The effect of sowing date and plant density on yield elements of different winter oilseed rape (*Brassica napus var. napus f. biennis L.*) genotypes

Éva VINCZE

Institute of Crop Science, Faculty of Agricultural and Food Sciences and Environmental Management, University of Debrecen E-Mail: vincze.evike@gmail.com

Abstract: Rapeseed is worldwide the 3rd, while regarding Hungary – beside sunflower – the 2nd most important oil crop produced. In our country winter oilseed rape is grown. Its cultivation area has been increasing since 1990; currently it varies between 200 and 250 thousand ha. The variety/hybrid palette has changed significantly during the past decade. As the result of this process hybrids are produced regarding the national average on 90%, while varieties on 10% of the total 230 thousand hectares production area. The experiment was set up at the Látókép Plant Production Research Site of the University of Debrecen. Three different sowing times were investigated and three different plant densities were set in 2015 200, 350 and 500 thousand plant/ha^{-1}. Uniform nutrient supply and a row spacing of 45 cm were applied. Winter wheat was used as pre-crop. Plant physiological measurements (relative chlorophyll content analysis (SPAD) and leaf area index (LAI)) were made in the populations of the Arkaso and Hybridrock rapeseed hybrids and Ontario variety. Relative chlorophyll content (SPAD) and leaf area index (LAI) were monitored in 7 different measurement times. Plant densities were counted before the winter and after the winter in the all experiment. The primary and secondary braniching, number of siliquae and seed yield have been determined.

Keywords: winter oil seed rape, sowing date, plant density, overwinter, yield quantity

Introduction

Demand on plant oil has shown increasing tendency in the past decades both world- and countrywide. Regarding the most important produced oil crops rapeseed is ranked 3rd worldwide and 2nd in Hungary at present (Pepó-Vincze, 2015). According to the data of the Central Bureau for Statistics (2015) rapeseed was sown in Hungary on a territory of 225 thousand hectares. Its sowing area was 9 thousand hectares higher than that of the previous year, but regarding the 2010-2014 average, that showed significant deviations in sowing area, this area was only 8 thousand hectares higher. In the 2015 57% of the total area sown with rapeseed was located in Central Hungary and in the Transdanubian region, while 43% in the regions Northern-Hungary and Northern Great Plain. According to Eőri (2012) the least suitable production regions in Hungary are the northeaster counties and the regions by the river Tisza due to the cold, continental winter weather conditions. Strong night radiation increases the risk of late frosts as well. Concerning the statistical data it can be stated that most of the freeze in rapeseed populations occur in the region Great Plain, especially in case – due to any reason – a given rapeseed population was not well-prepared for the winter. Therefore an important aspect of this research is to choose the optimal sowing time and plant density in order to have favourably developed rapeseed population in the autumn period that is less sensitive towards winter frost. Sváb and Simits (1980) analysed different experimental data and concluded that there was a positive relationship between yield and the total applied nitrogen fertilizer-amount, as well as the depth of soil tillage, but there was a negative correlation between yield and spring weed coverage, just as sowing time. Yield exceed 2.5 t ha^{-1} overall the country, but this can be improved to a significant extent. Potential yield capacity of rapeseed is about 6 t grain yield ha^{-1}. However, criteria of that are perfect winter hardiness, good regeneration ability, optimal plant density, just as tolerance to late sowing time etc. (Röbbelen, 1975).

According to the results of Blum (2009) there is a difference in the production technology of varieties and hybrids regarding seed rate and spring nutrient supply. Necessity of autumn N-fertilization, just as the use of growth regulators in the autumn and spring periods are determined by sowing time, the development of the given population and the properties of the applied varieties or hybrids. In their experiments Risnoreanu and Buzdugan (2011) found the sowing time interval 5-10 September to be optimal. 17-25 August is considered as optimal sowing time in Germany. In accordance with German researchers each day delay in sowing results in yield loss (Eőri, 2012). However, Schuster (1965) stated that yield loss is not realized linear. Rapeseed population sown in September produced half the yield of that sown in August. In the experiments of Sharafizadeh et al. (2012) sowing time affected rapeseed yield to a significant extent.

Materials and methods

Our experiments were set up on calcareous chernozem soil in the Hajdúság, 15 km from Debrecen at the Látókép Plant Production Research Site of the University of Debrecen. The soil is characterized by favorable physical, chemical and biological traits. The humus content of the calcareous chernozem soil of the experiment is 2.76%, its AL extractable P_2O_5 content is 133 mg kg-1, its AL extractable K_2O value is 240 mg kg^{-1}. The soil has favorable water management conditions. The soil saturated up to the field water capacity can store 578 mm water in the 0-2 m layer, 50% of which is disposable water. The experiment design was set as split-plot, plot areas were 36 m^2 in four replications and we used two hybrids (Arkaso and Hybridrock) and one varieties (Ontario). Three different sowing times were investigated in the experimental year (2015/2016). Three different plant densities were set: 200, 350 and 500 thousand plants ha^{-1}. Uniform nutrient supply and a row spacing of 45 cm were applied. Winter wheat was used as pre-crop. In the crop year were an early sowing date: August 28 (SD1), average: September 12 (SD2), late: September 23 (SD3). The harvest was done with a SAMPO plot combine harvester.

In the crop year 2015/2016 altogether 694.6 mm precipitation fell during the vegetation of rapeseed (1 August 2015 – 30 June2016). This amount was about one and a half times higher than the several years' average (Table 1.). The significant amount of precipitation in August (84 mm) was higher than the several years' average value (60.7 mm), which enabled the execution of soil preparation works in a rather good quality. September and October were very wet. This was favourable from the aspect of uniform emergence and adequate early development of rapeseed populations. Vegetative development of rapeseed populations was favoured by the weather conditions of autumn months. An amount of precipitation that fell in October (86.6 mm) was higher than the several years' average (30.8 mm). The monthly average temperature (10.0 ˚C) was similar to the several years' average (10.3 ˚C). Measured average temperature at the experimental field was higher in November (5.3 ˚C) than the average value (4.5 ˚C). Due to the combined effect of the mentioned factors, just as the optimal applied agrotechnical management, rapeseed populations started winter in favourable development stage. Monthly temperature average values were higher than the several years' average values – except for October and May.

For the statistical evaluation of the experiment, SPSS 13.0 for Windows and Microsoft Excel 2010 programs are used. The statistical evaluation, the bifactorial variance analysis and correlation analysis were done according to Sváb (1981), with regression equations.

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In the correlation analysis, the following types of correlations according to the r values were determined: r<0.4: loose, 0.4-0.7: medium, 0.7-0.9: tight, >0.9: strong.

Table 1: Amount of precipitation (mm) and temperature (˚C) during rapeseed vegetation period (Debrecen)

		Months											
		VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	Total/ Average
Precipitation (mm)	2015/2016	84	49	87	43	13	59	79	51	15	69	146	**694,6**
	30 year's average	60,7	38	31	45	44	37	30	34	42	59	79,5	**499,6**
Temperature (°C)	2015/2016	23,3	18	10	5,3	2,2	-2,3	5,5	6,4	13	16	20,1	**10,6**
	30 year's average	19,6	16	10	4,5	-0,2	-3	0,2	5	11	16	18,7	**8,9**

Results and discussion

Freezing rate was studied in the crop year 2015/2016 in case of two hybrids (Arkaso and Hybridrock) and a variety (Ontario) for three different applied plant densities and three different sowing times. The number of primary and secondary branches just as the number of siliquae per plant were registered (Table 2.) in case of the application of different plant densities and sowing times. It can be stated that parallel to increasing plant density the rate of winter loss increased as well. Results of the measurements confirm that the lower plant density was applied at sowing produced higher number of primary and secondary branches, just as the higher number of seed shells could be registered.

Table 2: Number of registered primary and secondary branches and number of shell of the studied rapeseed genotypes in 2015/2016 (Debrecen)

		Primary branches			Secondary branches			Number of siliquae			Winter loss (%)		
		Plant density (thousand ha^{-1})											
Sowing date	Genotype	200 t ha^{-1}	350 t ha^{-1}	500 t ha^{-1}	200 t ha^{-1}	350 t ha^{-1}	500 t ha^{-1}	200 t ha^{-1}	350 t ha^{-1}	500 t ha^{-1}	200 t ha^{-1}	350 t ha^{-1}	500 t ha^{-1}
SD1	1	14.8	10.5	9	24.5	5.3	5.3	890	450	440	12%	18%	28%
	2	15	10.5	7.8	38.8	16.8	4.3	1409	803	358	18%	27%	44%
	3	12.8	11.5	13.3	32	9	16.5	1207	529	691	11%	21%	23%
SD2	1	13.3	9.8	7.8	28.8	8.8	9	1144	536	425	13%	16%	17%
	2	10	9.3	9	12.3	10.3	4.3	620	549	421	14%	16%	18%
	3	12	11	9.5	17	13.8	6	714	733	382	14%	14%	15%
SD3	1	9.3	7	7.3	15.8	2	0	707	301	256	15%	26%	29%
	2	8.8	6.8	6.8	6	1	6.3	383	298	333	15%	30%	31%
	3	9.3	8	6.8	6.8	5.3	3	581	550	257	20%	21%	28%

Correlation analysis results of data in the crop year 2015/2016 are shown in Table 3.

Medium negative correlation was found between sowing time and the number of primary (r=-0.673) and secondary (r=-0.501) branches, just as the number of siliquae (r=-0.488). As the later sowing was done, the less number of primary and secondary branches, consequently the less number of siliquae was developed. Medium negative correlation between sowing time and seed yield (r=-0.686) explains that in the earlier sowing dates the higher seed yield could be produced. Sowing time affects plant physiological processes. Rapeseed seed yield is determined by the number of siliquae that develop on secondary branches. Sowing time affects the number of branches negatively and thus the number of siliquae, consequently seed yield as well. Strong positive correlation was found between primary and secondary branches (r=0.870), and between primary branches and the number of siliquae (r=0.863). The number of primary branches determines the number of secondary branches, that determines the number of siliquae developed per plant – this is confirmed by the strong positive correlation (r=0.979). As less loss of the studied population occurs from winter to spring, the higher number of primary (r=-0.556) and secondary (r=-0.612) branches will be developed, consequently the higher number of siliquae will be developed later. This is confirmed by the medium negative correlation that was found between all three studied parameters.

Table 3: Correlation analysis of the studied parameters (Debrecen, 2015/2016)

Parameters	Sowing date	Genotype	Plant density	Primary branches	Secondary branches	Number of iliquea	Yield	Winter loss
Sowing date	1	0	0	-0.673**	-0.501**	-0.488**	-0.686**	0.104
Genotype	0	1	1.000**	0.104	0.047	0.078	0.162	0.019
Plant density	0	1.000**	1	0.104	0.047	0.078	0.162	0.019
Primary branches	-0.673**	0.104	0.104	1	0.870**	0.863**	0.341	-0.556**
Secondary branches	-0.501**	0.047	0.047	0.870**	1	0.979**	0.298	-0.612**
Number of siliquae	-0.488**	0.078	0.078	0.863**	0.979**	1	0.317	-0.594**
Yield	-0.686**	0.162	0.162	0.341	0.298	0.317	1	0.087
Winter loss	0.104	0.019	0.019	-0.556**	-0.612**	-0.594**	0.087	1

** Correlation is significant at the 0.01 level (2-tailed).

Table 4. shows rapeseed seed yield obtained in the study. The highest seed yield was obtained in the early sowing time (5475 kg ha^{-1}). Regarding the applied sowing dates following yield results were registered: early sowing time: 5475 kg ha^{-1}, optimal sowing time: 4760 kg ha^{-1} and late sowing time: 4590 kg ha^{-1}.

Table 4: Rapeseed yield of the studied rapeseed genotypes in 2015/2016 (Debrecen)

	Sowing date								
	SD1			**SD2**			**SD3**		
Genotype	200 t ha^{-1}	350 t ha^{-1}	500 t ha^{-1}	200 t ha^{-1}	350 t ha^{-1}	500 t ha^{-1}	200 t ha^{-1}	350 t ha^{-1}	500 t ha^{-1}
1	4312	4668	5006	4196	4682	**4760**	4571	4584	4293
2	5160	5415	**5475**	4389	4485	4387	4043	3408	4104
3	4890	4912	5104	4752	4757	4696	4521	**4590**	4373

Genotype 1: Ontario, Genotype 2: Hybridrock, Genotype 3: Arkaso LSD 5%

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Conclusions

In the later sowing dates, the lower number of primary and secondary branches, thus the lower number of siliquae per plant were developed. Higher seed yield was obtained in the earlier sowing time: early sowing time: 5475 kg ha^{-1}, optimal sowing time 4760 kg ha^{-1} and late sowing time 4590 kg ha^{-1}. Sowing time had negative impact on the number of branches, number of siliquae and seed yield. With the increasing plant density the rate of losses during the winter increased as well.

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