ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2002
Volume 5
Issue 2
Series AGRONOMY

PRUSIŃSKI J. 2002. EFFECT OF FLURPRIMIDOL ON NARROW- LEAF (*Lupinus angustifolius* L.) AND WHITE (*Lupinus albus* L.) LUPINS SEED YIELDING **Electronic Journal of Polish Agricultural Universities**, Agronomy, Volume 5, Issue 2.
Available Online http://www.ejpau.media.pl

EFFECT OF FLURPRIMIDOL ON NARROW- LEAF (*Lupinus angustifolius* L.) AND WHITE (*Lupinus albus* L.) LUPINS SEED YIELDING

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ABSTRACT

Two strict field two-factor experiments were carried out at the Mochełek Experiment Station of the Bydgoszcz University of Technology and Agriculture over 1999-2001 and included traditional narrow-leaf lupin 'Troll' and white lupin 'Bardo' cultivars. At the beginning of budding (once) and flowering (once) and twice on those stages the plants were sprayed with Topflor 015SL containing 15% of flurprimidol at the doses of 0.15, 0.30 and 0.45 dm·ha^{-1} in 300 l of water per ha. The reaction of the lupin species researched to flurprimidol varied. Significantly highest narrow-leaf lupin seed yields were obtained when Topflor was applied at the dose of 0.30 dm·ha^{-1} at the beginning of flowering, and white lupin after the applying that dose twice, at the beginning of budding and at the flowering of the main stem. Flurprimidol enhanced the number of pods on lateral shoots and the number of pods per plant in white lupin; in narrow-leaf lupin there was observed its unfavourable (insignificant) effect on the number of pods developed, especially at higher doses applied twice. The number and weight of seeds developed on lateral shoots and per plant in narrow-leaf lupin increased significantly against the control after the application of the lowest dose of Topflor at the beginning of budding. In white lupin the number and weight of seeds on lateral shoots and per plant was significantly higher that the control following the application of Topflor at the low and medium doses once (at the beginning of budding) and twice. There was observed no effect of the dose and Topflor application date on the weigh of seeds per pod and 1000 seed weight and seed thickness structure in the yield of any of the species researched. A single application of Topflor at the beginning of narrow-leaf lupin plant flowering at the dose of 0.30 dm·ha^{-1} resulted in an increase in the seed yield by about 15%, and white lupin by 12.5% if Topflor was applied at the dose of 0.30 dm·ha^{-1} twice, at the beginning of budding and at the beginning of flowering.

Key words: flurprimidol, narrow-leaf lupin, white lupin, seed yield and yield components, Topflor 015SL

INTRODUCTION

Potential of narrow-leaf and white lupins seed yields obtained by COBORU [16,17] in Poland amount to 3-4 $t \cdot ha^{-1}$, however in practice they are often lower than 2 $t \cdot ha^{-1}$ [14]. The productivity of lupin much depends on weather conditions [4,9], plant hormonal economy [2,8], and also results from a varied availability of assimilates and nutrients over seed yield formation [11]. Variable across years relatively low legume seed yields are a result of a considerable blossom fall and pod primordia [3], an excessive advantage of vegetative organs over the generative ones [15] and their competition for assimilates, nutrients and water [1]. A limited plant vegetative growth and developing branches which compete for resources can enhance assimilates distribution to the main stem. The excessive branching in lupin plants is undesirable as it prolongs the vegetation period and increases non-simultaneous ripening, which does not enhance the seed yield increase. Although breeding methods are targeted at the reduction in the vegetative weight and the number of branches, however the self-completing cultivars which do not have them are still less productive than the traditional ones [17].

The competition for assimilates can be weakened at the expense of the main stem due to the application of endogenic (auxin and giberrellin) or exogenic (triapenthenol) plant growth regulators inactivating or blocking the synthesis of growth substances. Very good results in yield enhancing and structural yield components in yellow and narrow-leaf lupins with growth retardants Baronet (triapenthenol), Cultar (paklobutrazol) and Cutles (flurprimidol) were obtained by Gromadziński et al. [6]; a maximum increase in the seed yields of these species was 20%, the number of pods on the main stem - 16%, on lateral shoots - 32%. Klasa et al. [10] applying Cutles in the 2-4 leaf stage in faba bean did not obtain a significant increase in the number of pods and seeds. Rola et al. [12] observed that flurprimidol applied at the beginning of flower bud formation in winter rape significantly increased the seed yield and decreased the plant height and that applied in the 4-5 leaf stage strongly inhibited the growth of the lower plant parts, effectively prevented lodging and increased the number of branches and considerably increased the number of siliques per plant and the yield per ha. According to Hamid and Williams [7], the effect of flurprimidol in the cultivation of *Pea desert* L. showed only a shortened main stem and not affecting the length of lateral shoots.

Flurprimidol linearly decreases, with increasing doses, the temporary rate of exchange of carbon dioxide and increase the content of chlorophyll in leaves [5], and also increase tillering, e.g. in grasses, and known its role as an inhibitor of giberrellin biosynthesis [13] responsible also for stimulating longitudinal growth of shoots [8].
In the present research it was assumed that inhibiting the growth of branching of narrow-leaf and white lupins with flurprimidol decreased the number of active and mutually competing assimilates acceptors. Also a different share of seed yield from the main stem and lateral branches in the species researched will affect its varied reaction to the dose and date of the retardant application.

The aim of the present research was the evaluation of the applicability and the effect of flurprimidol – a growth retardant from the group of pyrimidines contained in Topflor 015SL on the yielding of narrow-leaf and white lupins and also yield components of these species.

MATERIALS AND METHODS

Two strict two-factor field experiments in randomised block design with the control in 4 replications were carried out at the Mochełek Experiment Station of the Faculty of Agriculture of the Bydgoszcz University of Technology and Agriculture over 1999-2001 and covered traditional cultivars of narrow-leaf lupin, 'Troll', and white lupin, 'Bardo'.

The experiment scheme for each of the species included:
Factor A – date of applying Topflor 015 SL, containing 15% of flurprimidol
a_1 – a single time early – at the beginning of budding,
a_2 – a single time late – at the beginning of flowering,
a_3 – twice – at the beginning of budding and at the beginning of flowering.
Factor B – dose of Topflor 015 SL
b_1 – 0.15 $dm^3 \cdot ha^{-1}$,
b_2 – 0.30 $dm^3 \cdot ha^{-1}$,
b_3 – 0.45 $dm^3 \cdot ha^{-1}$.

Topflor 015 SL (α-(methyloethylo)-α-[4-(troifluromeoksy)phenylo]-5-pirymidomethanol) was applied in the concentration of 0.05%, 0.10% and 0.15% in 300 l of water per ha. The spray of plants of both cultivars compliant with development phases in the methodology coincided with 19 and 29 of May over 1999 and 2000; in 2001 the second one – the 'Bardo' plants were sprayed with June 7, and 'Troll' cultivar – June 15.

The experiments were set on light soil (IVa and IVb quality class) of the good rye complex of the average richness in phosphorus and high in potassium and pH in 1M KCL – 5.6-6.5. Over the successive research years on April 3, March 31 and April 4, 100 germinating seeds per 1 m^2 of narrow-leaf and 75 – white lupin, were sown in rows every 20 cm and depth of 3-4 cm. The plot area before sowing was 18 m^2, and prior to harvest – 14.4 m^2. Funaben seed-dressing was applied. In spring 80 kg P_2O_5 and 120 kg K_2O was used; nitrogen was not applied. For weed control, directly after seed sowing 1.25 $dm^3 \cdot ha^{-1}$ of Afalon 50 WP and after emergence – 2 $kg \cdot ha^{-1}$ of Goltix 70 WP as well as harrowing were applied. Prior to harvest 20 plants were randomly sampled from each plot to evaluate the structural yield components. The seed yield and its components were given at 15% of the water content. The seed thickness structure was defined with 500 g in the sample with 4 replications with seed sorter developed by the Bydgoszcz Research Institute of Baking Industry Ltd. When comparing the effect of Topflor doses against the control the Dunnet test was applied, and the results were expressed as a percentage. The effect of Topflor doses is presented graphically according to the order scale with respective grading: the control, low dose, mean and high. To define the significance of differences the Tukey test at p=95% was used. The statistical analysis was carried out with the Puławy AWAR IUNG, and graphical development – with STATISTICA PL software.

RESULTS

The weather conditions over years varied (Table 1). In 1999 a slightly lower temperature than the multi-year mean in April, May and June and exposed to high precipitation affected a strong increase in the vegetative growth. However in July a very high temperature which coincided with a lower total precipitation accelerated the ripening of plants whose harvest was after 118 days in 'Troll' and 143 in 'Bardo'. In April, May and June 2000 a high mean air temperature when exposed to, in successive months, 36, 70 and 36% of the mean multi-year total precipitation for that period. In July air temperature did not exceed 16 °C, and the total precipitation as much as 101 mm; the harvest of 'Troll' was carried out at the end of July, after 121 vegetation days, and 'Bardo' – at the end of August, after 150 days. The year 2001 recorded a chilly April and high air temperature from May to the end of August and very favourable at that time moisture (total precipitation in June and July was 226 mm). 'Troll' was harvested after 122 days, and 'Bardo' as late as after 163 days off the sowing, which coincided with mid September due to continuous precipitation which prevented seed drying. Over the lupin vegetation, April through the end of August in 2001 353 mm precipitation was recorded, in 2000 – 217 mm, and in 1999 – 264 mm; a varied mean air temperature at that time was very low (14.9 –15.0 °C).

Table 1. Mean air temperature and total precipitation according to the Mochełek Experiment Station

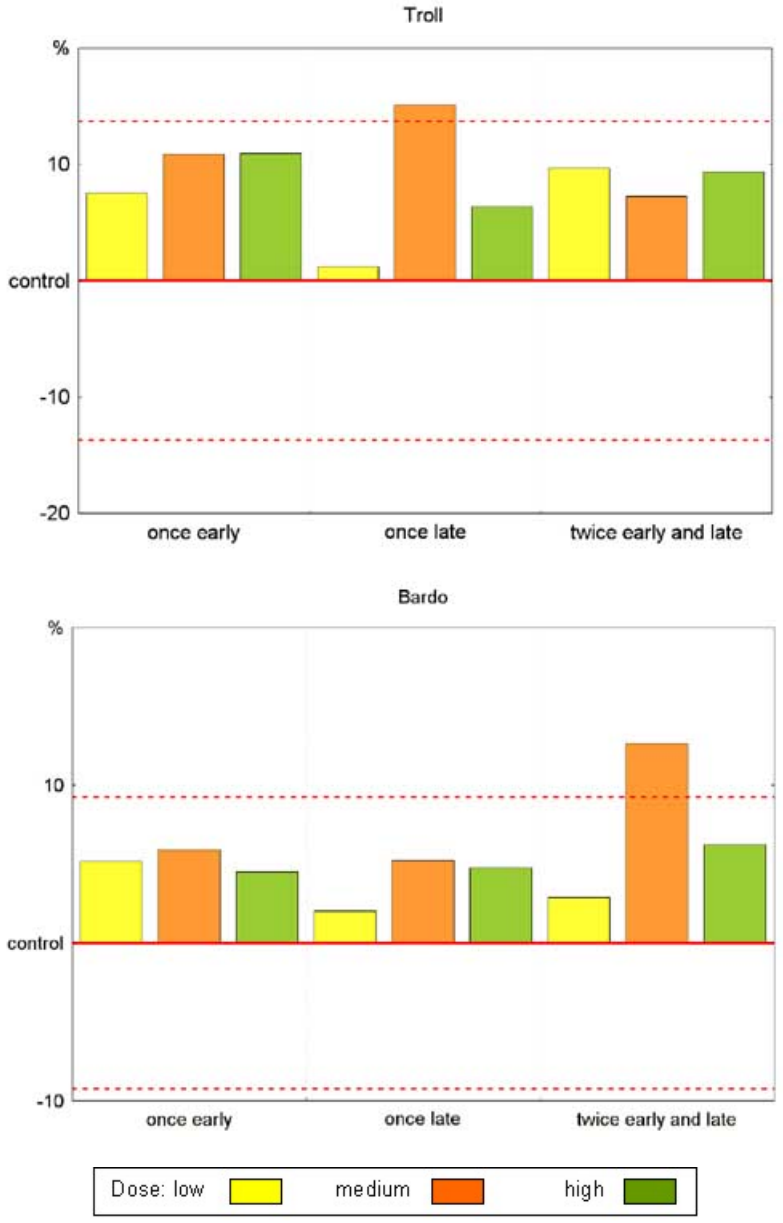
Specification	Year	Month					
		April	May	June	July	August	September
Mean air temperature, °C	1999	8.6	12.2	16.5	20.0	17.4	17.8
	2000	11.0	14.5	16.7	15.7	17.3	11.7
	2001	7.0	13.1	16.6	20.3	17.5	11.2
1999-2001 mean		8.8	13.2	16.6	18.6	17.4	13.5
Total precipitation, mm	1999	62.1	45.5	58.6	43.9	53.8	19.7
	2000	14.6	24.6	19.1	100.9	58.4	57.8
	2001	42.4	34.9	80.5	146.1	49.7	122.6
1999-2001 mean total		39.7	35.0	52.7	96.9	53.9	66.7

The seed yields of both species cultivated on good rye complex was comparable, however the narrow-leaf lupin straw yield was by 13% higher, and the harvest index was almost 18% lower, than in white lupin (Table 2). A multi-year mean yield from the narrow-leaf lupin controls amounted to 3.31 $t \cdot ha^{-1}$, and white lupin – 3.10 $t \cdot ha^{-1}$. There was observed no significant effect of flurprimidol on the yielding of the species researched. From the experimental narrow-lupin plots the seed yield was 8.7% (from 4.6% in 1999 to 15.1% in 2000) higher than from the control, and white lupin – only 5.4% (from 3.8% in 2000 to 9.4% in 1999) higher. Despite no significant differences in the mean seed yield obtained from experimental objects, narrow-leaf lupin yielded significantly higher than the control by 15.1% after the application of 0.30 $dm^3 \cdot ha^{-1}$ of Topflor at the beginning of plant flowering, however white lupin, when Topflor at the dose of 0.30 $dm \cdot ha^{-1}$ was applied twice, at the beginning of budding and plant flowering; an increase in the seed yield against the control in both species amounted to 15.1% (by 500 $kg \cdot ha^{-1}$) and 12.6% (by 393 $kg \cdot ha^{-1}$), respectively (Fig. 1).

Table 2. Narrow-leaf and white lupins yielding

Specification	Troll		Bardo	
	Control	Topflor	Control	Topflor
Seed yield, t·ha^{-1}	3.31a	3.59a	3.10a	3.27a
Straw yield, t·ha^{-1}	4.39a	4.52a	3.87a	3.84a
Harvest index	0.39a	0.41a	0.46a	0.48a

Fig. 1. Effect of Topflor on narrow-leaf and white lupins yielding



In narrow-leaf lupin (Table 3) there was observed slightly more pods and seeds on lateral shoots than on the main stem, however in white lupin (Table 4) – just the opposite; slightly more pods and seeds was harvested from the main stem. In the first of the species discussed there was observed a significant effect of flurprimidol on mean values of structural yield components. However in white lupin treated with flurprimidol, a mean number of pods and seeds and weight of seeds developed on lateral branches of a single plant assumed significantly higher values than the control plants.

Table 3. Narrow-leaf lupin seed yield components

Seed yield components	Per main stem		For branches		Per plant	
	Control	Topflor	Control	Topflor	Control	Topflor
Number of pods	5.27a	5.23a	6.53a	5.91a	11.8a	11.1a
Number of seeds	16.8a	18.2a	20.9a	23.2a	37.7a	40.3a
Seed weight, g	2.68a	2.73a	3.13a	3.30a	5.81a	6.03a
Seed weight per pod, g	0.49a	0.51a	0.44a	0.45a	0.47a	0.46a
1000 seed weight, g	-	-	-	-	145a	145a

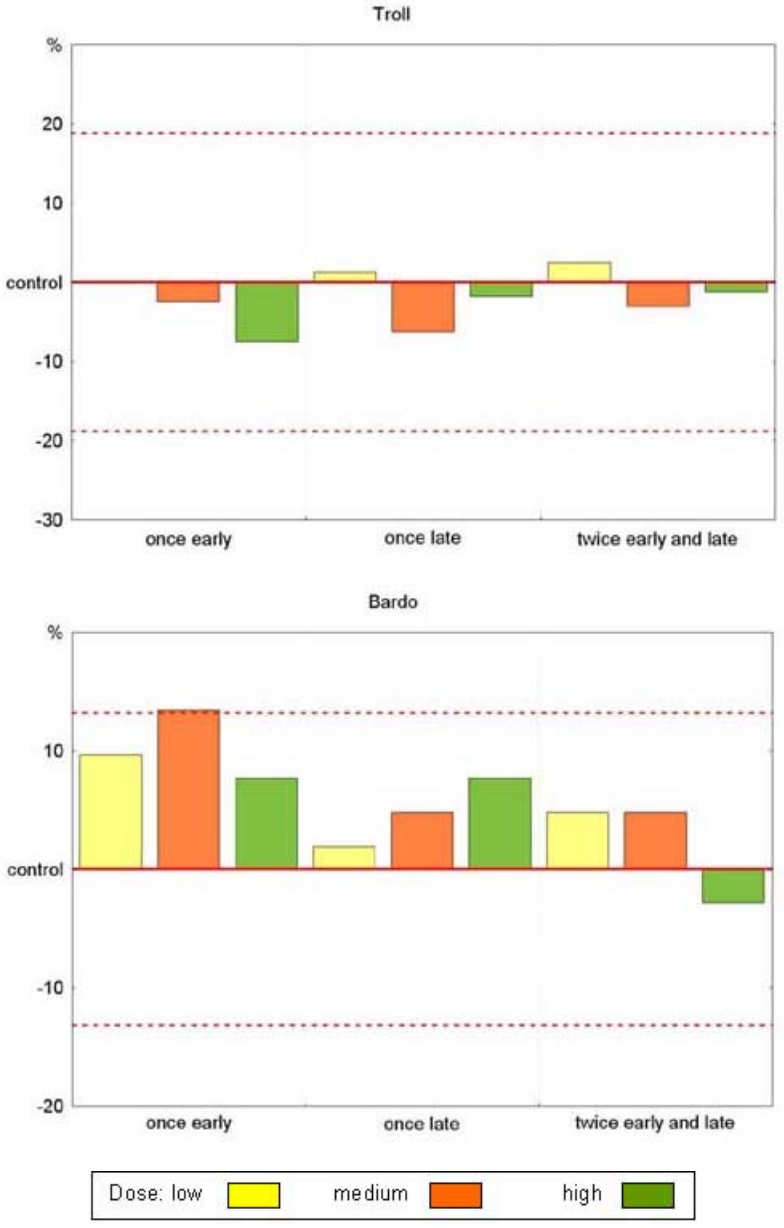
Table 4. White lupin seed yield components

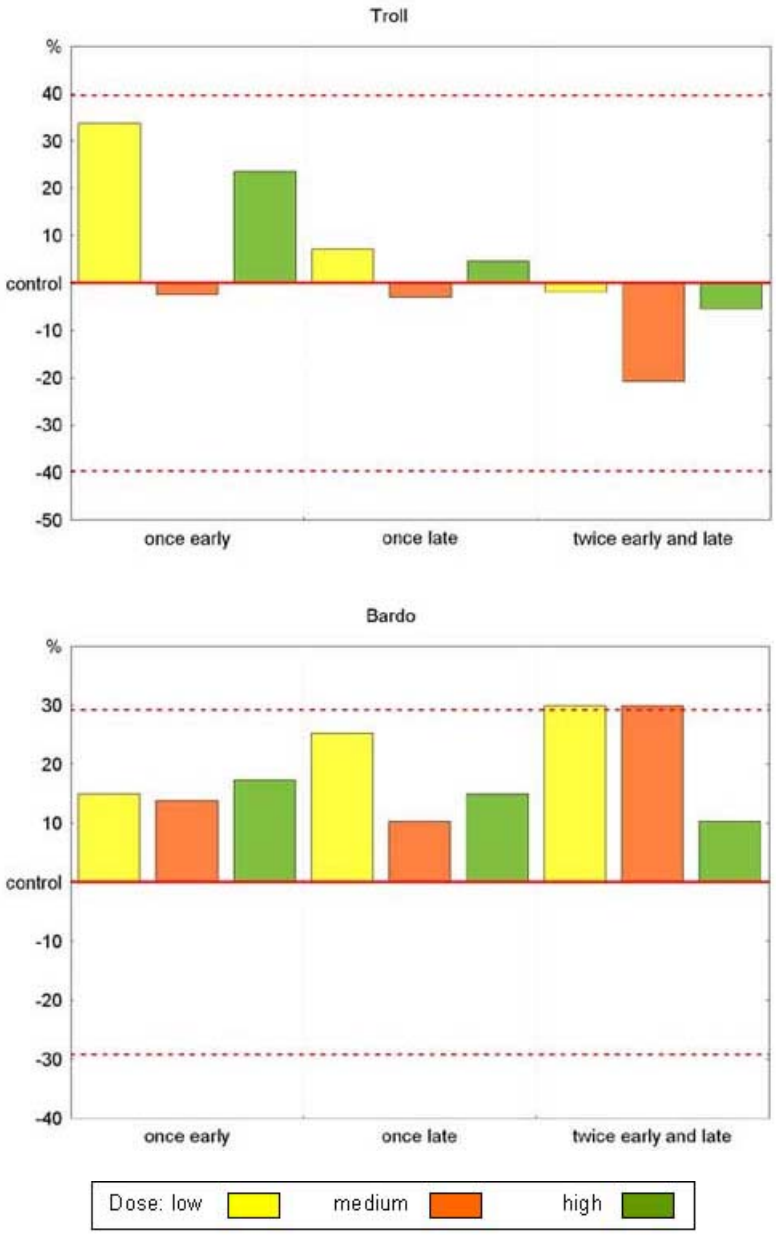
Seed yield components	Per main stem		For branches		Per plant	
	Control	Topflor	Control	Topflor	Control	Topflor
Number of pods	3.47a	3.66a	2.90b	3.43a	6.37b	7.09a
Number of seeds	13.3a	14.1a	9.30b	11.4a	22.6b	25.5a
Seed weight, g	3.75a	4.00a	2.35b	2.89a	6.10b	6.89a
Seed weight per pod, g	1.10a	1.09a	0.75a	0.81a	1.00a	0.99a
1000 seed weight, g	-	-	-	-	276a	278a

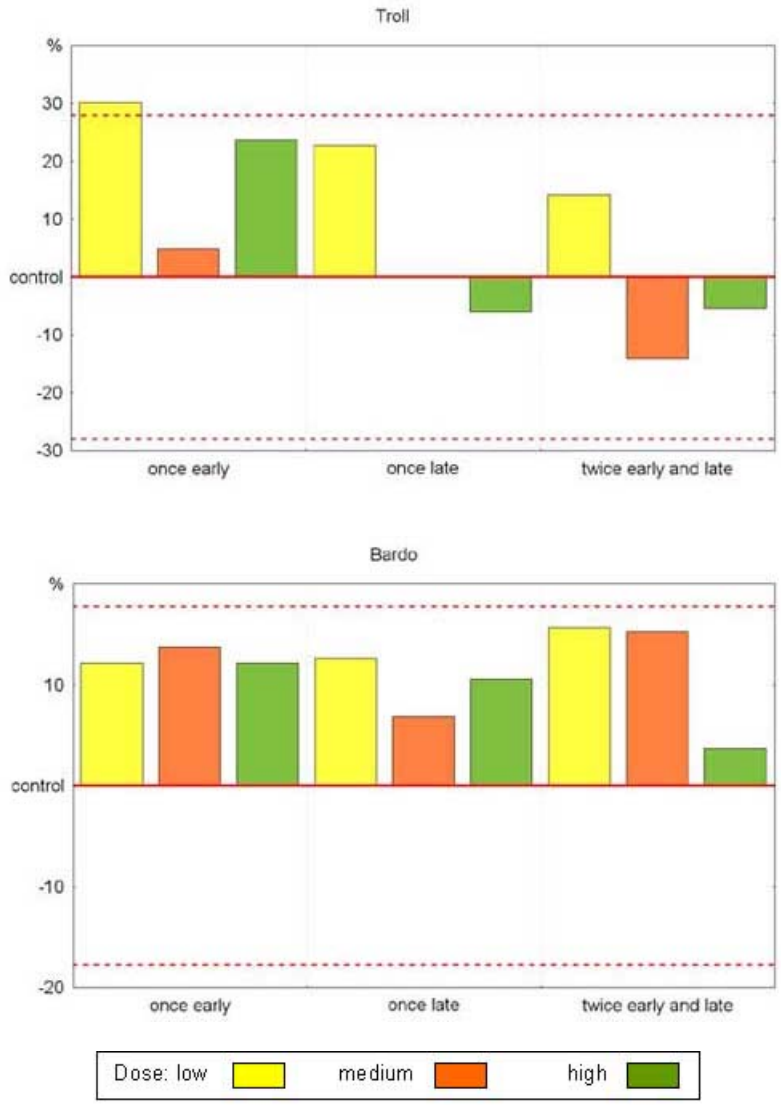
Structural yield components of the lupin species researched depended on the dose and date of Topflor application. In narrow-leaf lupin, Topflor showed an insignificant effect on the number of pods on the main stem (Fig. 2.1) and lateral branches (Fig. 2.2) and resulted in a significant increase, by 30.7% of the number of pods per plant (Fig. 2.3) when its dose amounted to 0.15 $dm^3 \cdot ha^{-1}$ at the beginning of plant budding. With higher and double retardant doses there was observed an unfavourable (insignificant) effect of flurprimidol on the number of pods developed on the main stem of this species. However in white lupin there was observed a favourable effect of flurprimidol on the number of pods developed on the main stem – significant after the application of 0.30 $dm^3 \cdot ha^{-1}$ of Topflor at the beginning of budding (by 13.4%) and on lateral shoots when plants were sprayed twice with 0.15 $dm^3 \cdot ha^{-1}$ and 0.30 $dm^3 \cdot ha^{-1}$ (by 29.8%) against the control.

Fig. 2. Effect of Topflor on the narrow-leaf and white lupins number of pods
2.1 per main stem
2.2 for branches
2.3 per plant

2.1



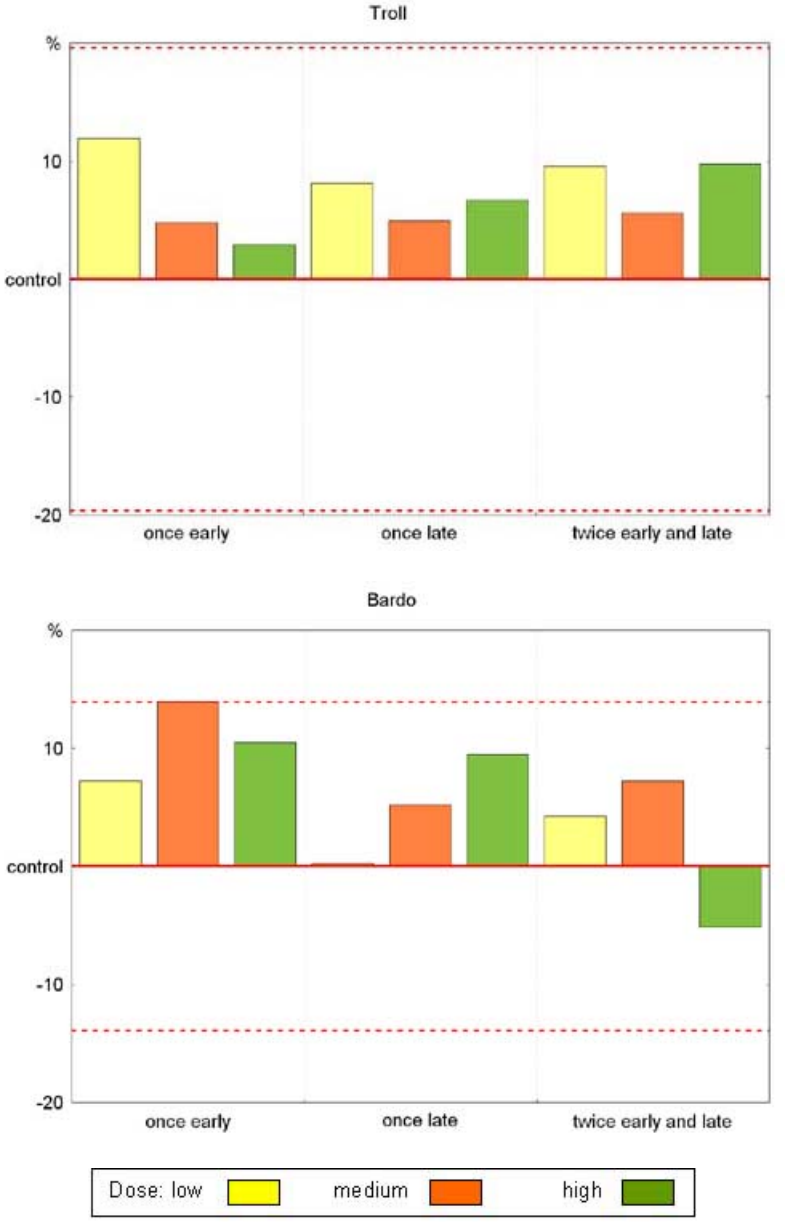

Troll
%
40
30
20
10
control
-10
-20
-30
-40
-50
once early
once late
twice early and late
Bardo
%
30
20
10
control
-10
-20
-30
-40
once early
once late
twice early and late
Dose: low
medium
high

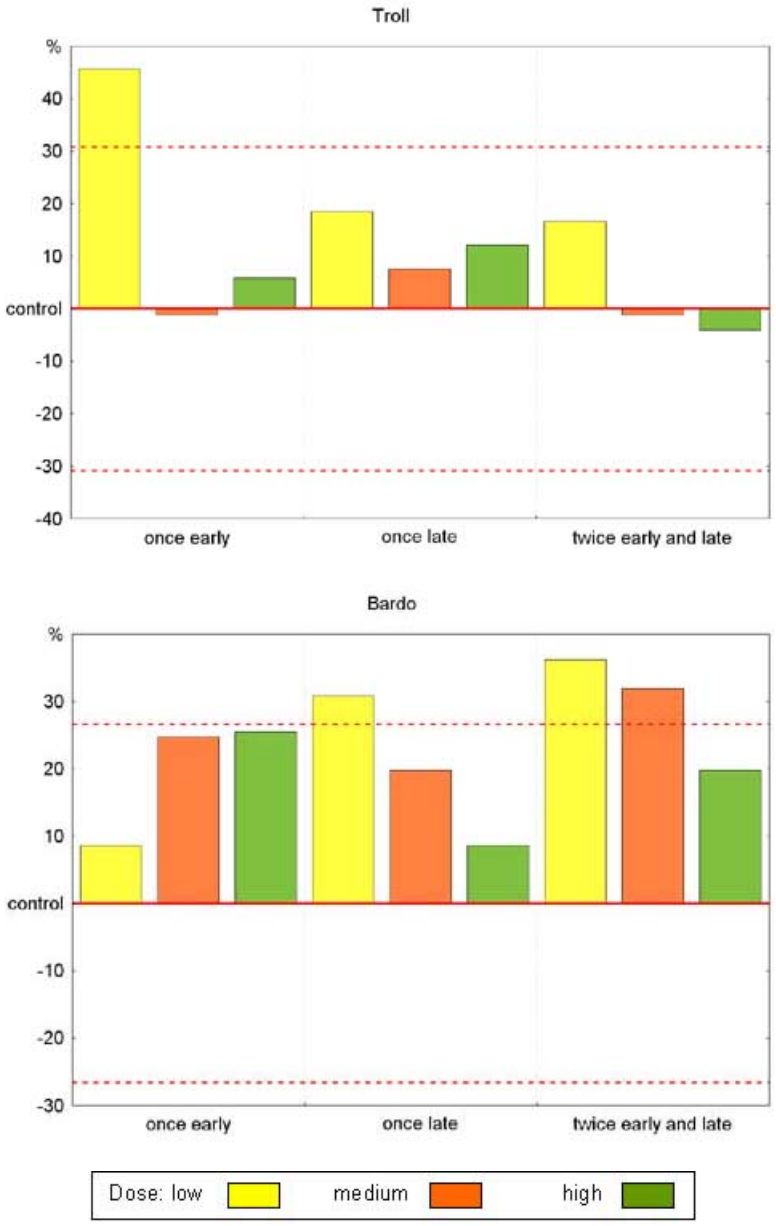


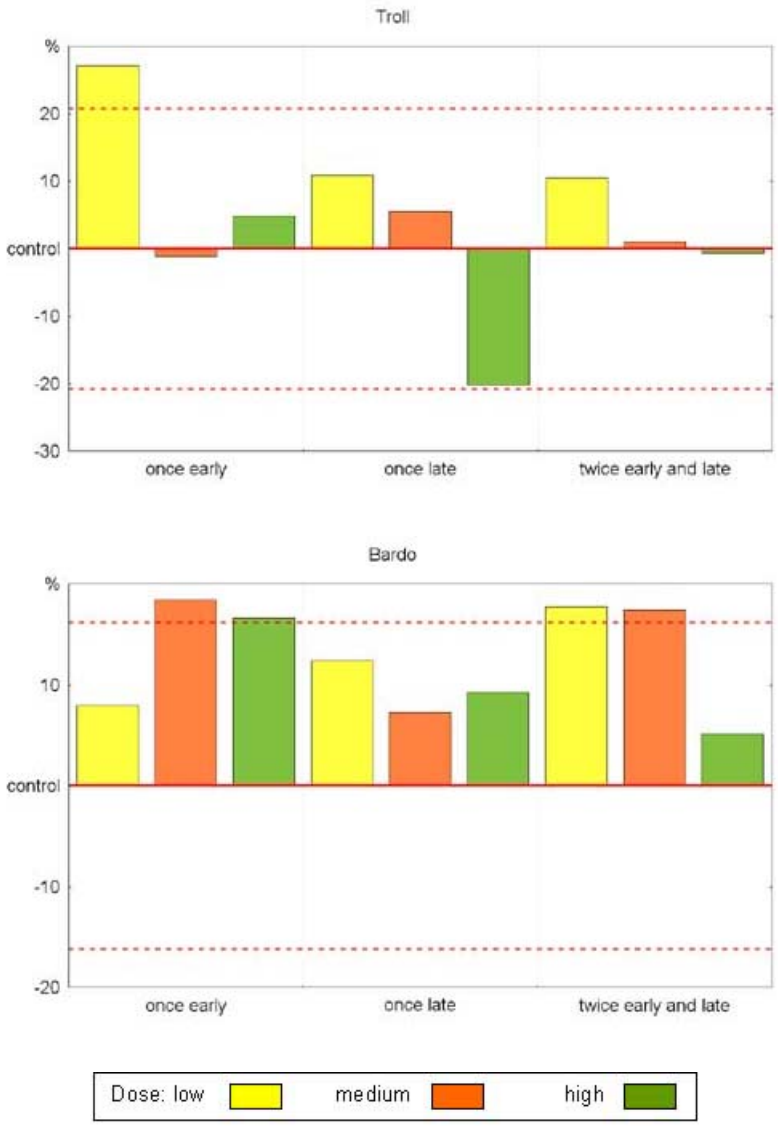
The number of seeds from the main stem (Fig. 3.1) did not depend significantly on the dose and date of retardant application, and on lateral shoots and a single narrow-leaf lupin plant was significantly higher than the control, respectively by 45.5% and 27.2% after the application of the lowest dose of Topflor at the beginning of budding (Figs. 3.2 and 3.3). However in white lupin there was observed significantly more seeds than in controls on lateral shoots when the lowest dose of Topflor was applied at the beginning of April (by 30.8%) and twice – the lowest (by 36.2%) and a mean dose (by 31.9%). As a result the number of seeds harvested from a white lupin plant was significantly higher than the control when mean and high doses of Topflor were applied – once at the beginning of budding (by 18.4% and 16.6%) and low and mean – twice, at the beginning of budding and plant flowering (by 17.5% and 17.4%).

Fig. 3. Effect of Topflor on the narrow-leaf and white lupins number of seeds
3.1 per main stem
3.2 for branches
3.3 per plant

3.1

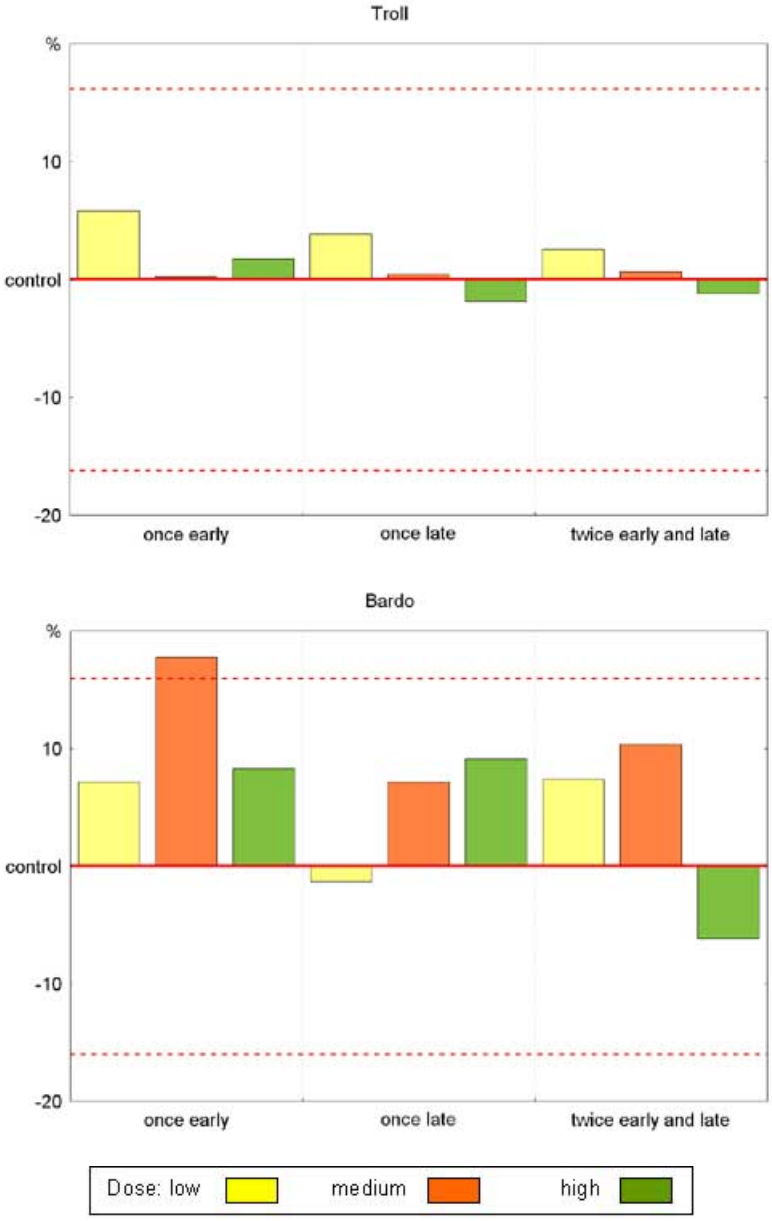


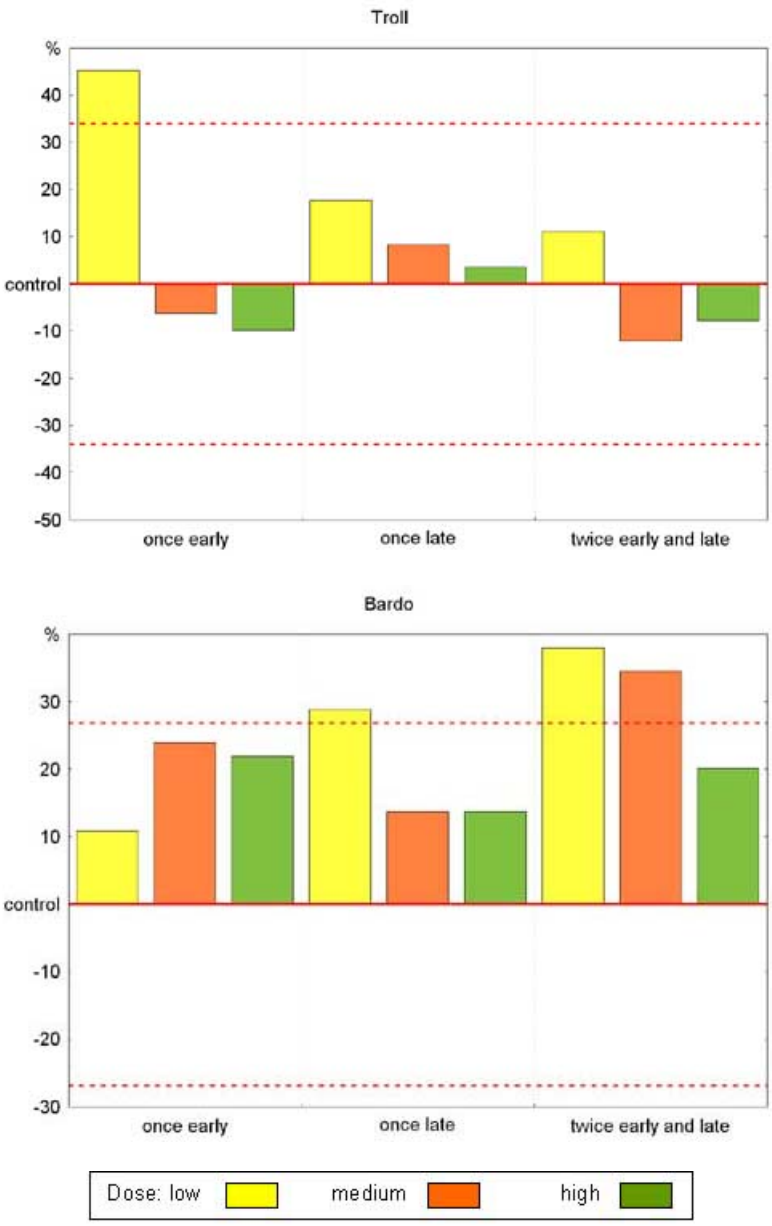

Troll
%
40
30
20
10
control
-10
-20
-30
-40
once early
once late
twice early and late
Bardo
%
30
20
10
control
-10
-20
-30
once early
once late
twice early and late
Dose: low
medium
high

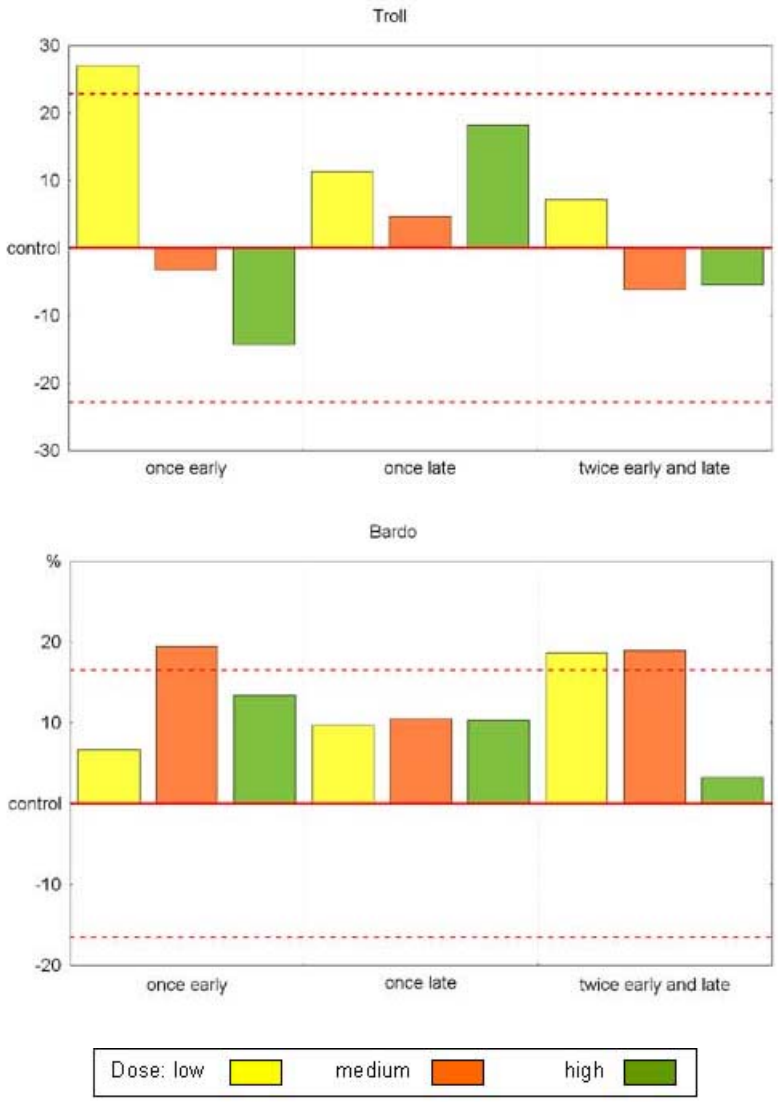


The weight of seeds from lateral shoots (Fig. 4.2) and a single narrow-leaf lupin plant (Fig. 4.3) was significantly higher than the control, respectively by 45.4% and 27.0% following the application of Topflor at the dose of 0.15 $dm^3 \cdot ha^{-1}$ at the beginning of budding. The other doses and dates of spraying plants with Topflor did not show a significant effect on this yield component; it easily observable that an earlier use of Topflor even showed an unfavourable effect on the weight of seeds collected both from lateral shoots and from a single plant. In white lupin there were noted similar relationships for the weight and number of seeds. Topflor enhanced the seed weight of that species when a mean dose was applied at the beginning of budding – on the main stem (increase by 17.7%), a low dose at the beginning of flowering – on lateral shoots (by 28.8%) and a low and mean dose applied twice – on a single plant (by 38.0% and 34.5%).

Fig. 4. Effect of Topflor on the narrow-leaf and white lupins weight of seeds developed on
4.1 main stem
4.2 for branches
4.3 plant



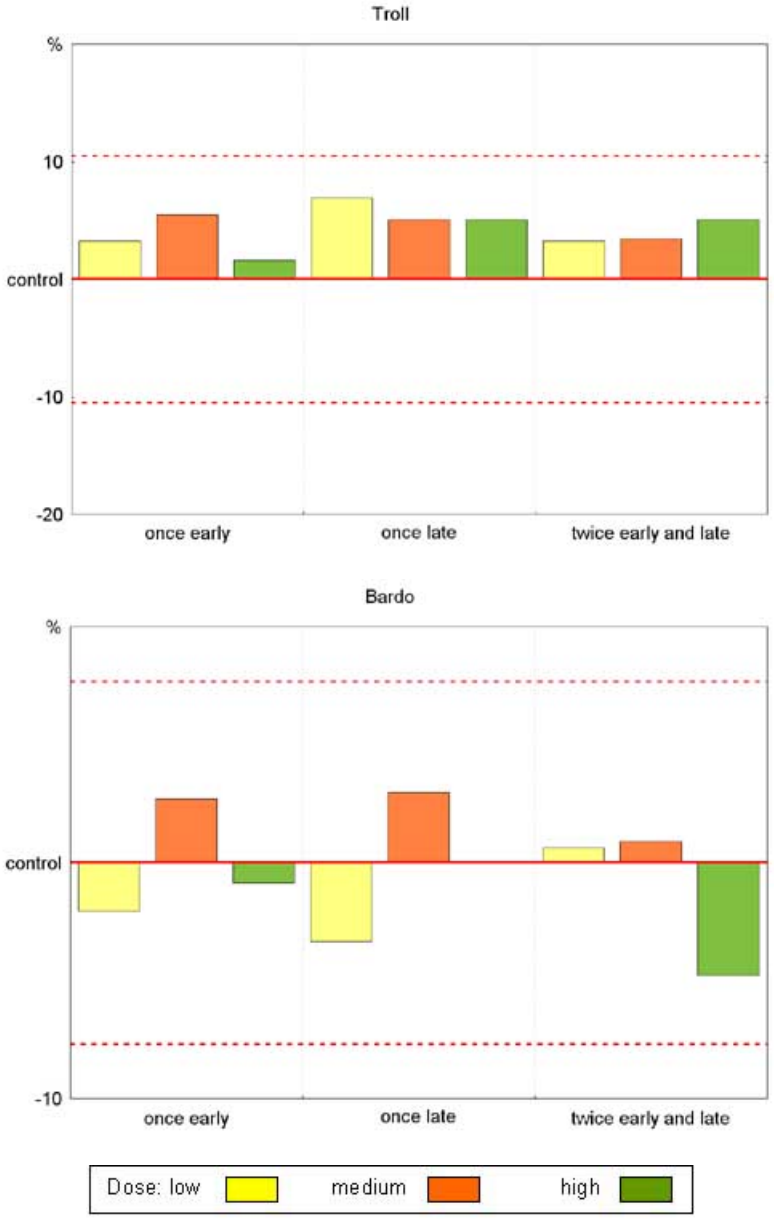

Troll
%
40
30
20
10
control
-10
-20
-30
-40
-50
once early
once late
twice early and late
Bardo
%
30
20
10
control
-10
-20
-30
once early
once late
twice early and late
Dose: low
medium
high

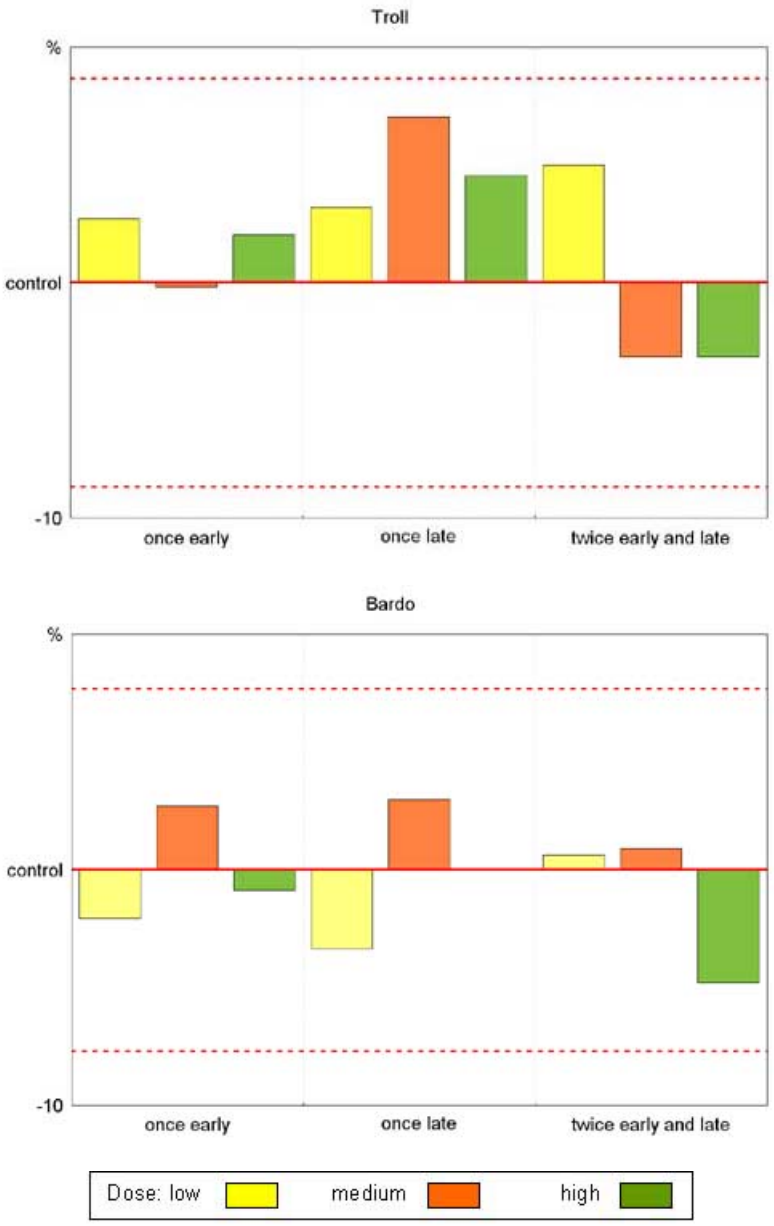


There was noted no significant effect of the dose and date of Topflor application on the weight of seeds developed in pods of both species (Fig. 5) as well as the 1000 seed weight (Fig. 6). Despite an insignificant but favourable effect of the retardant on those features, there was also recorded a rather quite random unfavourable effect of the retardant applied on both.

Fig. 5. Effect of Topflor on the narrow-leaf and white lupins seed weight in pod developed on
5.1 main stem
5.2 for branches
5.3 plant

5.1




Troll
%
control
-10
once early
once late
twice early and late
Bardo
%
control
-10
once early
once late
twice early and late
Dose: low
medium
high

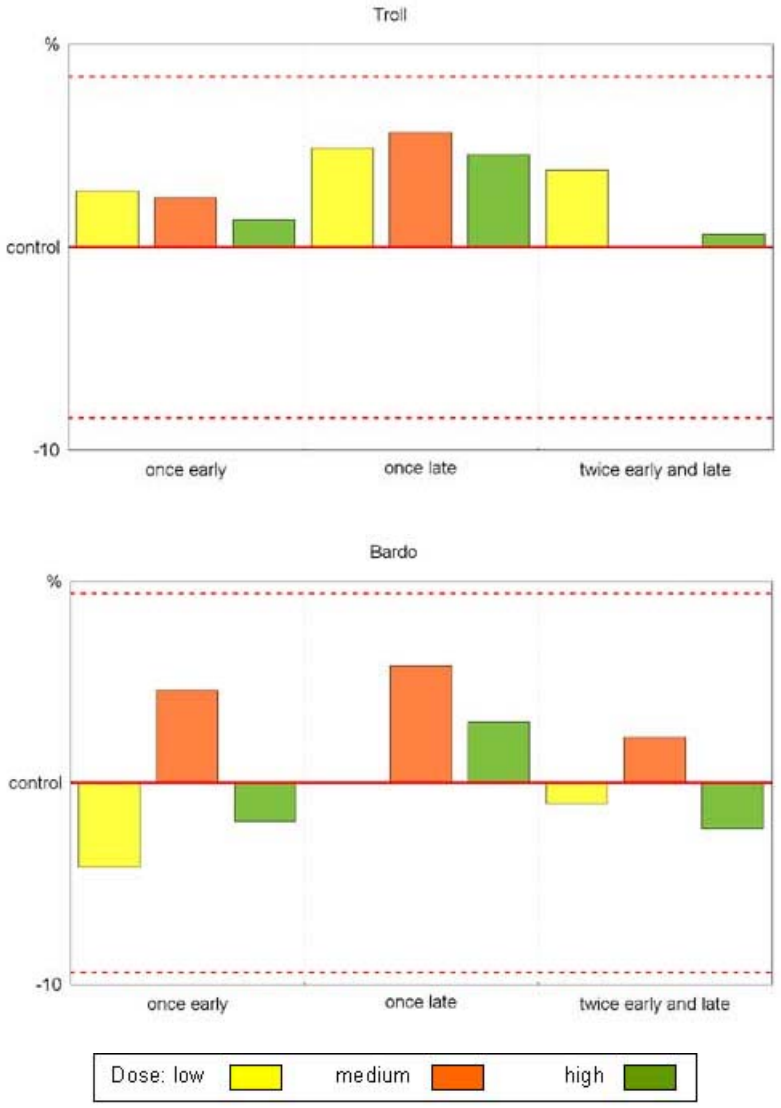
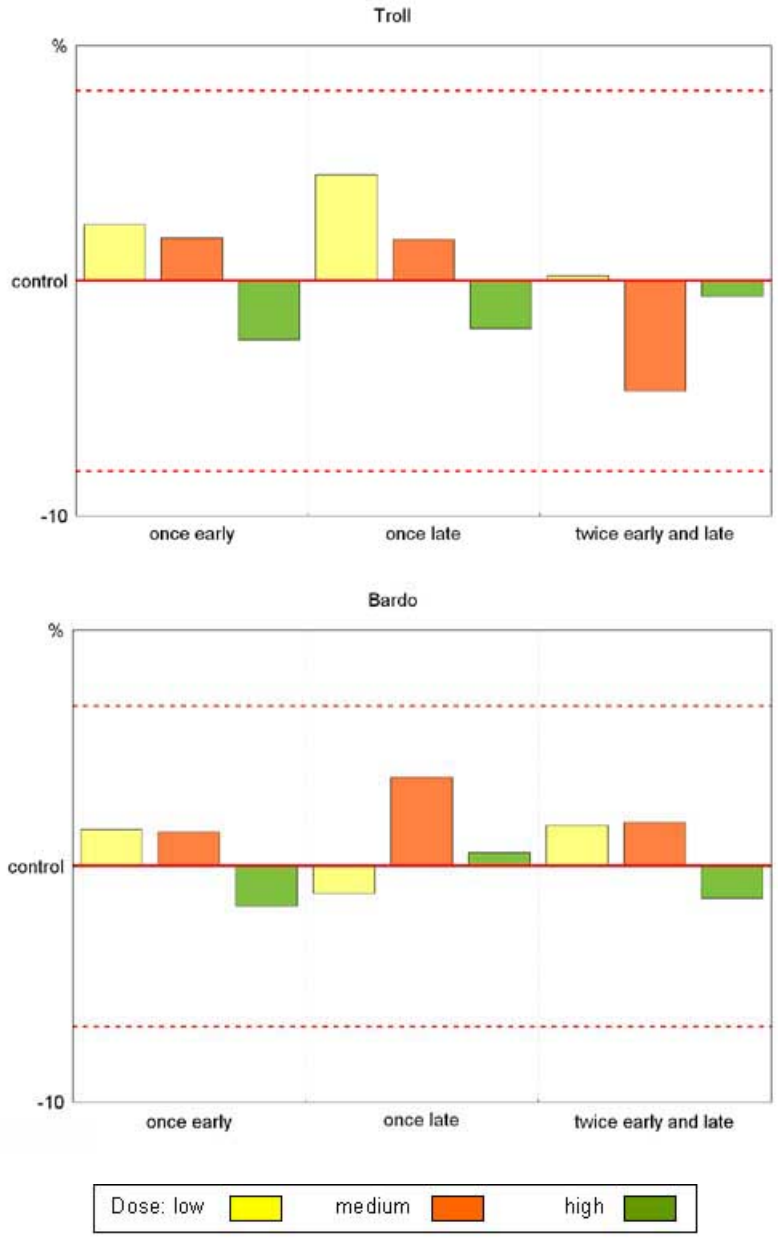

Troll
%
control
-10
once early
once late
twice early and late
Bardo
%
control
-10
once early
once late
twice early and late
Dose: low
medium
high

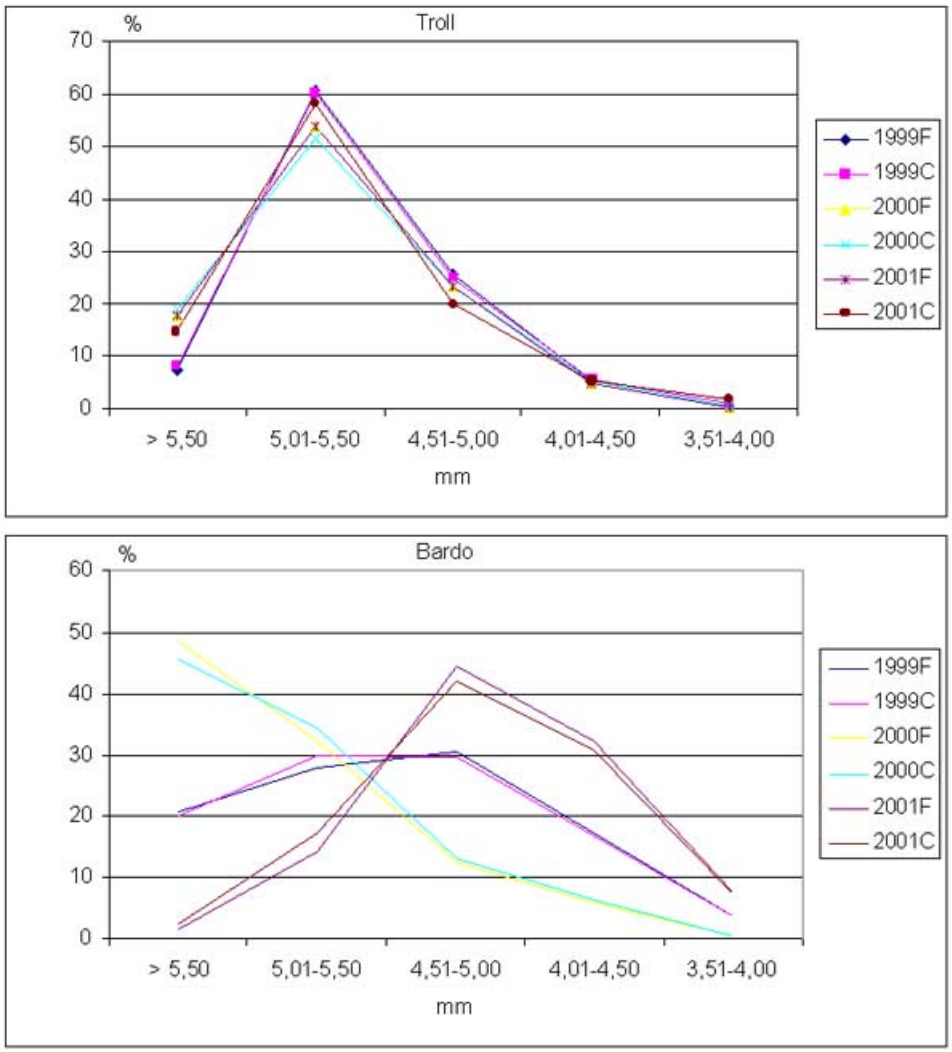
Fig. 6. Effect of Topflor on the narrow-leaf and white lupins 1000 seed weight



In none of the species researched there was noted a significant effect of the dose and date of Topflor application on the plant height, their lodging and seed viability and vigour (data not presented).

The seed thickness structure in the yield depended on the course of vegetation period conditions in successive research years; however the doses and dates of plant spraying with Topflor did not affect it significantly in any of the species (Fig. 7). In narrow-leaf lupin over all the research years seeds of the thickness of 5.01-5.50 mm remained predominant. In white lupin there was noted a considerable effect of the weather course over the vegetation period on the structure of seed thickness – in the driest year of 2000 the yield was dominated by the seeds over 5.50 mm thick, in 2001 – 4.01-4.50 mm, while in 1999 – 4.51-5.00 mm thick.

Fig. 7. Seed thickness structure in the control yield (C) and following the application of Topflor (F) in narrow-leaf and white lupins



DISCUSSION

The course of weather conditions over the lupin vegetation period is one of the most important factors affecting yields [4,9,14]. In the present research the highest seed yields were recorded in 2001 exposed to the total precipitation over the vegetation period of over 350 mm, and the lowest in 2000 when only 217 mm was recorded over the same period. An average narrow-leaf lupin seed yield was slightly higher than the white lupin yield for which the soil conditions at Mochełek must have been slightly too poor. The research by COBORU report on average narrow-leaf lupin seed yields of 3.03 $t \cdot ha^{-1}$ (mean for 1999-2001) [17], and white lupin – 3.18 $t \cdot ha^{-1}$ (mean for 1994 -1995) [16].

Growth retardants inhibit the synthesis of giberrellin which is one of the compounds stimulating longitudinal shoot growth and they are mostly applied limiting cereal lodging. Flurprimidol, retardant representing pyrimidines, has been applied so far in horticulture only to limit the vegetative growth of ornamental plants grown under shields [8]. When applied to other plants, it also significantly increased the rape seed yield [12], enhanced the number of pods of the main stem and significantly increased the seed yield of yellow lupin and narrow-leaf lupin [6], not affecting the faba bean yielding [10]. In the present research flurprimidol did not show a significant effect on the mean yields of seeds of the lupin species researched. In narrow-leaf lupin there was recorded also no significant effect of the dose and date of Topflor application on structural yield components, which contradicts the results given earlier reported by Gromadziński at al. [6], despite the application of the same dose of flurprimidol per ha. A different reaction was noted in white lupin where the best results of both seed yield and values of yield structural components were obtained when Topflor was applied at the dose of 0.30 $dm^3 \cdot ha^{-1}$ twice, at the beginning of budding and at the beginning of main stem flowering. Significantly higher

values of yield components concerned lateral shoots and the plant as a whole. A smaller reaction of narrow-leaf lupin to Topflor could have been due to an intensive production and growth of lateral shoots at least two rows of which are produced by this species [9], and at the same time a faster neutralising the retardant applied. Maybe for that reason there was noted no significant effect of the doses and date of Topflor application on the seed biological value and its structure.

Over years of high moisture retardants are taken up faster and in bigger amounts – they show the most favourable effect when applied at the beginning of flowering of the main stem [6]. In the present research these observations were confirmed in narrow-leaf lupin as in white lupin the treatment applied twice showed more favourable – at the beginning of budding and flowering of the main stem. As flurprimidol results in short-term decrease in the rate of exchange of CO_2 and increases the content of chlorophyll, its physiological effect on plants under varied conditions of temperature and precipitation are difficult to define [7]. The increase in the seed yield observed in the present research following the application of flurprimidol could have resulted from a change in the morphological structure of plants, decreasing not only the risk of lodging but also enhancing the light penetration and slightly enhancing pod-filling.

CONCLUSIONS

1. The reaction of the lupin species researched to flurprimidol varied. Significantly highest seed yield of narrow-leaf lupin was obtained when Topflor was applied at the dose of 0.30 $dm^3 \cdot ha^{-1}$ at the beginning of flowering, whereas white lupin after its application at the same dose twice, at the beginning of budding and the main stem flowering.
2. Flurprimidol enhanced the number of pods on lateral shoots and per plant in white lupin; in narrow-leaf lupin there was recorded its negative (but insignificant) effect on the number of pods developed, especially when higher doses were applied twice.
3. The number and weight of seeds developed on lateral shoots and a single narrow-leaf lupin plant increased significantly against the control after the application of the lowest dose of Topflor at the beginning of plant budding. In white lupin the number and weight of seeds developed on lateral shoots and a single plant was significantly higher than the control after the application of the lowest and average doses of Topflor a single time early and twice.
4. There was recorded no effect of the dose and the date of Topflor application on the weight of seeds per pod and 1000 seed weight and the seed thickness structure in the yield of any of the species researched.
5. 0.30 $dm^3 \cdot ha^{-1}$ of Topflor applied once at the beginning of narrow- leaf lupin flowering increased the seed yield by about 15%, and white lupin by 12.5%, if 0.30 $dm^3 \cdot ha^{-1}$ of Topflor was applied twice, at the beginning of budding and at the beginning of plant flowering.

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