The optimization environment-friendly cultivation technology of spring oilseed rape under Latvia agroecological conditions

Lilija Borovko, Aivars Jermuss

Research Institute of Agriculture, Latvia University of Agriculture, LV-5126, Skriveri, Latvia
Email: borovko@inbox.lv; borovko@e-apollo.lv

Abstract

Skriveri Research Institute of Agriculture in 2001-2003 carried out field trials with spring oilseed rape `Olga` on the optimization of nitrogen and potassium nutrition under Latvian soil and climatic conditions. We tested the influence of nitrogen (N) and potassium (K) fertilizer rates 60, 80 (60+20), 100 (60+40), 120 (60+60), and 140 (60+80) kg ha^{-1} on the formation of spring oilseed rape yield, and quality of seed was tested against phosphorus background P_{70}. In 2002 – 2004, preparation mixtures: Moddus+ Folicur, Modus + Juventus; Cycocel + Folicur, Cycocel + Juventus during the trial were tested applying half doses (0,5 1 ha^{-1}), by spraying them throughout the plant florescence-bud formation (GS 50). During 2003-2004 we tested the influence of different biological preparations – trichodermin, azotobacterin, germin and humus substance – within seed treatment on the yields, and seed quality of spring oilseed rape.

The results show the following: nitrogen and potassium fertilizers provided seed yields 2.06-3.15 t ha^{-1}. Application of nitrogen 60-100 kg ha^{-1} and potassium 60-100 kg ha^{-1} resulted the yield increase 0.75-1.09 t ha^{-1} ($LSD_{0,05}$= 0.22 t ha^{-1}). The seed yields showed the tendency to decrease when increasing NK fertilizer rates to 120-140 kg ha^{-1}. The use of NK fertilizers promoted the accumulation of crude protein (22.12-24.13 %) but decreased the content of oil (47.06-43.72 %) in the seeds. The economic optimal rate of nitrogen and potassium in the sowings of spring oilseed rape `Olga` was $N_{88}K_{88}$ kg ha^{-1}, providing the highest seed yields – 3.07 t ha^{-1} and yields of oil – 1286 kg ha^{-1}. Owing to the mixtures of preparations, the number of side branches increased, on average, for 1-2, the number of legumes on a plant for 22-25, the number of seeds per legume for 2-4, the mass of 1000 seeds: from 3.7 to 4.2 g; the length of rape's stems at that time grew down to 10-20 cm, and the branching height to 5-14 cm. Compared to the Control, the increase of harvest was 0.53 – 0.81 t ha^{-1} ($\gamma_{0,05}$ 0.24 t ha^{-1}). During the trial-years the best preparation mixture was nominated, and it was the Cycocel + Juventus, which, on average, provided the seed harvest 3.31 t ha^{-1}, and the oil output 1409 kg ha^{-1}. Other mixtures ensured a related seed output 3.03-3.15 t ha^{-1}, and the oil output 1270-1302 kg ha^{-1}.

The treatment of biological preparations on spring oilseed increased rape yield by 0.22 – 0.46 t ha^{-1}: in comparison with untreated variants. The use of preparations provided the seed yields increase by 0.61 – 1.63 t ha^{-1}, and the oil yield increase by 113 – 245 kg ha^{-1}. The highest increase of seed yields (0.46 t ha^{-1}) and oil yields (995 – 1019 kg ha^{-1}) was obtained after application of humus substance and germin. The use of biological seed preparations influenced positively the development of plants, and the elements formed the structure of the yield.

Key words: spring oilseed rape, mineral fertilizer, growing-regulator and fungicides, biological preparations.

Introduction

Deficient nutrient quickly causes interruption of growth and yield inhibition of spring oilseed rape (Шпаар и др., 1999). Plants are supplied with phosphorus mainly at the expense of reserves in soil (70-80 %) as oilseed rape efficiently assimilates background phosphorus from soil (Schroder, 1992). There is no consensus of opinion in reference literature regarding influence of potassium onto the spring oilseed rapeseed yields, and the seed quality. According to Savenkov V. P. (2000), application of potassium fertilizers has not lead to substantial increase in the seed yields and has made just a slight influence on protein content and oil content of oilseed rapeseeds. The tests carried out in Germany have shown that a full-value nutrition increases both the seed yields, by 0.02-0.03 t ha^{-1}, and the oil content in seeds. Provided that a correctly set dose is applied, nitrogen increases the seed yields while overdosing can promote lodging of plants, outbreak of fungic diseases and reduction of oil content in seeds (Шпаар и др., 1999). In order to achieve sufficient formation of the seed yields components, split to 60-80 kg ha^{-1} before sowing and 40-60 kg ha^{-1} at the stage of formation of stems of the introduced doses of nitrogen fertilizer is recommended. (Beer et al., 1990; Cramer, 1990; Feger, Orlovius, 1995; Finck, 1991; Fruchtenicht et al., 1993; Sturm et al., 1994). The field trials have been aimed at both determining the role played by nitrogen and potassium fertilizers in the increase of the spring oilseed rape seed yields and seed quality, and finding the optimal nitrogen and potassium nutrition for the purpose of using of oilseed rape biological potential in a more complete manner, under specific conditions.

All growing-regulators, applied currently in sowing-fields, are enclosed in a gibberellins and auxins growing-hormone system. In the production branch the best are the regulators of azoli group: they increase in plants the cytocinins, which inhibit in plants the impact of gibberellins and auxins. For the first time under Latvian conditions, the strengthening actions of azole-preparations (fungicides) were used compounded with the increasing regulators, on the basis of chlormequate and trineksapak-ethyl, in order to influence the harvest and quality of the spring rape seeds. The trial aims at investigating the impact performed by the mixture of a growing-regulator and fungicides upon summer rape productivity, the crop structure, and quality, to justify applying of agrochemicals in smaller doses thus eliminating environment pollution and winning

labor-saving resource and financial applying per unit of sowing-fields, and per unit of the gained production (Makowski N., Gienapp Ch. 1998; Vošak a kolektiv. 2000; Шпаар и др., 1999).

To improve microbial activity in the soil, and to uplift health and immunity of plants, the microbiological preparations like *trichodermin, azotobacterin, germin* and *elixir of turf* extracted from Latvian soils should be used. To clarify the influence of the above-mentioned elements in Latvian-made preparations, the field trials were conducted in 2003 – 2004.

Materials and methods

Field trials in 2001 – 2003 were conducted in soddy - podzolic sandy clay pH- 6.2, organic matter content 33 g kg^{-1} (method of Turin), P_2O_5 content (high) 195 mg kg^{-1}, K_2O content (medium) 147 mg kg^{-1} (DL method). The clay parameters fit for oilseed rape cultivation. Their predecessor is autumn fallow. Conventional farming techniques were used. Prior to sowing the spring oilseed rape `Olga`, there were applied mineral fertilizers P_2O_5 70 кg ha^{-1} in the form of superphosphate, K_2O in the form of potassium chloride, and nitrogen in the form of ammonium nitrate. The following NK doses were studied: 0, 60, 80 (60+20), 100 (60+40), 120 (60+60) and 140 (60+80) kg ha^{-1}. $N_{60}K_{60}$ was introduced as a basic fertilizer, and at the stage of stem formation 20-80 kg ha^{-1} according to variants.

In 2002 – 2004, Research Institute of Agriculture tested the following preparations with the aim to expound the impact performed by the applied growing-regulators/fungicide mixture on the growth and development of rape – the elements that determine harvest, seed quality and efficiency concerning disease elimination: fungicide Folicur (tebucanazole 125 g 1^{-1}, triadimephone 100 g 1^{-1}), Juventus (metconazole– 60 g kg 1^{-1}), and a plant-growing regulators. Moddus 250 e.k (trinexapac-ethyl 250 g 1^{-1}) and Cycocel 750 (chlormequate chloride 750 g 1^{-1}). During the trials preparations were tested applying half doses (0.5 1 ha^{-1}), creating the preparation mixtures: Modus+ Folicur, Modus + Juventus; Cycocel + Folicur; Cycocel + Juventus, by spraying them throughout plant florescence-bud formation (GS 50). As a rule, preparation effectiveness within mixtures increased. Data analysis was done by ANOVA [1]. Interactions between factors were calculated using the dispersion analysis. Meteorological conditions during the research period were extremely variable.

Also in organic field Research Institute of Agriculture conducted trials with organic preparations in spring rapeseed treatment. Field trials were conducted in soddy - podzolic sandy clay pH- 6.3, organic matter content 36.3 g kg^{-1} (method of Tiurin), P_2O_5 content (high) 123 mg kg^{-1}, K_2O content (medium) 149 mg kg^{-1} (DL method). Previous crop was spring barley. 1 kg of seeds was treated with 6 ml of *trichodermin*, 20 g of *azotobacterin*, 5 ml of *germin* and 10 ml kg^{-1} *elixir of turf*. Oil seed rape was sowed 150 seeds per m^2 by Nordsten seeding machine. To restrict weeds at the stage of 2 – 3 leaf the field was harrowed.

Results

The research proved that mineral fertilizers had exerted a positive influence on growth and development of spring oilseed rape plants and this, in the end, redounded considerably upon volume and quality of harvest of seeds. The seed yields of spring oilseed rape `Olga` fluctuated from 2.06 – 3.15 t ha^{-1} in three-year field trials. Using of nitrogen and potassium fertilizers at the rate of 60 kg ha^{-1} to 100 kg ha^{-1} substantially increased the harvest of oil seeds. The further increase of nitrogen and potassium rates did not lead to rise of the spring oilseed rapeseed yields. The highest seed yield was obtained when introducing $N_{100}K_{100}$ – 3.15 t ha^{-1} oilseed rape oil seeds. The increase of harvest when introducing nitrogen 60-100 kg ha^{-1} and potassium 60-100 kg ha^{-1} fertilizers was 0.75-1.09 t ha^{-1} ($LSD_{0,05}$= 0.22 t ha^{-1}). The seed yields showed the tendency to decrease on 1 kg of NK (from 6.25 to 3.36 kg) if rates of fertilizer were increased from $N_{60}K_{60}$ to $N_{140}K_{140}$ (Table 1).

Table 1. The influence of different rates of NK fertilizers on the spring oilseed rapeseed yields and yield components (2001-2003)

Variants	Seed yield	Oil yield	Protein content	Oil content of seeds	Height of plant	Branching height	Legumes on plant	Seeds in legumes	Mass of 1000 seeds
	t ha^{-1}	kg ha^{-1}	%	%	Cm	cm	apiece	apiece	g
N_0K_0	2.06	881	22.12	47.06	116	52	49	21	3.5
$N_{60}K_{60}$	2.81	1173	22.61	46.09	131	59	75	23	3.8
$N_{80}K_{80}$	3.02	1268	22.82	45.54	136	61	90	24	3.8
$N_{100}K_{100}$	3.15	1295	22.95	45.01	139	63	103	24	3.9
$N_{120}K_{120}$	3.09	1254	23.70	44.02	142	69	106	25	4.0
$N_{140}K_{140}$	3.00	1199	24.13	43.72	145	68	133	26	4.2
$LSD_{0,05}$	0.22		0.62	1.22					

The average change in the spring oilseed rape seed yields under the influence of adding different rates of nitrogen and potassium fertilizers within 2001-2003 can be represented with the equation for second degree polynomial equation $y=-8E-05x^2 + 0.0189x + 2.0463$ ($r=0.99$). In this instance, the equation reflects 98.90 % of the cases at coefficient of determination $R^2=0.9890$ (Fig.1)

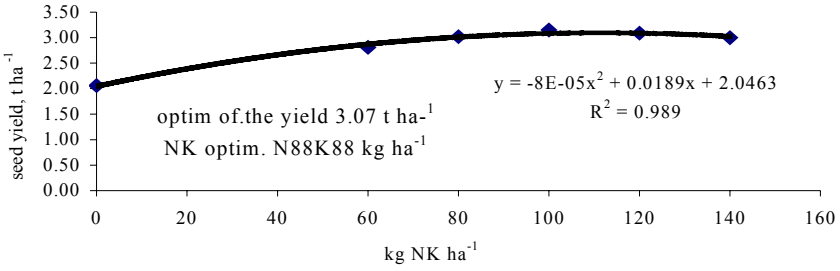

Fig. 1. Polynomial regressive interrelation between the harvest of seeds and the rate of the NK fertilizers (2001-2003)

Mineral fertilizers have caused a considerable increase of protein content of the spring oilseed rapeseed yields. As a result of the introduction of nitrogen and potassium fertilizers, crude protein content increased by 0.49-2.01% in 2001-2003 while oil content decreased by 0.97-3.34 %. In spite of reduction in oil content of the seeds, total yield of crude fat made up 881-1295 kg ha^{-1} depending on rates of mineral fertilizers. The highest yield of crude fat – 1295 kg ha^{-1} was obtained when introducing 100 kg ha^{-1} of nitrogen and 100 kg ha^{-1} of potassium fertilizers that was conditioned by higher seed yields in this variant. The economic optimal rate of nitrogen and potassium fertilizers after autumn fallow on sandy clay was N_{88} K_{88} kg ha^{-1} where the spring oilseed rapeseed yields made up 3.07 t ha^{-1}

Regression equation shows that increase in harvest of oilseed rape is determined by nitrogen and potassium fertilizer, and this is connected with increase of amount of pods on the plant. Owing to the NK fertilizer, the number of side branches increased, on average, for 2-3, the number of legumes on a plant for 26-84, the number of seeds per legume for 2-4, the thousand seeds weight for 3,5-4,2 g (table 1).

The results of field experiments confirm that the application of regulators of increase in the mixture with the fungicides have had a positive impact on the harvest of the seeds of spring rape. Our summer rape research displays different harvests for each year (Table 2).

Table 2. The influence of different mixtures of growth regulators and fungicides on the spring rape 'Olga' yield (2002-2004)

Variants	Seed yield	Oil yield	Protein content of seeds	Oil content of seeds	Height of plant	Branching height	First grade branches
	t ha^{-1}	kg ha^{-1}	%	%	cm	cm	apiece
Control	2.50	1033	**22.87**	**45.36**	140	67	4
Moddus + Folicur	3.15	1302	22.87	45.17	128	60	5
Moddus + Juventus	3.03	1270	**22.66**	**45.69**	130	61	5
Cycocel + Folicur	3.08	1293	**23.29**	**45.74**	126	62	6
Cykocel + Juventus	3.31	1409	**22.78**	**46.51**	120	53	6
$LSD_{0,05}$	0.24						

On average, throughout all the three years, thanks to applying of the growing-regulators and fungicides mixtures the spring rapeseed harvesting essentially increased, if compared to the Control. The harvest increase was 0.53-0.81 t ha^{-1} ($\gamma_{0,05}$ 0.24 t ha^{-1}). During the trials, the best preparation mixture was the Cycocel + Juventus, which, on average, provided the seed harvest 3.31 t ha^{-1}, and the oil output 1409 kg ha^{-1}. Other mixtures ensured a related seed output – 3.03-3.15 t ha^{-1}, and the oil output 1270-1302 kg ha^{-1}. The research proved: while applying the azoli preparations in mixture with the preparations of chlormequate and trinexapac-ethyl junctions and employing minified doses (Modus + Folicur, Modus + Juventus, Cycocel + Folicur, Cycocel +Juventus), there was observed the impact on rape plant development, and harvest-structure formation elements (Table 2). Owing to the mixtures of preparations, the number of side branches increased, on average, for 1-2, the number of legumes on a plant – for 22-25, the number of seeds per legume for 2-4, the mass of 1000 seeds: from 3,7 to 4,2 g, at the same time the length of rape's stem's shorted down to 10-20 cm, and the branching height to 5-14 cm. The highest efficiency, however, was reached when applying the mixture of Cycocel and Juventus. Throughout the research period it was observed that plant-growing regulators if mixed with fungicides, provided evenness of florescence and legume ripening.

During the two years the using of organic preparations provided 2.02-2.26 t ha^{-1} high seed yield, and this was for 0.22 – 0.46 t ha^{-1} more in comparison to control (1.80 t ha^{-1}). There was a significant difference by $LSD_{0,05}$ = 0.16 t ha^{-1}; P - value = 0.0002 < 0.05. The highest increase of seed yield 0.46 t ha^{-1} provided the application of preparations of germin and elixir of turf (table 3).

During the trials there was observed a positive influence of organic preparations on oil seed rape yield components (Table 3). The usage of organic preparations increased total oil yield from 774 to 1019 kg ha^{-1} in variant with *Germin* treatment. The plants also were for 2 – 6 cm higher in parcels with treatment of organic preparations. There was observed the increase of first

grade branches from 4 to 5-6 and number of legumes per plant from 46 to 52-69, and seeds per legumes from 21 to 22-24 (table 3). The mass of 1000 seeds increased from 3.7 g in control variant to 4.2 g in variant with *Germin* treatment. The usage of *Germin* and *Turf elixir* preparations presented the highest efficiency during these trials.

Table 3. The influence of organic preparations on the spring oilseed rapeseed yield and yield components (2003-2004)

Variants	Seed yield t ha $^{-1}$	Oil yield kg ha^{-1}	Height of plant cm	Branching height Cm	First grade branches apiece	Legumes on plant apiece	Seeds in legumes apiece	Mass of 1000 seeds g
Control	1.80	774	101	43	4	46	21	3.7
Trichodermin	2.10	962	105	44	5	55	22	4.0
Azotobacterin	2.02	887	103	46	5	52	22	3.9
Germin	2.26	1019	107	45	6	69	24	4.2
Elixir of turf	2.26	995	103	44	6	64	23	4.0
$LSD_{0,05}$	0.16							

Conclusions

1. The results of the three-year field trials show that the introduction of nitrogen and potassium fertilizers at the rate from $N_{60}K_{60}$ to $N_{140}K_{140}$ kg ha^{-1} considerably increases the harvest of spring oilseed rape. A significant increase of harvest 0.75-1.09 t ha^{-1} was obtained when introducing $N_{60\text{-}100}K_{60\text{-}100}$ kg ha^{-1}.

2. The economic optimal rate of nitrogen and potassium in the sowings of spring oilseed rape `Olga` was $N_{88}K_{88}$ kg ha^{-1} the highest among the seed yields – 3.07 t ha^{-1} and yields of oil – 1286 kg ha^{-1}.

3. Applying of fungicides and growing-regulators in mixtures, in minified doses, provides evenness of florescence and legume ripening, and essential increase of rapeseed yield, improving its quality as well.

4. The applications of the studied mixtures of preparations ensured the addition of the harvest of seeds 0.53-0.81 t ha^{-1} and oil outlet to 237-376 kg ha^{-1}.

5. The usage of organic preparations for treatment of rapeseeds positively affected the growth and development of oilseed rape, seeds yield and yield quality.

6. The field trials results show that highest yield of seeds (2.26 t ha^{-1}) and oil (995-1019 kg ha^{-1}) was provided by *Germin* and *Turf elixir* preparations.

References

1. Beer K., at al (1990) Organische und mineralische Dungung. Deutscher Landwirtschaftsverlag. – Berlin, 480.
2. Cramer N.(1990) Raps. Zuchtung, Anbau und Vermarktung von Kornerraps. Ulmer-Verlag, Stuttgart, 147.
3.Feger G., Orlovius K.(1995) Wichtige Nathrstoffe fur den Raps. Ratgeber fur die Landwirtschaft 10, 19.
4.Finck A. (1991) Dungung – ertragsteigermd qualitatsverbessemd, umweltgerecht. Eugen Ulmer Verlag Stuttgart, 310.
5.Fruchtenicht K., at al (1993) Pflanzenermahrung und Dungung. In: Faustzahlen fur Landwirtschaft und Gartenbau. Hydro Agri Duhnen GmbH. Landwirtschaftsverlag Munster-Hiltrup. 12 Aufl., 254-275.
6. Makowski N., Gienapp Ch. (1998) Entscheidungshilfen fur die Rapsbestellung. Neue Landwirtschaft., 7, 54-55.
7.Sturm H., at al (1994) Gezielter dungen. Integriert wirtschaftlich, umweltgerecht 3. uberarb. Aufl. Frankfurt: DLG-Verlag, Verlags-Union Agrar, 471.
8. Vošak a kolektiv. (2000) Repka. Praha, 321.
9. Шпаар Д., и др. (1999) Рапс. Минск, 204.