier than in 2005, but the mean temperature from April to June in the years compared was similar.

Table 1

Mean air temperature and precipitation according to the ATR Research Station in Mochełek
Średnia temperatura powietrza oraz suma opadów wg Stacji Badawczej ATR w Mochełku

Specification *Wyszczególnienie*	Year *Rok*	Month — *Miesiąc*										
		IX	X	XI	XII	I	II	III	IV	V	VI	VII
Mean air temperature *Średnia temperatura powietrza* [°C]	2003/2004	13.6	4.8	4.2	0.9	-5.3	-0.4	2.8	7.5	11.3	14.7	16,4
	2004/2005	12.7	8.8	2.8	1.1	0.5	-3.0	-0.5	7.4	12.1	14.9	19,4
Mean air temperature in 1949–2004 *Średnia temperatura powietrza w latach 1949–2004* [°C]		13,1	8.3	3.0	-0.7	-2.3	-1.5	1.9	7.3	12.8	16.2	17.8
Precipitation *Suma opadów* [mm]	2003/2004	16.7	34.0	22.8	25.5	20.4	60.9	35.8	32.1	54.4	39.6	53,5
	2004/2005	40.0	63.8	36.2	49.8	38.1	28.7	22.5	34.8	82.6	30.5	33,6
Mean precipitation in 1949–2004 *Średnia suma opadów w latach 1949–2004* [mm]		41,8	32.8	32.0	30.4	23.7	18.8	22.8	27.0	40.6	54.2	72.0

The diversity of precipitation in this period applied mainly to its distribution. Early spring 2004 might be characterized as humid, and the amount of precipitation from April till the end of rapeseed vegetation as moderate, in comparison with the multi-year mean for this region. In 2005, the beginning of spring plant vegetation proceeded with rather low precipitation, moisture conditions being only improved by rainfall in May, but it influenced to some extent a reduction in flower insect pollination. At plant budding in 2005, night falls in temperature even below –8°C near the ground was noted several times.

After the winter rest in 2004 the rapeseed cultivars varied significantly in plant density (Table 2) and this variation remained till the harvest. A significantly higher

Table 2

Number of winter rapeseed plants per 1 m^2 — *Liczba roślin rzepaku ozimego na 1 m^2*

Factor *Czynnik*	After the re-start of vegetation *Po ruszeniu wegetacji*	Before harvest *Przed zbiorem*
2003/2004		
Date of bio-stimulant application — *Termin stosowania biostymulatora*		
control — *kontrola*	58	49
beginning of growth — *początek wegetacji*	56	52
budding — *pąkowanie*	55	58
beginning of growth + budding *początek wegetacji + pąkowanie*	58	57
LSD — $NIR_{\alpha = 0.05}$	ns	6,6
Cultivar — *Odmiana*		
Californium	73	72
Lisek	53	47
Libomir	44	44
LSD — $NIR_{\alpha = 0.05}$	6,9	5,2
2004/2005		
Date of bio-stimulant application — *Termin stosowania biostymulatora*		
control — *kontrola*	69	66
beginning of growth — *początek wegetacji*	74	68
budding — *pąkowanie*	73	69
beginning of growth + budding *początek wegetacji + pąkowanie*	73	73
LSD — $NIR_{\alpha = 0.05}$	–	ns
Cultivar — *Odmiana*		
Californium	79	76
Lisek	78	72
Kaszub	62	58
LSD — $NIR_{\alpha = 0.05}$	–	10,7

ns — no significant difference — *różnica nieistotna*

plant density was observed in the case of a single application of the bio-stimulant at budding, as well as after its two-time application, in comparison with the object without a bio-stimulant (Table 2).

The bio-stimulant Asahi SL applied in the experiment did not differentiate significantly any major morphological features of winter rapeseed evaluated before the harvest in any vegetation seasons tested (Table 3). However, the morphological

Table 3

Morphological features of winter rapeseed before the harvest
Cechy morfologiczne rzepaku ozimego przed zbiorem

Factor *Czynnik*	Height of plants *Wysokość roślin* [cm]	Number of primary branches *Liczba rozgałęzień I rzędu*	Number of siliques per plant *Liczba łuszczyn na roślinie*
2003/2004			
Date of bio-stimulant application — *Termin stosowania biostymulatora*			
control — *kontrola*	133	4,0	73
beginning of growth *początek wegetacji*	136	4,1	68
budding — *pąkowanie*	133	3,6	65
beginning of growth + budding *początek wegetacji + pąkowanie*	135	4,0	70
LSD — $NIR_{\alpha = 0.05}$	ns	ns	ns
Cultivar — *Odmiana*			
Californium	129	3,6	63
Lisek	135	3,9	64
Libomir	137	4,3	79
LSD — $NIR_{\alpha = 0.05}$	3,695	0,571	10,6
2004/2005			
Date of bio-stimulant application — *Termin stosowania biostymulatora*			
control — *kontrola*	141	6,3	106
beginning of growth *początek wegetacji*	140	6,1	101
budding — *pąkowanie*	140	6,2	104
beginning of growth + budding *początek wegetacji + pąkowanie*	141	6,2	106
LSD — $NIR_{\alpha = 0.05}$	ns	ns	ns
Cultivar — *Odmiana*			
Californium	134	6,5	91
Lisek	137	6,4	98
Kaszub	152	5,6	125
LSD — $NIR_{\alpha = 0.05}$	3,9	0,70	16,5

ns — no significant difference — *różnica nieistotna*

features were subject to cultivar variation. In 2004, the plants of the cultivars Lisek and Libomir were significantly higher and they branched stronger in comparison to the cultivar Californium. Moreover, the plants of the cultivar Libomir made significantly more siliques than the plants of the other cultivars tested. In 2005, the rapeseed cultivar Kaszub was the highest significantly and the plants of this cultivar had also significantly more siliques set in comparison with the cultivars Californium and Lisek (Table 3).

In 2004, winter rapeseed seed yield and its components were not significantly differentiated by the application of the bio-stimulant Asahi SL (Table 4). In 2005,

Table 4

Seed yield and its basic components — *Plon nasion i jego podstawowe komponenty*

Factor *Czynnik*	Seed yield *Plon nasion* [t·ha^{-1}]	Seed weight per plant *Masa nasion z rośliny* [g]	Thousand seed weight *Masa 1000 nasion* [g]
2003/2004			
Date of bio-stimulant application — *Termin stosowania biostymulatora*			
control — *kontrola*	4,68	3,5	5,0
beginning of growth *początek wegetacji*	4,62	3,6	5,1
budding — *pąkowanie*	4,54	2,9	5,1
beginning of growth + budding *początek wegetacji + pąkowanie*	4,61	3,2	5,0
LSD — $NIR_{\alpha = 0.05}$	ns	ns	ns
Cultivar — *Odmiana*			
Californium	5,24	2,9	4,8
Lisek	4,26	3,4	4,9
Libomir	4,36	3,6	5,3
LSD — $NIR_{\alpha = 0.05}$	0,43	0,43	1,78
2004/2005			
Date of bio-stimulant application — *Termin stosowania biostymulatora*			
control — *kontrola*	3,59	5,2	4,5
beginning of growth *początek wegetacji*	4,00	5,4	4,7
budding — *pąkowanie*	3,64	5,3	4,9
beginning of growth + budding *początek wegetacji + pąkowanie*	3,97	5,2	4,7
LSD — $NIR_{\alpha = 0.05}$	0,349	ns	0,41
Cultivar — *Odmiana*			
Californium	3,85	2,6	4,7
Lisek	3,87	3,1	4,9
Kaszub	3,67	3,0	4,5
LSD — $NIR_{\alpha = 0.05}$	ns	0,36	0,44

ns — no significant difference — *różnica nieistotna*

a single application of Asahi SL at the beginning of the spring vegetation, as well as its two-time application: at the beginning of the vegetation and at budding, resulted in a significant increase in seed yield by 11 and 10%, respectively, in comparison with plants with no bio-stimulant applied during cultivation. A significant effect of Asahi SL on winter rapeseed thousand seed weight was also noted in the same year (Table 4). Rapeseed cultivars varied significantly in seed yield (only in 2004), seed weight per plant and thousand seed weight in both years of the study.

Large-area experiment

In the large-area experiment winter rapeseed plant density before harvesting ranged from 27 to 32 plants per 1 m^2. The plant density was low but even in the area of the field and not differentiated by the bio-stimulant Asahi SL.

Incorporating Asahi SL into winter rapeseed cultivation regime modified significantly morphological features of the plants, the yield and its basic components. Both single and two-time application of the bio-stimulant resulted in a significantly larger growth of rapeseed stems in length and setting larger amount of siliques per plant in comparison to plants cultivated without a bio-stimulant (Table 5).

Table 5

Number of plants per 1 m^2 and morphological features of winter rapeseed Kaszub cultivar before harvesting — *Liczba roślin na 1 m^2 i cechy morfologiczne odmiany rzepaku ozimego Kaszub przed zbiorem*

Date of bio-stimulant application *Termin stosowania biostymulatora*	Number of plants before harvest *Liczba roślin przed zbiorem* [szt.·m^{-2}]	Height of plants *Wysokość roślin* [cm]	Number of primary branches *Liczba rozgałęzień I rzędu*	Number of siliques per plant *Liczba łuszczyn na roślinie*
Control — *Kontrola*	32	147	7,6	191
Beginning of growth *Początek wegetacji*	30	157	10,7	329
Beginning of growth + budding *Początek wegetacji + pąkowanie*	27	163	9,3	273
LSD — $NIR_{\alpha = 0.05}$	ns	14,3	ns	51,2

ns — no significant difference — *różnica nieistotna*

Bio-stimulant used at both dates resulted in a significant increase in yield in comparison to winter rapeseed in the field not treated with Asahi SL: by 19%, when the preparation was applied at the beginning of spring growth and by 9%, when the bio-stimulant was applied at both dates (Table 6). Also a number of seeds per silique and thousand seed weight reached significantly higher values when Asahi was applied, particularly when used twice (Table 6).

Table 6

Seed yield and its basic components — *Plon nasion i jego podstawowe komponenty*

Date of bio-stimulant application *Termin stosowania biostymulatora*	Seed yield *Plon nasion* [t·ha^{-1}]	Number of seeds per silique *Liczba nasion w łuszczynie*	Weight of 1000 seeds *Masa 1000 nasion* [g]
Control — *Kontrola*	3,86	26,5	4,10
Beginning of growth *Początek wegetacji*	4,61	29,9	4,66
Beginning of growth + budding *Początek wegetacji + pąkowanie*	4,21	30,3	5,06
LSD — $NIR_{\alpha = 0.05}$	0,417	3,12	0,465

Discussion

The course of weather during vegetation is the main factor which determines winter rapeseed seed yield in Poland beside the stand quality, nitrogen fertilization and plant protection (Golinowska 1994, Kotecki et al. 2004, Wójtowicz 2005).

The weather conditions in the season 2003/2004 favored rapeseed vegetation. A long, warm autumn with an appropriate amount of precipitation for rapeseed allowed the plants to grow well before winter rest. The plant condition at the moment of starting the spring vegetation was very good due to the mild winter, while the even distribution of precipitation and the temperatures adequate to the requirements during the spring and summer growth resulted in rapeseed proper development and its even maturing. Consequently, in the present study the rapeseed seed yield ranged from 4.26 to 5.24 t·ha^{-1} and it can be characterized as high, particularly in comparison to the mean domestic yield, which in 2004 amounted to 3.01 t·ha^{-1} (GUS 2005). Numerous research works point at the favourable impact of Asahi SL on the yields of various species of field crops (Basak 1998, Cholewiński 1998, Mikos-Bielak and Kukiełka 2000, Czeczko and Mikos-Bielak 2004). All the authors stress the fact that the bio-stimulant has a particularly favourable effect when the plants are subject to stress conditions. Plants possess natural mechanisms allowing them to adapt to unfavourable conditions, however, this reaction is frequently not sufficient and lasts too long, which results in decreasing yield height and quality. The effect of Asahi SL consists in supporting the natural processes, making the plant reaction more energetic (Słowiński 2004). In the present study in the season 2003/2004, rapeseed was not subject to substantial environmental stress. Therefore, there is an assumption that that is why Asahi SL applied at different times did not influence significantly seed yield, its basic components or majority of morphological features.

The condition of rapeseed plants after the winter 2004/2005 was very good. However, rather low precipitation was noted at the beginning of the spring vegetation, which had a negative effect on plant condition. The reaction was visible, as winter rapeseed is sensitive to spring droughts, especially during intensive vegetative growth (Walkowski et al. 2006). High precipitation in May, falling on the plant flowering, increased the rank growth, but reduced the flower insect pollination. Moreover, in the third decade of April, when the rapeseed plants were at budding, several days long ground frosts occurred. In spring vegetation 2005, being less favourable for rape, both seed yield and thousand seed weight in the present study were significantly differentiated due to the application of the bio-stimulant. The seed yield from the control amounted to 3.59 $t \cdot ha^{-1}$, while a single application of Asahi at the spring starting vegetation or at budding contributed to a significant increase in yield by 11%.

The advantageous effect of Asahi SL application was also noted in the large-area experiment, with a low plant density before harvesting, amounting to 30 plants per m^2 on average, and a high level of fertilization, nuture and plant protection. The application of the bio-stimulant influenced significantly an increase in seed yield (from 9 to 19%), a number of branches (by 46%), a number of siliques per plant (by 57%), number of seeds (by 14%) and thousand seed weight (by 18%).

The cultivars tested differed significantly in nearly all analyzed features, which seems to be obvious due to the individual cultivar properties.

The ambiguous reaction of winter rapeseed to the time of Asahi SL application during the study indicates the need for further examination of this issue. According to Słowiński (2004), the bio-stimulant Asahi SL can be used in rapeseed cultivation as a technological treatment in the stage of plant growth, which is the most essential in terms of quality and height of future yield, or emergency treatment recommended after the occurrence of unfavourable conditions for plants. Moreover, it can be applied together with pesticides or foliar fertilizers, which is advantageous for organizational and economic reasons.

The cost of a single dose of the bio-stimulant amounts to 50 zlotys. Applying it together with pesticides, we do not incur other outlays of incorporating Asahi SL into rapeseed cultivation. The profitability of this treatment in the present study was evaluated for significantly differentiated yields in 2005 (assuming following requirements for calculations — 7% humidity and seed prices according to the Matif Stock Exchange — the quotations of 26.12.2005 – 01.01.2006 — 837.33 $zlotys \cdot t^{-1}$). A single application of Asahi SL (after starting the vegetation) in strict experiments increased the yield value per hectare by 322 zlotys, and a two-time application (after vegetation starting and at budding) — by 299 zlotys, while in the large-area experiment — by 586 zlotys and 276 zlotys, respectively.

Conclusions

1. In the season 2003/2004, the winter rapeseed cultivars Californium, Lisek and Libomir were not exposed to the stress of low temperatures or moisture deficiency during the vegetation period and they showed no reaction to the bio-stimulant Asahi SL irrespective of the time of its application.
2. Inclusion of the bio-stimulant Asahi SL to the winter rapeseed production technology in the season 2004/2005, when a strong ground frost occurred at budding as well as water deficit after the re-start of vegetation and at seed ripening, resulted in the increase in seed yield by 11% in comparison to the yield obtained without a bio-stimulant.
3. The winter rapeseed Kaszub stand, with a low plant density but intensive tillage, was highly productive due to the inclusion of the bio-stimulant Asahi SL to the cultivation technology.

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