

The effect of rapeseed stand density on the formation of generative organs

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ABSTRACT

This experiment was carried out for the study of differences in dynamics of formation and reduction of generative organs from the beginning of the flowering to the harvest, under different stand density of the winter rapeseed. The evaluation of the results of the study of stand density, confirms that from the technological point of view it is appropriate to choose a thinner population of rapeseed. Starting with the stand density of 60 plants/m² we do not observe significant differences in plants during the generative stage, neither in the number of branches nor in the number of created generative organs. At this density (60 plants/m²) a significant reduction of generative organs takes place, especially on the secondary branches. Differences in the number of fertile branches are visible in case of more dense populations only in the harvest. From the point of view of the yield it is more advantageous to support the creation of generative organs on primary racemes by agricultural interventions.

Keywords: winter rapeseed; generative organs; formation; reduction; stand density

The creation and distribution of seed yield on the primary racemes and on the primary branches of rapeseed are well documented (Tayo and Morgan 1979, Daniels et al. 1983), but the dynamic of the relationship between individual branches is unknown. The compensation abilities of lower branches, especially of branches of lower grade, are not quantified.

The value of the formation and reduction of generative organs is obviously not dependent only on the level of nitrogen fertilization. Obviously, it is necessary to look for the relationship not only in values of the stand density, i.e. in the competition among vegetation and in the conditions of environment, but also in the competition between developing organs on the plants as such, which introduces secondary racemes into the relation. The creation and reduction of generative organs on the secondary racemes developed in a different way than on the primary ones.

The highest reductions were registered in the time of the begin of ripening of the first created pods: Keiller and Morgan (1988) equally as de Bouille et al. (1988) stated, that apical zones play the role of strongest sinks for assimilates mainly in this period and therefore they have priority to younger pods and their seeds, which are for this reason more susceptible to die off.

The accessibility of assimilates before and during the flowering period is the limit for the creation of flowers (Tayo and Morgan 1979) and the total number of flower is limiting the yield potential (Mendham et al. 1981). The realization of this po-

tential is limited by the fall of flowers (Mendham and Scott 1975, McGregor 1981). As soon as the main components of the future yield are installed, i.e. the earliest developed generative organs, the yield is constituted mainly by flowers, which develop in the first 10 days from the beginning of flowering (Tayo and Morgan 1979, Tittone 1991) the reduction of the later created generative organs takes place (Bilsborow and Norton 1984). The primary racemes and primary branches have in general more fertile pods and they are from the point of view of the seed yield more productive (Daniels and Scarisbrick 1983).

MATERIAL AND METHODS

Experimental areas of the station are situated on the east side of the territory in the community of Červený Újezd. It belongs to the sugar beet production type, wheat subtype (Švachula et al. 1992).

The territory is a part of the mildly warm, relatively dry climatic region, with mild winters. The yearly average air temperature is 7.7°C and the average yearly precipitation totals 507.1 mm. The average temperature during the vegetation period is 13.9°C and the average total of precipitation 333 mm. The vegetation period lasts 150–160 days (4th–9th month) (Švachula et al. 1992).

Variants of the experiment were based on 4 repetitions and maintained in accordance to the standard technology of rapeseed growing – SVŘ (System of rapeseed production). Used variety Lirajet is

Table 1. Dates of counting in the individual years of experiments

Year	Stage of development					
	DC 60	DC 63	DC 64	DC 65	DC 69	DC 80
1997	6.5.	12.5.	22.5.	2.6.	9.6.	10.7.
1998	29.4.	6.5.	14.5.	22.5.	28.5.	30.6.
1999	26.4.	3.5.	10.5.	17.5.	24.5.	2.7.

DC 60 = yellow bud, DC 63 = start of flowering, DC 64 = entire flowering, DC 65 = end of flowering, DC 69 = start of green ripeness, DC 70 = green ripeness, DC 80 = 1st harvest ripeness

00 line half-late to late high variety suitable for all growing areas of rapeseeds. The value of seeds dose was determined by stepping up the weighting of seeds converted according to the weight of one thousand seeds (TSW) 90% termination according to required stand density. In the springtime the plots were adapted to stand densities of 10, 40, 60, 80 and 110 plants/m².

In all variants there was determined unified nitrogen fertilization. Nitrogen was applied in the total amount of 150 kg N/ha subdivided into 3 spring doses: (1) spring reprise, (2) begin of the elongation growth and (3) green bud up to yellow buds to individual plots by hand fertilizing at possibly highest homogeneity of granulate distribution in the form of ammo nitrate (LAV). One plot harvest area was 10 m².

The average number of plants per m² was determined in each repetition of each of the variants every year in the early spring. In regard to the relatively high number of seeds per m² it was necessary to reduce the population to the required density: 10, 40, 60, 80 and 110 plants per m².

At the beginning of the flowering period 5 plants were selected and marked in each unified meter for manual counting: 1 strong – 3 standard – 1 weak. For statistic purposes 1 plant represents for us one repetition.

Generative organs were counted from the top raceme downwards in week intervals on marked plants starting by the period of yellow buds (Table 1): number of the living buds, living flowers and living pods. The counting finished in the time of green ripeness of pods, when the physiological fall of generative organs was terminated.

Five counted plants and another 5 of each repetition (totally 20) were manually harvested approximately one week before the combine harvest. After the complete drying, we carried out the individual analysis of plants and the number of pods was determined. After the manual rub off of seeds we have determined the following characteristics: (1) TSW (thousand seeds weight), (2) oil content, (3) weight of harvested seeds from

individual racemes, (4) average number of seeds per plant, per area, per pod. Those characteristics are not shown, only Table 4 to be related to it.

Results of the experiment were evaluated with the help of statistic program Statgraphics Plus for Windows 4.0 of company Manugistic, Maryland, USA. It tests for significant interactions between the factors, given sufficient data.

RESULTS AND DISCUSSION

The primary racemes (including the terminal racemes) show an increase in the number of generative organs in comparison to the 2nd date of counting (achieved maximal densities 60 and 110 plants/m²), respectively to the 3rd date of counting (achieved maximal densities 10, 40 and 80 plants/m²). The secondary racemes (densities 60, 80, 110 plants/m²) show an increase of the number until the 2nd date of counting (Tables 2 and 3).

The dynamics of increments of numbers of generative organs in case of thin densities of plants (densities 10 and 40 plants/m²) is totally different due to the small or non-existent competition. The number of generative organs on plants of the thinnest population has reached the maximum on the secondary racemes (Table 2) only in the 5th date of counting. This fact is from the agronomic point of view determined mainly by the lack of competition, as a matter of fact, plants grew in the solitary way. There was no shadow casting on lower parts and sources of assimilates were not limited as in the case of the dense population, which enabled plants to create new generative organs. But those did not manage to ripe (see the index of the reduction – 0.57 between the maximum and the harvest at the density 10 plants/m²). The population with the density 40 plants/m² has reached the maximum number of generative organs on secondary racemes at the 4th date of counting.

From the general point of view it came to a certain extent from the elimination of differences between primary and secondary racemes, i.e. densities 60,

80 and 110 plants/m² reach in average the maximum in the 2nd date of counting (Tables 2 and 3), both mostly thin variants (10 and 40 plants/m²) in the 3rd date.

With the increasing density of population increases also the reduction of initiated generative organs, both on the primary and secondary racemes (Tables 2 and 3). From the comparison of reductions in the period between the achieved maximum and the harvest (*m-h*) in case of all variants results in accordance to this trend up to the density of 60 plants/m². They vary only in the extent of reduction on primary and secondary racemes. Reductions on secondary branches are almost twice as high. From the population density of 60 plants/m² the extent of the reduction remains practically the same ($\pm 1\%$).

Concerning the share on the reduction, generative organs created in secondary racemes have the share on the entire decrease between the reaching of the maximum and the harvest (*m-h*) more than 60%, regardless of the density of the population. In the case of the thinnest populations the last

initiated flower organs simply do not ripe. There is no doubt, that the most early generative organs ripe to pods. We assume, that the reason for this nearly total reduction on secondary branches was mainly the stand density and the resulting competitive conditions: (1) architecture of individual plants, (2) plant cover, (3) shading. An important factor is obviously also the re-distribution of assimilates, when more developed generative organs are preferred in the period of insufficient nutrition. The distribution of assimilates in favour of earlier developed generative organs could be an answer to hormonal signals according to the hierarchy of developing organs (Rode 1988).

In case of the thin populations (10 and 40 plants/m²), the highest reduction of generative organs were found determined in the period between the last date of counting, in the time of the intense growth of pods and the harvest (Tables 2 and 3). In the case of the remaining variants (60, 80 and 110 plants/m²) as a result of higher to high competition for assimilates between developing organs this process was initiated already in the fall. The most critical

Table 2. The total numbers of generative organs in the period of individual counting and significance of differences in the number of living generative organs (Scheffe, $\alpha = 0.05$)

Racemes	Plants/m ²	Date of counting					
		1	2	3	4	5	6
Primary	10	302.5	456.3	510.8	479.3	450.3	340.7
	40	247.0	285.1	297.3	272.7	260.0	185.7
	60	257.9	342.7	317.8	305.9	255.9	153.3
	80	219.8	269.3	270.2	235.7	217.5	123.4
	110	184.3	232.1	225.3	197.1	162.8	105.3
Secondary	10	186.1	585.8	602.3	626.4	680.1	289.9
	40	101.1	174.6	198.9	204.3	181.5	43.4
	60	89.5	155.3	153.7	129.6	65.3	8.3
	80	67.7	109.8	94.7	77.8	40.7	2.0
	110	57.5	91.9	91.9	80.9	45.9	4.7
Amount	10	488.6	1 042.1	1 113.1	1 105.7	1 130.4	630.6
	40	348.1	459.7	496.3	476.9	441.5	229.1
	60	347.3	498.0	471.5	435.5	321.3	161.7
	80	287.5	379.1	364.9	313.5	258.2	125.4
	110	241.8	324.0	317.2	278.1	208.7	110.1
Amount	10	A	A	A	A	A	A
	40	ABC	AB	BC	B	B	B
	60	AB	A	B	B	B	BC
	80	BC	AB	BC	B	B	BC

Homogenous samples are denoted by identical capital letters

Table 3. Indexes of reduction in the period between individual counting, as well as the index of the entire reduction ($m-h$) between the achieved maximum and the harvest; average values 1997–1999

Racemes	Plants/m ²	Between date of counting					
		1–2	2–3	3–4	4–5	5–6	$m-h^*$
Primary	10	0.51	0.12	–0.06	–0.06	–0.24	–0.33
	40	0.15	0.04	–0.08	–0.05	–0.29	–0.38
	60	0.33	–0.07	–0.04	–0.16	–0.40	–0.55
	80	0.23	0.00	–0.13	–0.08	–0.43	–0.54
	110	0.26	–0.03	–0.12	–0.17	–0.35	–0.55
Secondary	10	2.15	0.03	0.04	0.09	–0.57	–0.57
	40	0.73	0.14	0.03	–0.11	–0.76	–0.79
	60	0.74	–0.01	–0.16	–0.50	–0.87	–0.95
	80	0.62	–0.14	–0.18	–0.48	–0.95	–0.98
	110	0.60	0.00	–0.12	–0.43	–0.90	–0.95
Amount	10	1.13	0.07	–0.01	0.02	–0.44	–0.44
	40	0.32	0.08	–0.04	–0.07	–0.48	–0.54
	60	0.43	–0.05	–0.08	–0.26	–0.50	–0.68
	80	0.32	–0.04	–0.14	–0.18	–0.51	–0.67
	110	0.34	–0.02	–0.12	–0.25	–0.47	–0.66

In case of negative values: index of reduction between particular dates of counting

* $m-h$ is index of reduction of numbers of generative organs between the achieved maximum number of generative organs (m) and number of harvested pods (h)

period from the point of view of losses of future pods commences by the fall, respectively by the beginning of pod growth, this is dependent on the density of population.

Nevertheless, in spite of this immense reduction, the share of secondary racemes on the yield on thin variants (10 and 40 plants/m²) is an important component of the yield. In the case of H₁₀ it is almost a share of 46% of secondary branches on the final yield of pods and in the case of 40 plants/m² almost 19%.

Though it was harvested in more than 600 pods/plant in the thinnest variant [Vašák et al. (1997) mentions the average number of harvested pods of 80–120 pieces per plant from the average population with the stand density \pm 60 plants/m²]. The thin population is not able to compensate yield loss even by the increased number of pods. More important is the number of pods per surface unit (m²), which is as follows (in brackets is given number of plants/m²): 6 306 pcs (10), 9 164 pcs (40), 9 702 pcs (60), 10 032 pcs (80) and 12 111 pcs (110).

Yield of grains was the highest on the variants with stand density 40 plants/m² fertilized by 150 kg N/ha. In case of fertilizing with 150 kg N/ha, the low density of the population (10 plants/m²) is not

compensated by the increase of generative organs on primary and secondary branches.

The final period of the living plant is not characterized by dynamic changes any more. We conclude from this, that in this period reductions of generative organs on all racemes are already terminated and the majority of pods, which we find on the plant, will ripe and more or less participate on the yield.

Using the statistical evaluation by the analysis of mean squares by the method of Scheffe (95%) was determined a statistically significant influence of the year, plants density and racemes on the number of generative organs on the significance level $\alpha = 0.05$ (Table 5).

Table 4. Calculated yield for variants of stand density

Plants/m ²	t/ha	% on the check
10	7.83	80.1
40	10.34	105.7
60-check	9.78	100.0
80	8.32	85.1
110	9.38	95.9

Table 5. ANOVA for generative organs on primary and secondary racemes, five stand densities (10, 40, 60, 80 and 110 plants/m²), based on three factors: year (A), stand density (B) and racemes (C); method 95% Scheffe

Date of counting		<i>S</i>	<i>Df</i>	<i>s</i> ²	<i>F</i> -test	<i>P</i>
1.	A. year	5 998.07	2	2 999.03	40.11	0.0000
	B. stand density	6 026.69	4	1 506.67	20.15	0.0000
	C. raceme	254 301.0	18	14 127.8	188.94	0.0000
	AB	4 424.14	8	553.017	7.40	0.0000
	AC	6 743.26	36	187.313	2.51	0.0000
	BC	4 553.64	72	63.245	0.85	0.8157
	ABC	7 574.8	144	52.6028	0.70	0.9960
2.	A. year	4 091.26	2	2 045.63	15.70	0.0000
	B. stand density	21 980.3	4	5 495.08	42.18	0.0000
	C. raceme	372 047.0	18	20 669.3	158.66	0.0000
	AB	13 528.4	8	1 691.05	12.98	0.0000
	AC	5 431.31	36	150.87	1.16	0.2415
	BC	12 932.6	72	179.62	1.38	0.0223
	ABC	13 722.6	144	95.2958	0.73	0.9910
3.	A. year	2 566.84	2	1 283.42	8.92	0.0001
	B. stand density	27 659.0	4	6 914.75	48.07	0.0000
	C. raceme	350 829.0	18	19 490.5	135.50	0.0000
	AB	8 725.15	8	1 090.64	7.58	0.0000
	AC	6 222.25	36	172.84	1.20	0.1940
	BC	19 179.8	72	266.387	1.85	0.0000
	ABC	15 366.9	144	106.715	0.74	0.9882
4.	A. year	8 487.64	2	4 243.82	34.58	0.0000
	B. stand density	28 517.1	4	7 129.28	58.10	0.0000
	C. raceme	325 889.0	18	18 104.9	147.54	0.0000
	AB	10 383.2	8	1 297.9	10.58	0.0000
	AC	11 973.0	36	332.582	2.71	0.0000
	BC	18 717.0	72	259.959	2.12	0.0000
	ABC	16 910.0	144	117.43	0.96	0.6244
	residual (inside classes) amount	139 890.0 560 699.0	1140 1424	122.71		
5.	A. year	10 966.7	2	5 483.33	51.76	0.0000
	B. stand density	29 983.1	4	7 495.77	70.76	0.0000
	C. raceme	312 244.0	18	17 346.9	163.76	0.0000
	AB	5 855.16	8	731.895	6.91	0.0000
	AC	18 311.6	36	508.656	4.80	0.0000
	BC	19 415.2	72	269.656	2.55	0.0000
	ABC	11 761.5	144	81.6769	0.77	0.9760
6.	A. year	2 285.75	2	1 142.87	17.56	0.0000
	B. stand density	26 758.0	4	6 689.49	102.77	0.0000
	C. raceme	185 479.0	18	10 304.4	158.30	0.0000
	AB	5 904.05	8	738.006	11.34	0.0000
	AC	4 399.14	36	122.198	1.88	0.0014
	BC	17 493.7	72	242.968	3.73	0.0000
	ABC	7 937.05	144	55.1184	0.85	0.8977

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ABSTRAKT

Vliv hustoty porostu ozimé řepky na tvorbu generativních orgánů

V letech 1996–1999 jsme experimentálně ověřovali vliv hustoty porostu na dynamiku tvorby a redukce generativních orgánů ozimé řepky (*Brassica napus* var. *napus* L.). Práce byly realizovány na pokusných pozemcích Výzkumné stanice Agronomické fakulty ČZU v Červeném Újezdě, okres Praha-západ. Vyhodnocení výsledků studia hustoty porostu potvrzuje, že z technologického hlediska je vhodnější volit řidší porosty řepky. Počínaje hustotou 60 rostlin/m² nepozorujeme významné rozdíly mezi rostlinami v průběhu generativního období v počtu větví ani vytvořených generativních orgánů. U této hustoty (60 rostlin/m²) nastupuje významná redukce generativních orgánů, hlavně na vedlejších větvích. Rozdíly v četnosti plodných větví jsou v případě hustších porostů zjistitelné pouze při sklizni. Z hlediska výnosu je mnohem výhodnější podpořit agrotechnickými zásahy tvorbu generativních orgánů na hlavních (primárních) květenstvích.

Klíčová slova: ozimá řepka; generativní orgány; tvorba; redukce; hustota porostu

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