FUNGICIDE APPLICATION EFFECT ON YIELD AND QUALITY FORMATION OF WINTER OIL-SEED RAPE *(BRASSICA NAPUS L.)*

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Abstract

Sowing area under oil-seed rape (*Brassica napus* L.) has grown dramatically only during the last 10 years in Latvia. Lack of knowledge and research on different issues is observed. The aim of our research, started on season 2005/2006 in Research and Study farm 'Vecauce', was to investigate the influence of split fungicide (1^{st} dose of fungicide juventus 90 s.c. (metconasol 90 g L^{-1}) used as growth regulator in autumn at the 4-6 leaf stage and the 2^{nd} dose – at the growth stage 63-64) application. Winter rape development in autumn, winterhardiness, disease incidence, and yield and its structure elements were estimated. Totally 13 cultivars were used in the trial, but several assessments were done for 5 cultivars. Additional objective was to evaluate economic effect of fungicide use. Winter rape biometrical indices were influenced by the fungicide application in autumn period and by used cultivar. Fungicide treatment in autumn increased also the rape winterhardiness. Our research for the first time indicated that *Phoma* stem canker could become a problem for rape growers in Latvia. Fungicide use (in growth stage 63-64) decreased incidence of this disease a little (on average by 5%). Fungicide treatment according to applied scheme increased the average seed yield (check – 5.37 t ha^{-1}, with fungicide – 5.80 t ha^{-1}; $LSD_{0.05}$ = 0.18 t ha^{-1}), but impact on yield structure elements was mainly non-essential. Despite agronomic improvements, economic calculation showed that on average fungicide use in 2006 was not profitable. Research should be continued for specification of conclusions.

Keywords: winter rape, growth regulation, winterhardiness, diseases, fungicide, yield.

Introduction

Sowing area under oil-seed rape (*Brassica napus* ssp. oleifera) has grown dramatically during the last 10 years in Latvia: from 400 ha in 1997 up to 77 000 ha in 2006. Winter form of crop is preferred due to possibility to obtain higher seed yield. Winterhardiness of winter oil-seed rape is one of the key factors for successful growing of this crop. Wintering of rape depends on the plant development stage in the autumn, which could be affected by the growing manner including used cultivar and agro-climatic factors. Before the winter period, rapeseed plant should create a sufficient aboveground and root mass, but on the other hand it should not be overgrown. Important characteristics are: root-neck diameter (should reach 8 to 10 mm), height of growth-point above the soil (should be less than 30 mm), and number of leaves (at least 6 to 8 leaves). Becka et al. (2004) reported that more leaves, less height of growth-point and greater diameter of root-neck are the result of lower crop density, when plants have enough space and there does not exist a strong intra-specific competition. Optimum crop density for successful wintering is reported 30 to 70 plants m^{-2} (Velicka, 2003; Leach et al., 1999). Some researchers from other countries and in different conditions reported (Gaveliene et al., 2002; Becka et al., 2004; Miliuviene et al., 2004) that application of growth regulator increases number of leaves per plant and root-neck diameter, and decreases height of growth-point of winter rape, thus favouring winterhardiness of the crop. In agro-ecological conditions of Latvia, winter rape growth in autumn period and any possibility to affect important plant characteristics for good wintering have not been documented. Similarly only few data exist on rape disease incidence and caused damage (Treikale et al., 2006). Our preliminary experience suggested that with increase of rape proportion in crop structure, growers in Latvia have to pay attention to *Sclerotinia* stem rot. Researchers in other parts of world widely draw attention to another disease: *Phoma* stem canker or *Phoma* leaf spot (West et al., 2002; Huang et al., 2005). In previous years nobody in Latvia has paid attention to this disease and its development cycle. Contradictory is the opinion about the necessity to apply fungicide for oil-seed rape, about which only very few papers have reported and analysed its economic substantiation in Latvia (Treikale et al., 2006). The possible fungicide effect on yield structure elements has not been documented in Latvia at all.

The aim of currently described section of our research was to investigate the influence of split fungicide (in autumn used as growth regulator) application on winter rape development in autumn, winterhardiness, disease incidence, and yield and its structure elements in agro-ecological conditions of Latvia. The economic effect of fungicide use has to be evaluated in addition.

Materials and Methods

Two-factor field trials were carried out in the Research and Study farm 'Vecauce' of the Latvia University of Agriculture starting with 2005. Autumn development of oil-seed rape is described from two-year field trials, but disease incidence in summer, seed yield and its quality, and economic aspects of fungicide use – only as results of 2006. Thirteen different winter rape cultivars (factor A) were included in the trial (see the names in Table 2). Fungicide application was factor B (B1 – control, without fungicide; B2 – split fungicide application). Fungicide application scheme: 1st dose (0.5 L ha^{-1}) of fungicide juventus 90 s.c. (metconasol 90 g L^{-1}; September 22 in both years) was applied at the 4-6 leaf stage, and the 2nd dose (0.5 L ha^{-1})– at the growth stage 63-64 (date in 2006 depends on the cultivar). Treatments were arranged in four times replicated randomised blocks, plot size was 7 m^2.

Soil in the trials' site was strongly-altered-by-cultivation loam with $pH_{KCl} = 6.7$ to 7.0; content of available for plants $K = 98$ to 122 mg kg^{-1} and $P = 103$ to 147 mg kg^{-1}; humus content 19 to 21 g kg^{-1}. Traditional soil tillage with mould-board ploughing was used. Crop was fertilized with special mineral fertilizer for rape containing also sulphur and microelements at the following rate: N 21 to 33 kg ha^{-1}, P 22 to 27 kg ha^{-1}, and K 52 to 57 kg ha^{-1} before sowing depending on a year. Top-dressing with nitrogen fertilizer at the rate of 70 kg ha^{-1} N (at the start of vegetation, 13 April 2006) plus 70 kg ha^{-1} N (at the stage of well developed rosette, 8 May 2006) was used. Sowing was done in optimal time (up to 20 August) for Latvia's conditions, and used seed rate was 5.0 kg ha^{-1} in 2005 and 4.0 kg ha^{-1} in 2006. Weeds were controlled using herbicide butisan star s.c. (metasachlor, 333 g L^{-1} + kvinmerac 83 g L^{-1}) 2.5 L ha^{-1} on 19 August 2005 and 29 August 2006; monocotyledons were controlled using azhil e.c. (propakvizaphop 100 g L^{-1}) 1.0 L ha^{-1} in 29 September 2005 and 0.7 L ha^{-1} in 11 September 2006. Insects were controlled by fastac e.c. (alfa cipermetrin, 100 g L^{-1}) 0.15 L ha^{-1} (5 May 2006). The yield was harvested by direct combining (plot combine HEGE-140, 3-4 August 2006) and was calculated to 100% purity and 8% moisture.

At the end of autumn vegetation (2005 and 2006), 10-plant samples were taken randomly for five randomly selected cultivars (see names in Table 1) from each plot for biometrical analysis (24 October 2005 and 30 October 2006). Number of leaves per plant, plant, root, and shoot weight, g, root length, cm, diameter of root neck, mm, and height of growth-point, mm, were measured in a laboratory. Disease incidence and severity in the autumn was evaluated for 50 plants per plot and expressed in percent (7 October 2005 and 23-24 October 2006). Disease incidence (expressed in percent) in summer 2006 was evaluated: for *Alternaria* pod spot 10 pods in 10 places per plot (17 July 2006), for *Sclerotinia* stem rot and *Phoma* stem canker 50 randomly selected stems per plot directly after harvest. Other observations described in current paper were as follows: plant density in autumn, in spring and after harvesting (plants per 1 m^2) and winterhardiness in points from 9 (very good) to 1 (all plants dead). Yield structure elements (plant productivity, g, number of silique per plant, number of seeds per silique) were detected in growth stage 87 from sample sheets (two sheets per plot from 0.1 m^2) for five varieties (see names in Table 3). Methodology described by D.Malinauskas (2005) was used.

After harvesting, 200-g samples per each variety were taken for analyses of seed oil content (analysed by LVS EN ISO 734-1 method, g kg^{-1} of dry matter) and crude protein (analysed by ISO 5983-2 method, g kg^{-1} of dry matter). Analyses were done in the Analytical Laboratory for Agronomy Research of thee Latvia University of Agriculture. Volume weight was analysed using standard method LVS 273, and 1000 seed weight – according to ISTA methodology.

ANOVA procedures and correlation analyses were used for processing the experimental data. Economical evaluation of obtained results was done using constructive and comparative methods.

Meteorological conditions of the research year 2005/2006 can be characterized by severe winter, late spring and an extremely hot and dry summer. Although summer of 2006 was extremely dry and air temperature was high, winter oil-seed rape used the moisture reserves suspended during winter and growth and development of crop occurred without irregularities. The fall of 2006 was warm with enough moist, and long.

Table 1

Effect of fungicide juventus 90 on the height of growth-point, number of leaves per plant, and root mass of winter rape in autumn, 2005 and 2006

Cultivars	Height of growth-point, mm				Number of leaves per plant				Root mass, g			
	2005		2006		2005		2006		2005		2006	
	C†	F‡	C†	F‡	C†	F‡	C†	F‡	C†	F‡	C†	F‡
Excalibur	38.7	22.6	24.4	18.0	8.7	13.2	7.0	7.2	7.5	8.9	7.8	7.0
Californium	24.8	17.8	15.5	16.4	9.2	10.8	5.9	6.4	4.1	5.5	2.9	4.0
Elixir	48.1	27.5	26.3	17.8	8.3	9.7	6.6	7.3	6.6	6.4	5.9	6.8
Orkan	38.2	20.8	24.8	17.5	8.5	11.1	7.6	8.2	5.8	7.5	6.5	7.6
Falstaf	29.4	22.2	18.3	15.8	9.8	10.0	7.4	7.3	6.4	7.5	5.3	3.9
Average	35.9	22.2	21.9	17.1	8.9	10.9	6.9	7.3	6.1	7.2	5.7	5.9
$LSD_{0.05}$	3.9		2.2		1.1		0.4		0.9		1.1	

C† – check without fungicide treatment; F‡ – fungicide treatment juventus 90 in autumn

Results and Discussion

Oil-seed rape development during autumn and its winterhardiness

Since conditions for germination were adequate, optimal average per trial crop density was noted in both trial years (on average 69 seedlings m^{-2} in 2005, and 57 seedlings m^{-2} in 2006). From the two-year results (2005-2006) it is evident that winter rape biometrical indices were influenced by the fungicide application in autumn period as well as by used cultivar (Table 1). A significant impact ($p < 0.05$) of fungicide application in autumn was noted on the height of growth-point in both trial years (by 42% in 2005, and by 24% in 2006). Two-year experiments showed that cultivar with the highest growth-point was 'Elixir'. Average height of growth point in 2005 (check – 35.9 mm; with fungicide – 22.2 mm) was higher than that in 2006 (check – 21.9 mm; with fungicide – 17.1 mm) that probably could be explained by slightly different crop density. A significant impact ($p < 0.05$) of fungicide application in autumn was noted as well for number of leaves per plant in both trial years (by 25% in 2005, and only by 6% in 2006). This is in accordance with results of other studies (Gaveliene et al., 2002; Miliuviene et al., 2004) where more leaves were obtained using specific growth regulators. Cultivar influence on this parameter was not significant ($p > 0.05$) in 2005, but significant ($p < 0.01$) impact was noted in 2006 (by 48%). The number of leaves per plant in trial years also was optimal for good wintering of winter rape.

Researchers in Lithuania (Gaveliene et al., 1998; Miliuviene et al., 2004) found that use of growth regulators significantly increases the main root diameter and root mass in autumn. Our results showed significant impact ($p < 0.05$) of fungicide application in autumn on the fresh root mass only in trial year 2005 (by 8%), but cultivar influence on this parameter was significant ($p < 0.05$) in both trial years (by 33% in 2005 and by 59% in 2006). Significant correlation ($r = 0.761 > r_{0.05} = 0.632$; $n = 10$) was found between root mass in autumn and seed yield.

Use of growth regulators in autumn can increase the root-neck diameter (Miliuviene et al., 2004), but use of fungicide juventus 90 as growth regulator in our experiment did not affect the root-neck diameter significantly ($p = 0.46$ in 2005; $p = 0.55$ in 2006). This parameter was affected by the cultivar ($p < 0.01$) only in 2006. Despite this, average root-neck diameter also was optimal in both years (2005: 9.3 mm without fungicide, 9.6 mm – when fungicide was used; 2006: 8.5 and 8.3 mm respectively) for good winter rape wintering. Probably root-neck diameter is mostly affected by other uninvestigated factors. The plant and shoot weight and root length were not influenced significantly ($p > 0.05$) by fungicide treatment, but influence of used cultivar was mainly significant ($p < 0.05$).

Winter oil-seed rape winterhardiness is almost the most important characteristic for the cultivar used in conditions such as in Latvia where winters with sharp temperature fluctuations, black frost and other adverse factors may occur. Possibility to improve rape winterhardiness using any growth regulation in autumn is not documented in Latvia and is poorly recorded also in neighbouring countries. Some references in literature show (Gaveliene et al., 2005) that use of growth regulators (auxin analogues) can improve winterhardiness of winter oil-seed rape. Our results from the first research winter showed that also fungicide treatment in autumn can improve this characteristic: plant decrease during autumn and winter in the treated part (on average 27 plants per 1 m^2) of the trial was lower ($p < 0.05$) if compared with untreated part (on average 37 plants per 1 m^2), but winterhardiness evaluated in points – higher ($p < 0.05$; Table 2). Significant positive correlation ($r = 0.396 > r_{0.05} = 0.388$; $n = 26$) was found between rape winterhardiness and seed yield.

Up to now we have analysed the plant fitometric indices and the growth regulation effect on them. Other important indicators of rape wintering are chemical composition of root column and crown bud (Gaveliene et al., 1998; Velicka et al., 2005); evaluation of it should be the next step in our invetigation for better comprehension of rape winterhardiness.

Disease incidence and fungicide effect on it

Fungal diseases such as *Alternaria* blight (*Alternaria* spp.) and *Phoma* leaf spot (*Phoma lingam*, teleomorf *Leptosphaeria* spp.) were noted in the autumn of both trial years. Incidence of *Phoma* leaf spot on leaves of up to 1% was observed in 2005, but in 2006 incidence of this disease was noted to be up to 8% without fungicide treatment and also up to 1% in the treated with fungicide part of the trial. The incidence of *Alternaria* blight on leaves was similar in both years in the untreated part of the trial (89% in 2005, 81% in 2006), but diverse in the treated with fungicide part: on average 63% in 2005 and 41% in 2006. The severity of *Phoma* leaf spot and *Alternaria* blight did not exceed 2% in both years, which is a typical situation in Latvian agro-climatic conditions. O.Treikale (2006) reported similar results of poor severity of both diseases in autumn in Latvia. In such conditions, fungicide use only for control of disease is disputable. Research results from countries with more mild climatic conditions, such as England, show that fungicide treatment in autumn is effective not only for *Phoma* leaf spot control, but also for prevention of *Phoma* stem canker incidence in the next spring; consequently follows also seed yield increase (West et al., 2002). On the other hand, research in Poland shows that development of *Phoma* stem canker in colder climatic conditions can be completely different (Huang et al., 2005), and thus another pattern for disease control is needed.

Table 2

Effect of fungicide juventus 90 application in autumn on plant density in spring and winterhardiness of rape, season 2005/2006

Cultivars	Plant density in spring, units m^{-2}		Winterhardiness, evaluated visually in points 9 - 1: 9 – very good, plants look vigorous; 1 – all plants dead	
	C†	F‡	C†	F‡
Olphi	38	45	8.3	8.3
Ella	27	47	7.0	8.5
Astrid	42	51	8.3	8.8
Caracas	49	56	9.0	9.0
Catalina	50	46	8.3	8.5
Excalibur	38	44	8.3	9.0
Californium	34	38	7.5	8.8
Elixir	34	37	5.0	8.0
Express	34	37	9.0	9.0
Orkan	29	42	6.5	8.8
Celsius	27	35	8.8	9.0
Falstaf	46	39	8.0	8.5
Banjo	39	33	8.8	8.5
Average	37	42	7.88	8.65
$LSD_{0.05}$	4.0		0.3	

C† – check without fungicide treatment; F‡ – fungicide treatment juventus 90 in autumn

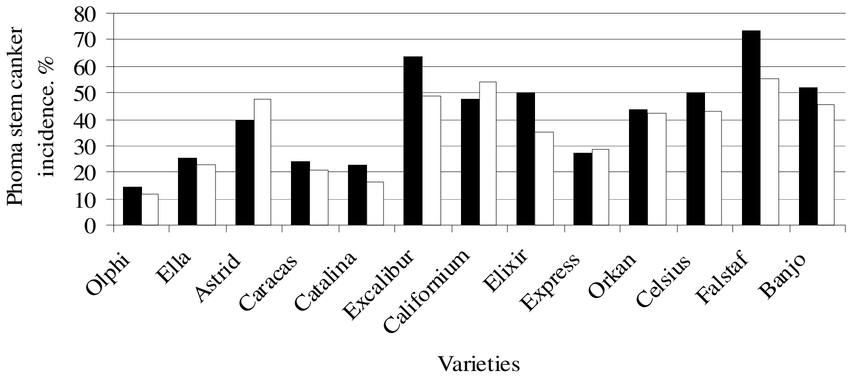

Figure 1. Effect of fungicide application on *Phoma* stem canker of winter oilseed rape in 2006 (■ – control without fungicide; □ – split application of fungicide juventus 90).

Phoma stem canker is a fungal disease which occurs during the following summer vegetative period; it has been left without particular attention in the previous years in Latvia. Our research for the first time indicated that this disease could become a problem for rape growers in Latvia. If fungicide was not used, *Phoma* stem cancer affected 12-74% of stems depending on the cultivar during harvest time (Fig. 1). A slight decrease in disease incidence caused split fungicide treatment (juventus 90; 0.5 L ha^{-1} in previous autumn + 0.5 L ha^{-1} in growth stage 63-64) almost for all cultivars; exceptions were cultivars 'Astrid' and 'Californium' (Fig. 1). Interesting and valuable for further investigation is the noted positive correlation between *Phoma* stem canker incidence and obtained seed yield ($r = 0.496 = r_{0.01} = 0.496$; $n = 26$). Since investigations on development cycle of *Phoma* stem canker in Latvia have only started, a further research on best fungicide use pattern for control of this disease is also needed. The incidence of *Alternaria* pod spot was insignificant (check – 4%, after fungicide treatment – 2%) in 2006. Development of the fungus *Alternaria* spp. on siliques is equally influenced by the air temperature and moisture in July when winter rape silique ripening period occurs. Lack of precipitation was noted in Vecauce in the summer of 2006, especially in July, thus decreasing the incidence of *Alternaria* pod spot. *Sclerotinia* stem rot (*Sclerotinia sclerotiorum*) did not occur in winter rape crop in the experimental year 2006. One percent of infected plants were found only in treated with fungicide plots of cultivar 'Ella' and in untreated plots of cultivar 'Banjo'. Similarly, for *Alternaria* blight, the weather conditions were also unsuitable for crop infection with *Sclerotinia sclerotiorum* during rape flowering stage.

Yield, its structure elements and quality

Values of winter rape yield structure elements have not been well documented in Latvia before; our experiments are in-between the first who pay attention to yield structure. Analyses of rape yield structure elements showed that fungicide application did not affect significantly neither seed number per silique ($p = 0.08$), nor seed number per plant ($p = 0.43$), nor mean plant productivity ($p = 0.38$), but a tendency was noted that fungicide treatment at least slightly increased the above mentioned indices (Table 3). Fungicide application did not affect significantly also the silique number per plant ($p = 0.76$). Similarly, a significant cultivar influence was not observed on seed number per silique ($p = 0.12$), seed number per plant ($p = 0.45$), and mean plant productivity ($p = 0.47$). Used cultivar significantly affected only the silique number per plant ($p = 0.02$). In the first research year (2006) we did not find a significant correlation between any of above mentioned rape yield structure elements and seed yield. N.Thurling (1974) in absolutely different growing conditions (in Australia) reported significant positive correlation between the number of silique per plant and seed yield, number of silique-bearing branches per plant and seed yield, and silique per branch and seed yield. Similarly to N.Thurling (1974), we also found a significant negative correlation between the number of seeds per silique and number of siliques per plant ($r = /-0.633/ > r_{0.05} = 0.632$, $n = 10$), which could be attributed to yield component compensation.

Investigation results in Lithuania indicated that the best seed yield is obtained when crop density at harvest is 40.9-46.7 plants per 1 m^2

Table 3

Effect of fungicide juventus 90 on structure elements of winter rape yield, 2006

Varieties	Seed number per plant		Seed number per silique		Mean plant productivity, g		Silique number per plant	
	C†	F‡	C†	F‡	C†	F‡	C†	F‡
Excalibur	2558	2058	22	21	10.38	10.24	111	109
Californium	2276	3153	22	35	9.07	12.84	114	83
Elixir	3013	3897	19	25	12.27	15.08	142	149
Orkan	2584	2258	28	29	10.38	8.88	92	75
Falstaf	2034	2796	23	24	7.85	10.34	89	113
Average	2493	2832	23	27	9.99	11.48	109	106
$LSD_{0.05}$	880		4.5		3.40		23	

C† – check without fungicide treatment; F‡ – fungicide treatment: split application of juventus 90

(Malinauskas, 2005). Average crop density at the rape harvest in our experiments was close to that, and we assessed it being optimal (check – on average 36 stems m^{-2}; with fungicide treatment – 41 stem m^{-2}). A slight (by 6%) significant impact ($p = 0.009$) of fungicide application was noted on crop density; also cultivar impact on this parameter was noted as significant (by 23%; $p = 0.01$).

No significant impact ($p = 0.403$) of fungicide application was noted on 1000 seed weight (average for check – 4.31 g, average with fungicide treatment – 4.28 g), but 1000 seed weight was significantly ($p < 0.001$) influenced by the cultivar. Other research (Treikale et al., 2006) showed 1000 seed weight increase when fungicide is applied. Interesting is correlation between 1000 seed weight and seed yield. When we analysed all 13 cultivars included in the experiment ($n = 26$) significant correlation between these parameters was not found, which is in accordance with the results of N.Thurling (1974). When we analysed only those five cultivars for which other structure elements were estimated (Table 3), a significant positive correlation was found ($r = 0.641 > r_{0.05} = 0.632$, $n = 10$).

A small fungicide treatment (by 2 %; $p = 0.0004$) and strong cultivar (by 83 %; $p < 0.001$) effect was noted to volume weight: average volume weight of treated with fungicide rape was 680 g L^{-1}, but of untreated – 677 g L^{-1} ($LSD_{0.05}$= 2 g L^{-1}).

High average seed yields (check – 5.37 t ha^{-1}, with fungicide – 5.80 t ha^{-1}) were obtained in our experiment. A significant impact ($p < 0.001$) of fungicide application was observed on seed yield (increase + 0.43 t ha^{-1}, $LSD_{0.05}$= 0.18 t ha^{-1}) (Fig. 2). This is in accordance with other research where use of growth regulators in autumn (Miliuviene et al., 2004; Treikale et al., 2006) improved the seed yield; also fungicide application during summer vegetation period (at full flowering) improve the seed yield (Treikale et al., 2006). Cultivar influence (by 62%) on seed yield was significant ($p < 0.001$), too. On average, most productive varieties were 'Excalibur' – 6.46 t ha^{-1}, 'Astrid' – 6.53 t ha^{-1}, and 'Banjo' – 6.46 t ha^{-1}. Seed yield was significantly increased by fungicide application for varieties 'Astrid', 'Elixir', 'Express', and 'Orkan', but for seven varieties ('Olphi', 'Ella', 'Caracas', 'Catalina', 'Excalibur', 'Celsius', and 'Falstaf') increase in yield with fungicide application was observed, but it was not statistically significant at the 95% confidence level. For two varieties ('Californium' and 'Banjo'), increase in seed yield with fungicide application was not observed at all (Fig. 2).

Crude protein and oil content in seeds was not affected significantly by fungicide application ($p > 0.05$). Average protein content in seeds depending on the cultivar varied from 195.7 g kg^{-1} to 216.8 g kg^{-1}, but on average for rape without fungicide treatment crude protein content was 202.5 g kg^{-1}, and with fungicide treatment – 204.4 g kg^{-1}. Oil content in seeds on average was 469.8 g kg^{-1} without fungicide treatment, but 470.0 g kg^{-1} if fungicide was used. Other research (Treikale et al., 2006) reported increase in oil content when fungicide was used.

As so high seed yield was obtained even without fungicide treatment (5.37 t ha^{-1}), the yield increase (0.43 t ha^{-1}) was too small to economically motivate fungicide application. Despite agronomic improvements (improved fitometric indices in autumn and winterhardiness, decreased *Phoma* stem canker incidence,

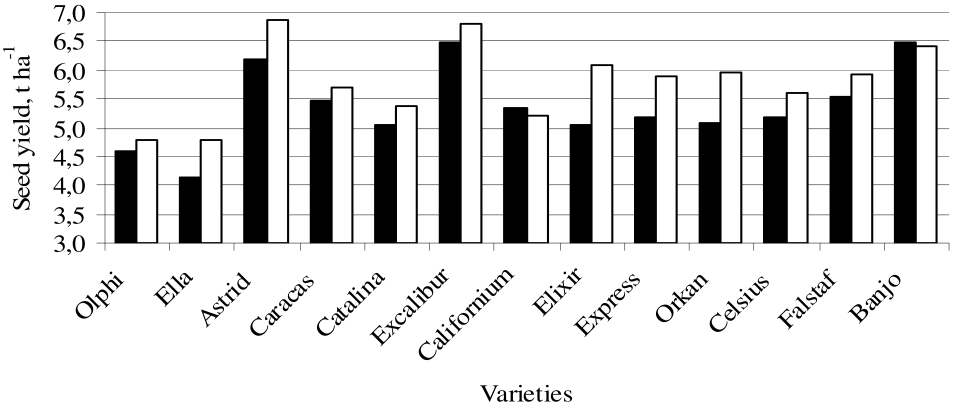

Figure 2. Seed yield of winter oilseed rape depending on variety and fungicide application, t ha^{-1}, 2006 ■ – control without fungicide; □ – split application of fungicide juventus 90).

increased seed yield), economic calculation showed that on average fungicide application in 2006 was not profitable: when fungicide was applied, proceeds per every invested LVL were decreased if compared with the untreated control; also product cost per 1 t increased when fungicide was applied.

Conclusions

The main benefit of our first years' investigations is clarifying of some further research directions. Split fungicide (juventus 90 s.c. – metconasol 90 g L^{-1}) application affected rape plant biometric indices during autumn – decreased the height of growth point and increased the number of leaves. Beneficial impact of fungicide was noted also on winterhardiness. Other important indicators for good rape wintering, such as chemical composition of main root column and growth bud, should be investigated in future. From observed three rape diseases, only incidence of *Phoma* stem canker was considerable in 2006. Fungicide application decreased the incidence of this disease, but life cycle of the disease should be investigated in Latvian conditions and, depending on it, a better fungicide application scheme should be worked out. Fungicide use did not affect significantly the rape yield structure elements in 2006. Although split fungicide application increased the rape seed yield and showed a positive effect on winterhardiness increase and disease incidence decrease, economical profitability was not observed. Research should be continued for clarifying all above-mentioned problems more deeply.

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