Lilija Borovko
Research Institute of Agriculture Agency of LUA Latvia

Application of biological preparations to spring oilseed rape under ecological conditions

Biologiczna ochrona rzepaku jarego w warunkach ekologicznej uprawy

Key words: spring oilseed rape, biological preparations for plant protection, diseases, pests, seed yield

Field trials on biological protection of spring oilseed rape against diseases and pests were carried out in the LUA Research Institute of Agriculture in Latvia. Research was necessary to provide environment friendly and ecologically clean oilseed rape production suitable for organic farming.

The seed treatments with Trichodermin (6 ml·kg^{-1} seeds), Azotobacterin (6 ml·kg^{-1} seeds) and Germin (5 ml·l^{-1} water·l·kg^{-1} seeds) for control of root diseases (*Pythium, Rhizoctonia, Fusarium* spp*., Phoma lingam*) were effective and increased spring rape seed yield by about 0.35–0.74 t·ha^{-1}. The highest increase of seed yield (0.74 t·ha^{-1}) and net profit (161.77 EUR·ha^{-1}) was obtained in the variant with Germin preparation (complex of phytohormones).

Spraying plants with Trichodermin 30 l·ha^{-1} at the beginning of flowering to control dark leaf spot of crucifers (*Alternaria* spp.), downy mildew (*Peronospora*), dry rot (*Phoma*) and others was effective. The most effective was variant seed treatment with Germin and spraying with Trichodermin which increased the seed yield by 0.6 t·ha^{-1} with net profit 76.28 EUR·ha^{-1}.

The spraying with Bacilon at the stage of germination for control of cabbage stem flea beetle (*Psylliodes chrysocephala* L. and *Phyllotreta nemorum* L.) and at the stage of flowering for control of oilseed rape blossom beetle (*Meligethes aeneus* F.) provided essential increase of yield by 0.40 t·ha^{-1} and extra net income of 41.16 EUR·ha^{-1}.

Słowa kluczowe: rzepak jary, biologiczna ochrona roślin, choroby, szkodniki, plon nasion

Do ochrony rzepaku jarego przeciw chorobom i szkodnikom w warunkach polowych Research Institute of Agriculture of LUA Latvia użyto metody ekologicznej.

W badaniach wykorzystano następujące preparaty do zaprawiania nasion: Trichodermin (6 ml·kg^{-1} nasion), Azotobacterin (6 ml·kg^{-1} nasion) i Germin (5 ml·kg^{-1} nasion). Środki te stosowano w celu ograniczania chorób korzeni rzepaku wywoływanych przez patogeny grzybowe (*Pythium, Rhizoctonia, Fusarium* spp., *Phoma lingam*). Skuteczność zabiegu oceniono na podstawie otrzymanego wyższego plonu nasion (od 0,35 do 0,74 t·ha^{-1}). Największy wzrost plonu rzepaku jarego (0,74 t·ha^{-1}) i równocześnie zysk netto (161,77 EUR·ha^{-1}) odnotowano w kombinacji z preparatem Germin (kompleks fitohormonów).

Oprysk cieczą roboczą zawierającą Trichodermin (30 l·ha^{-1}), przeciw: *Alternaria* spp., *Peronospora brassicae*, *Phoma lingam* i in.) w fazie początku kwitnienia rośliny rzepaku był także skuteczny w wariancie z preparatem Germin, który wpłynął na powiększenie plonu nasion (do 0,6 t·ha^{-1}) oraz zysk netto wynoszący 76,28 EUR·ha^{-1}.

Oprysk roztworem zawierającym Bacilon w fazie kwitnienia rośliny rzepaku był skuteczny przeciw szkodnikom: pchełkom *Phyllotreta* ssp. i słodyszkowi *Meligethes aeneus* F. Zabieg ten także wpłynął na zwyżkę plonu nasion (do 0,4 t·ha^{-1}) oraz zysk netto wynoszący do 41,16 EUR·ha^{-1}.

Introduction

Organic farming of spring oilseed rape needs the alternative growing technology which could replace chemical plant protection methods with biological, mechanical and other methods. It is necessary to maximally stimulate the natural resistance to various unfavourable factors, pathogens and pests.

To promote microbiological activity in soil and to improve plant health there were used some biological preparations for plant protection which were isolated from soil of Latvia, for example, Trichodermin, Azotobacterin and others (Papavizas 1985, Vaivare 1998, 2002). For plant strengthening Germin, the complex of phytohormones was used (Miske 1998).

Biological methods for pest and diseases control in oilseed rape plantations is necessary for environment friendly production. The aim of the work was to test the efficiency of different organic preparations for biological plant protection against pathogens and pests.

Methods and materials

The field trials were carried out at Skriveri, in the LUA Research Institute of Agriculture on biological field in 2002 and 2003. The soil of the experimental site is soddy podzolic medium sandy loam. The agrochemical characteristics of arable soil were as follows: soil acidity pH_{KCl} — 6.3; easily available P_2O_5 — 156 mg kg^{-1} and K_2O — 137 mg kg^{-1}; humus content 2.9%; MgO — 192 mg kg^{-1}; total nitrogen — 1.1 g kg^{-1}. Previous plant — bare fallow. For limiting root diseases (*Pythium, Rhizoctonia Fusarium* spp*., Phoma lingam*) the seeds were treated with Trichodermin (*Trichoderma harzianum*) or Azotobacterin (*Azotobacter* spp.) or new preparation Germin (phytohormone cytokinin, auxin). Germin was used to kill in soil the fungi harmful to plants, to force the germination of seeds, to promote strong root system establishment and better development of plants in the growing period. Trichodermin was sprayed on plants at the stage of flowering to control dark leaf spot of crucifers (*Alternaria* spp.), downy mildew (*Peronospora*) and dry rot (*Phoma*). The effectiveness of U-solution (for preparing 10 l of solutions 300 g ashes, 50 g garlic and 0.5 g $KMnO_4$ are needed) and mineral oil Ultra-Fine were tested to control cabbage stem flea beetle (*Psylliodes chrysocephala* L. and *Phyllotreta nemorum* L.). The effectiveness of Bacilon, U-solution and mineral oil Ultra-Fine were tested on possibility to control the oilseed rape blossom beetle. Bacilon is the preparation that contains entomopathogenical bacteria *Bacillus thuringensis* which causes death of leaf eaters and suckers pests. Mineral oil “Ultra fine” is influencing the pests on smother mode.

Trial design: number of replications — 4, total number of variants — 11, plots — 44. The area of plot was 30 m^2, for the testing were used — 20 m^2 of plot. The trial variants tested on the effectiveness in plant diseases control were as follows:
1 — control (without any treatment),
2 — the seed treatment with Trichodermin 6 ml/1 kg seeds,
3 — the seed treatment with Azotobacterin 6 ml/1 kg seeds,
4 — the seed treatment with Germin 5 ml/1 l water/1 kg seeds,
5 — the seed treatment with Trichodermin + plant spraying in stage DC 60 (flowering) with Trichodermin 30 $l \cdot ha^{-1}$ concentrate,
6 — the seed treatment with azotobakterin + plant spraying in the stage DC 60 with trichoderin 30 $l \cdot ha^{-1}$ concentrate,
7 — the seed treatment with Germin + plant spraying in the stage DC 60 with Trichodermin 30 $l \cdot ha^{-1}$ concentrate.

The incidence of oilseed rape root diseases and the degree of their infection were estimated as the number of disease affected plants at the stage DC 13 (cotyledons unfolded) of plant growth. The leaf damages were estimated at the stage DC 60 of plant development. The percentage of disease affected leaves and the percentage of disease affected parts of a leaf were evaluated. Rapeseed pod diseases were estimated after their occurrence (incidence and the degree of infection).

The preparations used in the trial to control the cabbage stem flea beetle and the oilseed rape blossom beetle were: Bacilon 20 $l \cdot ha^{-1}$, U-solution 30 $l \cdot ha^{-1}$ and mineral oil Ultra-Fine 2 $l \cdot ha^{-1}$ (evaluation at stages DC 13 and DC 50 — bud development).

The sowing rate of variety 'Olga' was 200 Germinating seeds per m^2. Plots were harrowed at the stage of 2–3 leaves to limit the amount of weeds. The oilseed rape was harvested with combine in September. Observations of germination, occurrence of pests and diseases were conducted on the trial in field and in laboratory. Variance analysis was used for seed yields elaboration.

Biological efficiency of conducted plant protection was resulting in specific conditions, which found expression in diminishing of harmful organisms and reduction of plant damage degree.

Determination of biological efficiency

Biological efficiency of plant pest control was determined with counting of pests carried out before and after their control. The comparison of both results gives approximate biological efficiency calculated according to following equation:

$$E = [(A - B) \times 100] : A$$

where:
E — biological efficiency, %
A — average number of pests or plant damages on control untreated plot;
B — average number of pests or plant damages on treated plot (Auzina 1988).

Results and Discussion

Meteorological conditions differed during the years of trial. The weather during sowing time in 2002 was favourable. There was sufficient moisture content in the soil for germination. Deficiency of moisture for plants at the beginning of May and June unfavourably influenced the development of plants and formation of productive parts. The warm and moist weather in July promoted the development of diseases. On leaves and pods of oilseed rape appeared dark leaf spot of crucifers.

The meteorological conditions in 2003 were unfavourable for oilseed rape growing. The wet conditions influenced negatively the flowering and ripening of oilseed rape. Oilseed rape lodged, ripened slowly and irregularly, in the lower pods were Germinated seeds. It was difficult to harvest the oilseed rape plants.

The observations made after sowings showed that on plots occurred black leg (plants prematurely died) and root neck rot caused by root and root neck diseases. More frequent was root neck dry rot which is one of the most harmful oilseed rape root diseases. The best results of disease control were obtained in variant where Germin was used. The use of Germin was highly effective in reduction of root infection (Table 1).

Table 1

The influence of biological preparations used for plant protection on the distribution of root diseases in the spring rape 'Olga' (average from 2002 and 2003) — *Ochronny wpływ biopreparatów na korzenie rzepaku jarego odmiany Olga (średnia z lat 2002 i 2003)*

Variants *Kombinacja*	Development of root diseases, % *% porażonych korzeni*		
	Pythium, Rhizoctonia	*Fusarium spp.*	*Phoma lingam*
Control (without any treatment) — *Kontrola (bez ochrony)*	1.0	5.8	9.3
Treatment of seed with — *Traktowanie nasion preparatem:*			
Trichodermin	0	0.1	0.5
Azotobacterin	0	2.9	5.7
Germin	0	0.1	0.2
Treatment of seed + plant spraying with *Traktowanie nasion preparatem + oprysk na rośliny:*			
Trichodermin + Trichodermin	0	0.1	0.4
Azotobacterin + Trichodermin	0	1.9	4.5
Germin + Trichodermin	0	0.1	0.1

Table 2 shows that in the years of research the downy powder on the leaves occurred with average development of 23%, dark leaf spot of crucifers and dry rot on pods with average development of 29.5% and dark leaf spot of crucifers with average development of 12.1%. The diseases that developed on the pods were more harmful than others. In our case, these were dark leaf spot of crucifers and dry rot.

Assimilation surface of pods decreased as a result of infection. Infected pods were deformed and seeds in pods were crumbly. It resulted in decrease not only in seed yields but in germination of seeds, too. Leaf diseases did not influence essentially the formation of seed yield. The best results were obtained in limiting of disease occurrence in variants where Trichodermin was sprayed at the stage of flowering. Infection with dark leaf spot of crucifers often happens at this time. The highest biological effectiveness (83–88%) was in a variant where seeds were treated with Germin and plants were sprayed with Trichodermin.

Table 2

The influence of biological preparations used for plant protection on the occurrence of root and pods diseases in the oilseed rape 'Olga' (average 2002–2003) — *Ochronny wpływ bio-preparatów na korzenie i łuszczyny rzepaku jarego odmiany Olga (średnia z 2002-2003 roku)*

Variants *Kombinacja*	Development of diseases, Biological efficiency (BE) *Rozwój patogenów, skuteczność ochrony (BE) - (%)*					
	Peronospora on underneath 3 leaf *na spodzie 3 liścia*		*Alternaria, Phoma* on pods *na łuszczynach*		*Alternaria* on stem *na łodydze*	
	%	BE	%	BE	%	BE
Control (without any treatment) *Kontrola (bez ochrony)*	23.0	–	29.5	–	12.1	–
Treatment of seed with *Traktowanie nasion preparatem:*						
Trichodermin	10.4	54.8	22.7	23.0	5.9	51.0
Azotobacterin	19.5	15.4	20.9	29.1	9.6	20.5
Germin	8.0	65.0	21.5	27.0	5.6	54.0
Treatment of seed + plant spraying with *Traktowanie nasion preparatem + oprysk na rośliny:*						
Trichodermin + Trichodermin	5.7	75.0	6.2	79.0	2.1	83.0
Azotobacterin + Trichodermin	6.9	70.0	13.6	54.0	4.2	65.0
Germin + Trichodermin	3.9	83.0	5.0	83.0	1.5	88.0

Lower effectiveness was found in variants where Trichodermin was used in seed treatment and was sprayed on plants.

The results show that the influence of biological preparations used for plant protection on spring rape seed yield was significant and in comparison with the control plots the seed yield increased about 0.35–0.74 $t \cdot ha^{-1}$. The highest yield was found in variant where seeds were treated with Germin — 3.14 $t \cdot ha^{-1}$ for seed yield or 1378 $kg \cdot ha^{-1}$ for oil yield (Table 3).

Table 3

The influence of biological preparations used for plant protection on spring rape seed yield and oil yield and seed chemical composition (average from 2002–2003) — *Wpływ biopreparatów na ploni skład chemiczny nasion rzepaku jarego (średnia z lat 2002-2003)*

Variants *Kombinacje*	Seed yield *Plon nasion*		Crude proteins *Białko surowe* [%]	Oil *Tłuszcz* [%]	Yield of oil *Plon tłuszczu* [kg·ha^{-1}]
	[t·ha^{-1}]	± to control *do kontroli*			
Control (without any treatment) *Kontrola (bez ochrony)*	2.40	–	22.22	47.69	1053
Treatment of seed with *Traktowanie nasion preparatem:*					
Trichodermin	2.79	0.39	23.37	47.51	1324
Azotobacterin	2.75	0.35	23.23	48.05	1216
Germin	3.14	0.74	22.84	47.70	1378
Treatment of seed + plant spraying with *Traktowanie nasion preparatem + oprysk na rośliny:*					
Trichodermin + Trichodermin	3.03	0.63	22.86	47.90	1229
Azotobacterin + Trichodermin	2.75	0.35	22.96	46.14	1167
Germin + Trichodermin	3.01	0.61	22.93	47.00	1302
$LSD_{0.05}$ — $NIR_{0,05}$	0.29				

The economical efficiency of biological preparations used for plant protection is shown in Table 4. The economical calculation was made for price of spring rape equal to 245 EUR t^{-1} (price of biological — ecological product was calculated from average shopping price of 188 EUR t^{-1} by increasing it by about 30%). The use of biological preparations for plant protection in the seed treatment and for plant spraying were economically sound. The use of preparations for seeds treatment provide net income from 76.42 to 161.77 EUR·ha^{-1}. The highest net profit was obtained in the variant where Germin was used — 161,77 EUR·ha^{-1}.

The highest economical efficiency by using seed treatment and plant spraying were in variant where seeds were treated with Germin and Trichodermin was sprayed on plants — 76.28 EUR·ha^{-1}. The lower profit was in variant where seeds were treated with Azotobacterin and Trichodermin was sprayed on plants — 2.58 EUR·ha^{-1}.

The pests were one of the factors that disturbed obtaining persistent oilseed rape seed yields. The most dangerous pests of oilseed rape are cabbage stem flea beetle (*Psylliodes chrysocephala* L., or *Phyllotreta nemorum* L.) and oilseed rape blossom beetle (*Meligethes aeneus* F.). The losses of seed yields can fluctuate from 50 to 80%.

The number of seedlings which died of cabbage stem flea beetle was lower for sprayed variants in comparison with variants not sprayed. The best results in limiting the cabbage stem flea beetle population were in the variant where Bacilon and U-solution were used (respectively 69.0% and 66.2%).

The occurrence of oilseed rape blossom beetle decreased by about 70–80% if preparations were sprayed in the phase of blossom development (Table 4).

Table 4

The biological efficiency of preparations (BE) in the limiting of cabbage stem flea beetle and oilseed rape blossom beetle (average 2002–2003) — *Biologiczna skuteczność (BE) biopreparatów w ograniczaniu chowaczy i słodyszka rzepakowego (średnia z 2002-2003 r.)*

Variants *Kombinacja*	Degree of damages by cabbage stem flea beetle *Stopień uszkodzeń przez chowacze* [%]	BE for cabbage stem flea beetle *Skuteczność (BE) dla chowaczy* [%]	BE for oilseed rape blossom beetle *Skuteczność (BE) dla słodyszka* [%]
Control (without any treatment) *Kontrola (bez ochrony)*	36.4	–	–
Bacilon — *Preparat Bacilon*	11.4	69.0	80.0
U-Solution — *Roztwór – U*	12.3	66.2	71.4
Mineral oil Ultra-Fine *Olej mineralny Ultra- Fine*	13.8	62.0	70.0

The results of pest control show that the use of preparations increased seed yields by about 0.17–0.40 t·ha^{-1}. Significant yield increase (0.40 t·ha^{-1}) was in the variant where Bacilon was used for control of oilseed rape flea beetle and blossom beetle (Table 5).

Table 5

Influence of biological preparations on spring rape seed yields (average for 2002–2003)
Wpływ biopreparatów na plon rzepaku jarego (średnia z lat 2002–2003)

Variants *Kombinacje*	Seed yields *Plon nasion* [t·ha^{-1}]	Increase of yields *Zwyżka plonu*	
		[t·ha^{-1}]	[%]
Control (without any treatment) *Kontrola (bez ochrony)*	2.88	–	100.0
Bacilon — *Preparat Bacilon*	3.28	0.40	113.9
U-Solution — *Roztwór – U*	3.05	0.17	106.0
Mineral oil Ultra-Fine *Olej mineralny Ultra- Fine*	3.13	0.25	108.6
$LSD_{0.05}$ — $NIR_{0,05}$	0.39		

The highest economical efficiency was in the variant where Bacilon was used in controlling the flea beetle and oilseed rape blossom beetle which provided extra profit of 41.16 EUR·ha^{-1}.

Conclusions

- The biological preparations used for plant protection — Germin and Trichodermin — are suitable for effective control of diseases in spring oilseed rape. The use of these preparations diminished the occurrence of root and root neck diseases by 99% on average and the occurrence of diseases on pods and on stems by about 83–88%, and the occurrence of diseases on leaf by about 83%.
- The best results in biological plant protection against pests was found for Bacilon used for the control of cabbage stem flea beetle and oilseed rape blossom beetle. Bacilon diminished the occurrence of these pests by about 63–80%.

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