EFFECT OF ORGANIC RAPESEED GROWING SYSTEM ON THE YIELD FORMATION

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Exact field experiments for determination of the effect of organic growing system on the winter rapeseed yield formation and reduction were carried out on the Experimental Station of Department of Plant Production of CULS Prague - Uhříněves, which is certified for trials in organic farming. Statistically significant differences have been noticed for variants of trial exposed to organic technology compared to conventional technology. It was recorded that rapeseed varieties under organic cultivation created less than 50 – 60 % of buds than those cultivated conventionally. Plants in the technological trials created about 35 – 85 % lower number of buds (according to several technological inputs) in organic system compared to conventional control.

***Key words**: rapeseed, yield, generative organs, organic cultivation*

Since 1991 the Czech University of Life Sciences in Prague is engaged in the research of organic growing of field crops with the focus on the sustainability of varieties for organic farming as well as on growing technology and quality of production [1]. Formation of winter oilseed rape yield is a process that begins with the establishment of vegetation, performance of the crops, nutrients and treatment of the stand.

Rapeseed yield is based on the TSW (Thousands Seeds Weight), number of pods per m^2 and number of pods per plant. Final crop yield is determined by the number of seeds per m^2 due to number of plants per m^2, number of pods per plant, number of seeds per pod and, finally, by TSW [2]. FÁBRY et al. states that the influence of genotype, determining the level of yield elements, is often overlapped by the influence of the year, ecological conditions and agronomic technology. Those relations influence each other and besides they are strongly modified by the competition relations and by the organization of the plant population [3]. Also structure of the stand, namely plant density, has a major role, "since the intra-plant competition decisively controls growth and development of the individual plants" [4]. Peltonen-Sainio & Jauhiainen characterize yield potential as real maximum

reachable if plant growth and yield formations are favorably influenced due to environmental conditions and farming management [5]. Yield potential of modern rapeseed sorts had been increased about 25-30 %. Compared with rapeseed, yield potential of wheat was increased about 45-50 %, however, it should be noted that there is more energy stored in winter rape seeds than in the kernels of cereals [6].

Vašák et al., cited by Kuchtová et al., stated that during spring period, rapeseed plant is able to create about 2-3 000 of primordiums, of them develop approximately 300-500 of buds, afterward 200-300 flowers and, finally, it is possible to record 80-180 pods per plant to harvest, small part of initial floral primordiums number [7].

Ideal stand of rapeseed should have high number of pods per m^2 (more than 4 000) and highest number of seeds per pod (more than 20) and TSW exceeded 5 g [8]. *Table 1* shows optimum levels of yield components necessary to reach of the yield potential.

Table 1

Optimal levels of the yield components

Plants per m^2	50	Pods per plant	150
Pods per m^2	7 500	Seeds per pod	20
Seeds per m^2	150 000	Seeds per plant	3 000
TSW (g)	5	Primary branches per plant	8
Yield potential ($t.ha^{-1}$)	7,5		
Source: BARANYK & FÁBRY [2007] Amended			

Results show an increase of yield in case hybrids in comparison with lines by 20% [9]. Hybrids create in the autumn 11%, during flowering 8% and after the fall 25% more dry matter than parent lines. During the spring population hybrids create more branches and have a stronger habitus [10], but hybrids sorts are suitable mainly for the intensive technology of growing for high yield and require a higher level of the agronomic technology.

In general we can say, that rapeseed plant significantly responds to environmental influences, but has a strong compensatory ability, not only because of the set of generative organs, but also through the mutual interactions between yields components.

MATERIAL AND METHOD

Exact field experiments for determination of different growing systems effect on yield formation and yield potential of winter rapeseed were carried out on Experimental Station of Department of Plant Production, CULS Prague at Uhříněves, in the years 2007-2008.

Experimental area of the station is situated in the district Prague east. It belongs to the sugar beet production type, wheat subtype. The territory is a part of the mildly warm region, relatively dry climatic region, with mild winters, 295 m above sea level.

The average year temperature is 8,3°C and the average sum of precipitation 575 mm. The average temperature during the vegetation period is 14,6°C and the average sum of precipitation 333 mm [11].

Table 2

Standard growing technology of trials

Organic		Conventional
Preceding crop:	Peas-Bean mixture	Peas-Bean mixture
Tillage:	14. 8. 2007	13. 8. 2007
Seed bed preparation:	23.–25. 8. 2007	25.–26. 8. 2007
Date of sowing:	26. 8. 2007	28. 8. 2007
Seeds per m^2	120	70
Row spacing:	250 mm	125 mm
Rolling:	29. 8. 2007	29. 8. 2007
Weed management:	Line weeding: 8.10. 2007 10.4. 2008	Pesticides: Butisan Star - 30. 8. 2007 Galera - 2. 10. and 13. 4. 2007 Nurelle D - 13. 4. 2008
Harvest:	20.7. 2008	27.7. 2008

Varieties Oponent (winter rapeseed) and Licolly (spring rapeseed) were used separately as well as mixed at sowing (80 % Oponent and 20 % Licolly) in exact field small-plot trials, conducted to test effect of growing technology (*tab. 2, 3, 4*) on yield, both at organic and conventional part of research area. Effects of plant protection preparations have been tested separately such as in combination with fertilizers both permitted to use in organic agriculture (*tab. 5*).

Table 3

Differences between levels of conventional growing technology

2008	Level I	Level II
Fertilization (kg N per ha) 18.2., 7.3., 8.4.	40 (LAD 27) 40 (LAD 27) 40 (LAD 27)	40 (Entec 26, + 20 kg of S/ha), 20 (LAD 27) 40 (Entec 26, + 20 kg of S/ha), 20 (LAD 27) 70 (LAD 27)
Growth regulators	No	Horizon, 1 l/ha (autumn, 5 leaves) Caramba, 1 l/ha (spring, 25-30 cm length)
Fungicides	No	Alto Combi 420 SC, 0,5 l/ha (full flowering - DC 64)
Harvest	23. 7. 2008	27. 7. 2008
LAD 27: Ammonium saltpeter, 27 % of nitrogen, Entec 26: 26 % of nitrogen, 13 % of sulfur		

Variants of all studies were based on 3 repetitions and maintained in accordance to the standard conventional technology of rapeseed growing (*tab. 2, 3, Level I.*).

At the beginning of the flowering period 5 plants were selected and marked in each unified plot for manual counting. Number of the generative organs: buds, flowers and pods were counted from the top inflorescence downwards. The counting finished in

the time of green ripeness of pods, when the physiological fall of generative organs was terminated. Dates of counting were: 24. 4., 29. 4., 6.5., 14. 5. and 23. 7., respectively 27. 7., 2008.

Table 4

Varieties used in varietal trials under organic, level I. and II. growing technology

Cultivation	Varieties / marking in trial
Organic cultivation	Cando-eko, Caracas –eko, Liprima-eko, Lisek-eko, Manitoba, Oksana, Ontario, Oponent, Slogan, Smart
Conventional cultivation	Cando, Caracas , Liprima, Lisek
Conventional cultivation – Level I.	Liprima I., Lisek I., Manitoba I., Oksana I., Ontario I., Oponent I.
Conventional cultivation – Level II.	Liprima II., Lisek II., Manitoba II., Oksana II., Ontario II., Oponent II.

Table 5

Variants of technology trials

Variants under organic growing interventions		
Description	Variety	Characterization
Licolly eko	Licolly	Spring rapeseed
12A Oponent/Licolly	Oponent/Licolly	Mixed (ratio 8:2)
Op/Poly eko	Oponent	Polyversum
Op/2xPyre eko	Oponent	Pyrethrum
Op/guano eko	Oponent	Guano
Op/PoPyGu	Oponent	Polyversum, Pyrethrum, Guano
Op/biokal eko	Oponent	Bio-sludge application
Op/lignoh. eko	Oponent	Lignitic materials aplication
Licolly eko p.v.	Licolly	Spring rapeseed Delayed sowing 14. 9.
Op/Lic. eko p.v.	Oponent	Delayed sowing 14. 9.
Op/bot.ins.I eko p.v.	Oponent	Botanical insecticide I. Delayed sowing 14. 9.
Op/bot.ins.II eko p.v.	Oponent	Botanical insecticide II. Delayed sowing 14. 9.
Oponent	Oponent	Check, varieties range Included in results
Variants under conventional growing interventions		
Licolly kon	Licolly	Spring rapeseed
12A Oponent/Licolly kon	Oponent/Licolly	Mixed (ratio 8:2)
Oponent kon	Oponent	Check

Five counted plants and another 5 of each repetition were manually harvested before the combine harvest. After the complete drying we carried out the individual analysis of plants and the number pods was determined. After the manual rub off of seeds following characteristics were determined: TSW (thousand seeds weight), oil content, weight of harvested seeds from individual racemes, average number of seeds per plant, per area, per pod. Data obtained from the generative organs counting was evaluated using analysis of variance (ANOVA, statistical program Statistica). All data are available at authors of the article.

RESULTS AND DISCUSSIONS

In the first term of counting, the average number of generative organs was significantly lower for organic variants compared to conventionally grown variants. There was a smaller number of buds on the level II technology of growing as compared to the level I (*tab. 4*), which is probably due to the delays as a result of developments at a higher level of fertilization and nitrogen uptake. Using Tuckey test, it was established that the variety Liprima, Manitoba and Oksana grown in the level I. significantly differ in the level of bud sets from the organic varieties Liprima, Manitoba, Oksana and Oponent.

Ontario variety on level II significantly differed in the number of generative organs from organically grown varieties Manitoba, Oksana and Oponent in the second term of counting. Varieties grown on the level II have already exceeded even the variety on the level I in the average number of created generative organs. On the other hand, Manitoba variety on level II was significantly different compared to organic varieties Liprima, Manitoba, Oksana and Oponent, in the third period as well as results of Ontario variety on level II differed statistically significantly from the varieties Manitoba and Oponent in organic part of trial.

Manitoba II in the third time of counting significantly differed from organic varieties Liprima, Manitoba, and Oksana. In the fourth term of counting, variety Liprima on the level II was significantly different from all varieties of eco-range variety, except in Ontario, Manitoba II variant differs from the varieties Liprima.

Varieties on level II of conventional growing in harvest reached on the main inflorescences the highest average number of pods. Lower number of pods was observed in the level I. and the lowest values of pods were determined for organic variants of varietal experiment.

Table 6

Varietal experiment. Average number of generative organs. All groups

Date of counting 2008	Organic 10 varieties	Organic 6 varieties	Level I. 6 varieties	Level II. 6 varieties
24.04.	49.4	48.5	81.3	71.0
29.04.	47.6	46.8	59.4	68.7
06.05.	45.8	46.0	56.8	64.5
14.05.	41.2	39.3	50.0	61.5
Harvest	36.5	34.8	49.6	61.4

In the varietal trial, plants grown organically create less of 50 to 60% of buds than plants grown conventionally. In the technology trial, Oponent variety, organically grown, created on 35% fewer buds (for the late sowing 45%) less and Licolly spring rape variety on 55% flower buds less than conventional Licolly (in the late planting of up to 85% less flower buds).

Concerning of number of pods, in varietal trial it was found that organically grown plants of oilseed rape creates 25% of pods less than conventionally grown canola in the level I and 50% less than canola in level II. In our technology trial, Oponent developed about 32% less of pods than conventional control (for late sowing, it was up to 65% less).

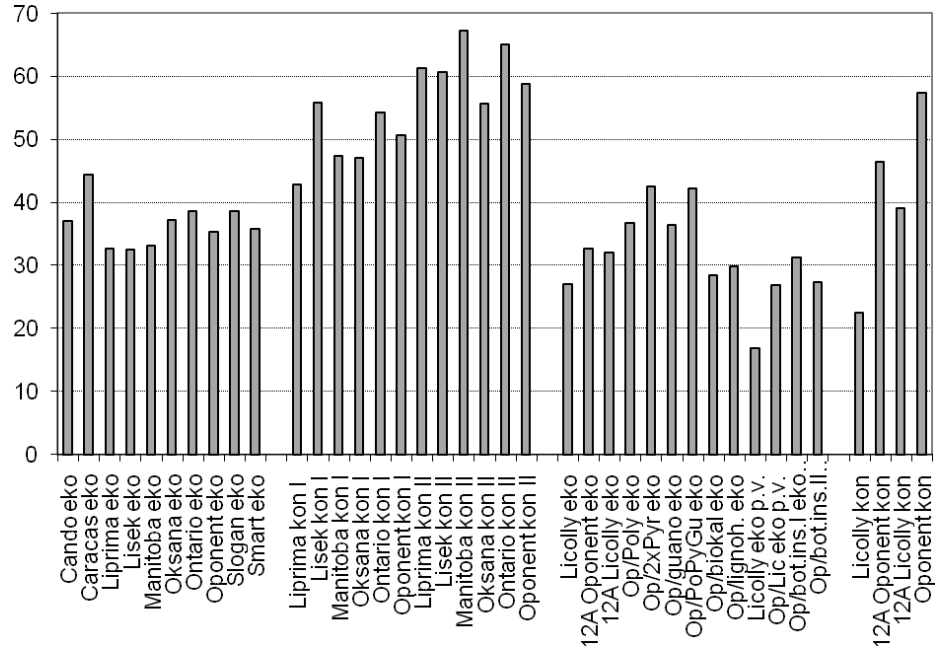

Figure 1 **Average number of pods in harvest. All variants of trials**

During monitoring, the highest numbers of pods were recorded for variants grown conventionally, especially on the level II (*Fig. 1*).

Statistical evaluation of results did not show statistically significant differences between organic and conventional variants of trials for the number of pods per plant (main inflorescence), therefore the values of variants varied considerably.

Although rapeseed plants based in general 200-300 flowers [12] and than 150-200 pods, in our trials plant of rapeseed in the organic system creates much less flower buds compared to plant in the conventional system (*tab. 7*). In this context, causal connection can be probably found mainly in the low and unequal

uptake of nutrients, especially of nitrogen, but possible relationship with a quantity of created dry biomass, could be the subject of further research.

As is clear from results, a precondition for a sufficient number of developed pods is creating the maximum number of generative organs still before the start of flowering, even if the final number of pods depends on other factors (early sowing, e.g.). DIEPENBROCK [13] confirms that the plants of rapeseed sown in August initiate the creation of primordiums since the beginning of November, which significantly affects the realized number of pods in harvest.

Table 7a

Number of pods per main inflorescence, number of pods per plant. All groups

Variant	n	Main inflorescence	Standard deviation	In total	Seeds/pod
Cando	5	37,0	2,5495	159,8	19,6
Caracas	5	44,4	3,1305	105,8	13,4
Liprima	5	32,6	9,6073	115,8	18,3
Lisek	5	32,4	8,2644	141,0	22,6
Manitoba	5	33,0	6,0415	110,8	18,1
Oksana	5	37,2	10,3537	142,4	14,1
Ontario	5	38,6	9,6850	88,8	16,7
Oponent	5	35,2	6,9426	151,4	19,6
Slogan	5	38,6	15,0765	109,8	18,4
Smart	5	35,8	14,8223	101,4	20,3
Average	50	36,5	8,6473	122,7	18,1
Licolly	4	27,0	18,2939	53,0	4,5
12A Oponent	5	32,6	12,6610	104,8	19,1
12A Licolly	4	32,0	14,4453	68,0	4,8
Op/Poly	5	36,6	10,3827	119,6	22,1
Op/2xPyr	5	42,4	11,0363	176,0	19,8
Op/guano	5	36,4	16,1957	82,0	17,2
Op/PoPyGu	5	42,2	8,7864	136,6	17,5
Op/biokal	5	28,4	5,5946	101,8	20,3
Op/lignoh.	5	29,8	8,9833	134,2	20,2
Licolly p.v.	4	16,8	7,2744	39,2	18,2
Op/Lic	5	26,8	5,9749	63,0	16,2
Op/bot.ins.I	5	31,2	11,2339	71,8	19,0
Op/bot.ins.II	5	27,2	8,8431	57,0	15,8
Average	62	31,5	10,7466	92,8	16,5

When comparing the number of pods per plant, we find, that plants from organic experimental area consists of 25% less of pods in comparison with the level I, which means that the rate of reduction of generative organs in plants at the level I was significantly higher than the level II. In addition, the percentage of shattered generative organs on the main inflorescence is the lowest at level II of all observed variants (*Fig. 2*).

Table 7b

Number of pods per main inflorescence, number of pods per plant. All groups.

Liprima I	5	42,8	13,1415	156,2	16,0
Lisek I	5	55,8	11,9666	207,6	17,9
Manitoba I	4	47,3	24,9850	186,3	9,6
Oksana I	5	47,0	16,1090	148,6	14,3
Ontario I	5	54,2	8,3487	139,6	17,2
Oponent I	5	50,6	18,8096	133,4	15,4
Average	29	49,6	15,5601	161,9	15,1
Liprima II	5	61,2	9,8843	251,0	12,8
Lisek II	5	60,6	19,5653	219,6	11,5
Manitoba II	5	67,2	18,2264	280,4	12,8
Oksana II	5	55,6	11,2161	191,8	14,7
Ontario II	5	65,0	17,9304	309,6	13,5
Oponent II	5	58,8	25,6457	205,6	14,6
Average	30	61,4	17,0780	243,0	13,3
Licolly	5	47,6	15,6780	65,6	7,3
12A Oponent	5	45,4	5,1284	149,0	19,1
12A Licolly	5	34,8	11,0770	109,5	4,8
Oponent	5	46,8	17,9639	252,5	16,5
Average	20	43,7	12,4618	144,2	11,9

The most significant rate reduction of pods was achieved in the spring variety Licolly, which is probably related to the significant reduction of generative organs, in particular in the second half of maturation, when the plants of spring oilseed rape sown in the autumn has long been ripe, and therefore they reduce pods more than winter oilseed rape plants (*Tab. 7*). (Compare the number of seeds per pods for Licolly, *tab. 7a, b.*)

In our experiments, we focused only on the yield components of individual plants, not of entire crop,or experimental plots, graphic representation (*Fig. 3*) of the proceeds of all experimental variants are used to supplement information.

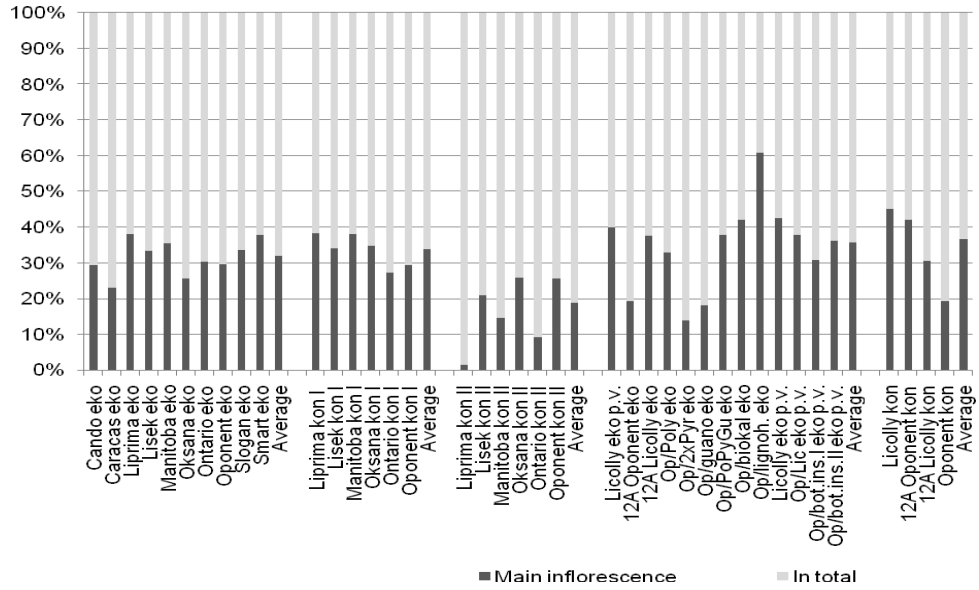

Figure 2 **The ratio of the main inflorescences on the total reduction of generative organs. All variants of trials**

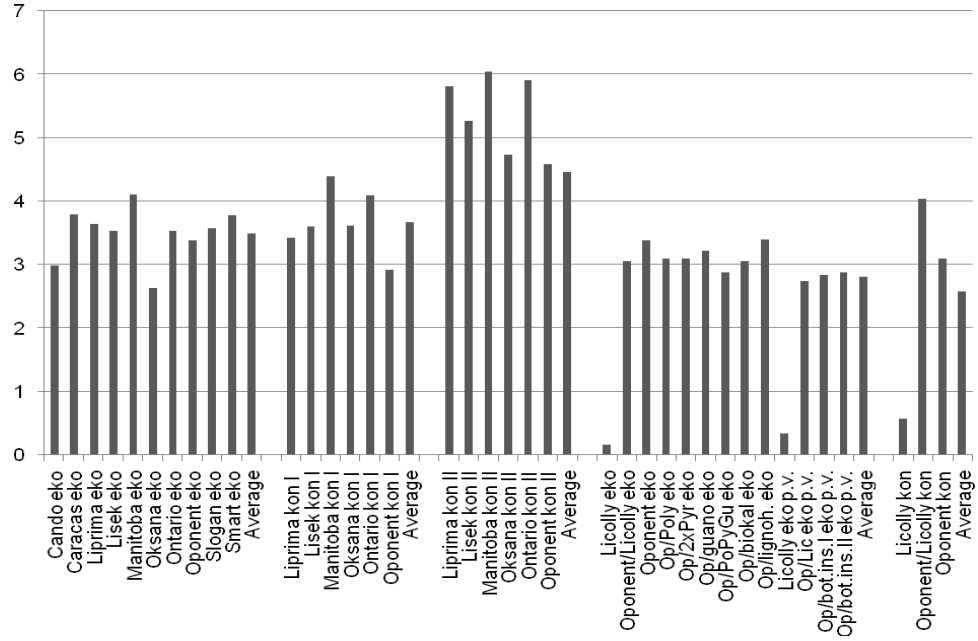

Figure 3 **Average yield (t.ha^{-1}) of all experimantal variants. Combine harvest**

In our trials, we examined also other primary yield components, such as the number of seeds in šešuli, TSW, number of plants per m^2, as well as second yield

components (number of seeds to plant, etc.) and yield characteristics (yield per plant and the area), the results, however, are not more measured or discussed.

CONCLUSIONS

Oilseed rape plants grown in organic farming systems form approximately half to a third number of generative organs compared to plants in conventional farming systems. The primary reason is low levels of nitrogen fertilization in organic farming systems. Limited possibilities for intervention against harmful biotic agents (such as fungal diseases, insect pests and partially significantly competing weed plant species) are the second major cause of this fact.

The evaluation of reduction of generative organs showed that organic variants in average reported 55.8 % reduction of generative organs per plant and 26% reduction of generative organs per main inflorescence. On the other side, it was found the rate of reduction of GO at 74.6% per plant and 38.3% per terminal for conventional variants in the level I and the level of II reached 56.1% reduction per plant and 13% per main inflorescence.

In general, reduction of generative organs on the main inflorescence is about half compared with the reduction on the whole plant. Plants of rapeseed grown organically form less flower buds, flowers and pods compared to plants in the conventional system, but the amount of reduction of generative organs (as compared with the standard level of the conventional system) is lower by up to 30% and is comparable with that of II.

In conclusion, we can say that:

- The organic cultivation increases the share of generative organs on the branches/racemes compared to conventional cultivation of rapeseed;
- This type of growing technology influences not only the number of the created and realized generative organs, but also the representation of generative organs on branches;
- The highest number of created generative organs usually, but not always, means the highest reduction of generative organs.

Maintenance of agronomic interventions play in the yield formation an important role, but it is much easier to choose appropriate variety (more line for fewer exigencies than hybrids) for organic cultivation and establish crop stand in optimal time and in optimal structure than to protect plants from harmful biotic agents. Taking into account the significant risks to which it is exposed organic rapeseed, it is necessary to take all measures of intensification that are possible and allowed. Substances improving nutritional status of plants were very successful in our experiments as well as use of bio-insecticides and bio-fungicides, registered for use in the EZ.

It would seem that when the proportion of conventionally grown rapeseed in the Czech Republic represents 13.9% of arable land (almost 355 thousand ha) are discussions about rapeseed cultivation in organic farming purely academic, but the

authors believe that interventions searching to increase productivity of plants under organic cultivation system has a significant long-term sense in terms of sustainability.

This study was supported financially by the Ministry of Agriculture of the Czech Republic, Project of the National Agency for Agricultural Research: QG 50107.

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