International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:10, No:11, 2016

Inner Quality Parameters of Rapeseed (*Brassica napus*) Populations in Different Sowing Technology Models

É. Vincze

Abstract**—**Demand on plant oils has increased to an enormous extent that is due to the change of human nutrition habits on the one hand, while on the other hand to the increase of raw material demand of some industrial sectors, just as to the increase of biofuel production. Besides the determining importance of sunflower in Hungary the production area, just as in part the average yield amount of rapeseed has increased among the produced oil crops. The variety/hybrid palette has changed significantly during the past decade. The available varieties'/hybrids' palette has been extended to a significant extent. It is agreed that rapeseed production demands professionalism and local experience. Technological elements are successive; high yield amounts cannot be produced without system-based approach. The aim of the present work was to execute the complex study of one of the most critical production technology element of rapeseed production, that was sowing technology. Several sowing technology elements are studied in this research project that are the following: biological basis (the hybrid Arkaso is studied in this regard), sowing time (sowing time treatments were set so that they represent the wide period used in industrial practice: early, optimal and late sowing time) plant density (in this regard reaction of rare, optimal and too dense populations) were modelled. The multifactorial experimental system enables the single and complex evaluation of rapeseed sowing technology elements, just as their modelling using experimental result data. Yield quality and quantity have been determined as well in the present experiment, just as the interactions between these factors. The experiment was set up in four replications at the Látókép Plant Production Research Site of the University of Debrecen. Two different sowing times were sown in the first experimental year (2014), while three in the second (2015). Three different plant densities were set in both years: 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. Plant physiological measurements were executed in the populations of the Arkaso rapeseed hybrid that were: relative chlorophyll content analysis (SPAD) and leaf area index (LAI) measurement. Relative chlorophyll content (SPAD) and leaf area index (LAI) were monitored in 7 different measurement times.

Keywords —Inner quality, plant density, rapeseed, sowing time

I. Introduction

THE economic significance of oilseed rape has been greatly increasing for the last few years [1], as rapeseed oil is being produced in ever increasing amount by the bioenergetics industry and food industry. Pepó and Vincze said that the in the world the oilseed rape is the third and in Hungary the second most important cultivated oil plant after sunflower. In our country grow species of winter oilseed rape. Nowadays cultivation is between 200 and 250 thousand ha [5]. In recent years, oilseed rape production has also been initiated on farms that had not previously cultivated this plant. An appropriate nutrient supply and optimal sowing time are of especial importance in oilseed rape production [3]. Sowing performed at the optimum time and with good quality results in a yield of proper quantity and quality. Sowing time should be selected in such a way that oilseed rape could reach the 9-10 rosette leaves stage before the winter frosts [2]. The optimal selection of sowing time of oilseed rape is very important for germination, the development of homogeneous stocks and over-wintering. Risnoveanu and Buzdugan [7] found the period between 5 and 10 September as the optimal sowing time. In the studies of Sharafizadeh et al. [8] the sowing time significantly influenced the yield of oilseed rape. In Hungary only limited data are available on the nutrient supply and sowing time of oilseed rape [4]. The growth status can be controlled by the optimal seeding time and in addition plant density. According to Péti and Tihany [6] r = 0.3 to 0.45 correlation was found between sowing date and plant density.

É. Vincze is with the Institute of Crop Sciences, FAFSEM, CAAES, University of Debrecen, Hungary (e-mail: vincze.evike@gmail.com)

II. Materials and Methods

A. Experimental Settings

The experiment presented in this paper was set up on a calcareous chernozem soil in the Hajdúság region of Hungary, 15 km to the east from Debrecen at the Látókép Plant Production Research Site of the University of Debrecen. The experimental soil has favorable physical, chemical and biological traits. The soil humus content is 2.76%, its AL (ammonium-lactate)-extractable P_2O_5 content is 133 mg kg^{-1}, while its AL-extractable K_2O content is 240 mg kg^{-1}. The soil type has favorable water management. The soil, in case it is saturated up to the field water capacity, can store 578 mm water in the 0-200 cm layer, 50% of which is plant-available [5]. The experiment design was set as split-plot, plot areas were 36 m^2 in four replications. In the first experimental year, in two different sowing times (I. sowing time on 08/22/2014 and II. sowing time on 09.09.2014, which was executed again due to poor emergence seeding 1/10/2014). In the second year were an early sowing date: August 28, average: September 12, late: September 23. We harvested the experimental plots with a SAMPO plot combine harvester.

B. A Short Guide of the Annual Weather

In the crop year of 2014/2015 (1.08.2014.-30.06.2015.) altogether 491.4 mm precipitation was measured during rapeseed vegetation period that is almost the same value as the several years' average value (Table I). The precipitation in August (44.8 mm) was lower than the several years' average value (60.7 mm). Then September and October were especially wet. On the one hand it was favorable for the emergence and early development of rapeseed, while on the other hand it resulted in the filling of the experimental soil water stock which was able to ensure the water demand of rapeseed populations later in the vegetative growth and grain yield production phases of rapeseed. Monthly average temperature values were higher than the several years' average value – except for the month April.

Weather conditions of the crop year 2015/2016 can be considered as favorable from the aspect of rapeseed vegetative and generative development, just as yield production. The significant amount of precipitation in the previous August (84.0 mm, the 30-years average value is 60.7 mm) enabled the execution of soil preparation works in a good quality. The amount of precipitation in September (48.9 mm) was higher than the several years' average (38.0 mm) and temperature showed favorable development as well (17.8 ˚C, several years' average: 15.8 ˚C). These ecological conditions enabled the quick, uniform and homogenous emerging and early development of the sown rapeseed. Hard temperature drops in January did not harm rapeseed populations due to the good development, hardiness and snow cover. However, the cold and low rainfall weather conditions in the second half of April affected flowering and fertilization processes negatively. These negative weather effects could be compensated by the favorable weather in May-June that favored the development of seeds and the translocation of nutrients. Overall, favorable yield results were produced in our experiment in the crop year 2015/2016 due to the given weather conditions.

TABLE I
PRECIPITATION (MM) AND TEMPERATURE (^{O}C) VALUES IN WINTER OILSEED RAPE GROWING SEASON (DEBRECEN, 2014/2015-2015/2016)

		Months											
		VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	Total/ Average
Precipitation (mm)	2014/2015	44,8	95,7	88,6	20,8	37,9	40	18,6	10,2	21,9	52,9	60,5	491,4
	2015/2016	84	48,9	86,6	43,2	13,3	58,6	78,8	51	14,7	69,2	146,3	694,6
	30 year's average	60,7	38	30,8	45,2	43,5	37	30,2	33,5	42,4	58,8	79,5	499,6
Temperature (^{O}C)	2014/2015	19,8	16,7	11,2	6,4	2,4	1	1,5	6,2	10,1	15,8	19,9	10,1
	2015/2016	23,3	17,8	10	5,3	2,2	-2,3	5,5	6,4	12,5	15,7	20,1	10,6
	30 year's average	19,6	15,8	10,3	4,5	-0,2	-3	0,2	5	10,7	15,8	18,7	8,9

C. Examination Methods

For the statistical evaluation of the experiment we used SPSS 13.0 for Windows and Microsoft Excel 2010 software. The statistical evaluation, the bifactorial analysis of variance and correlation analysis were run according to Sváb [9], with regression equations. In the correlation analysis, we determined the following types of correlations according to the r values: r<0.4: loose, 0.4-0.7: medium, 0.7-0.9: tight, >0.9: strong.

III. RESULTS AND DISCUSSION

In the crop year 2014/2015 the effect of three different plant densities, just as two sowing times were studied on the LAI and SPAD values of Arkaso rapeseed hybrid populations.

Regarding SPAD values of the first sowing time rapeseed populations no significant difference could be detected between the three applied plant densities, except for the measurement date 28.04., when the population of 200 thousand seeds per hectare showed lower chlorophyll content (51.62) than populations of 350, just as 500 thousand seeds ha^{-1} (57.42; 57.15). After reaching maximum chlorophyll content values in case of all three plant densities on 17.04 (64.65; 63.80; 66.13) continuous decrease of SPAD values could be observed.

No significant difference could be stated between the three applied plant density treatments of the second sowing time, except for a small a slight difference that was observed also in case of the smallest plant density treatment (54.21). The decrease of the LAI values measured in the second sowing time treatments could be also observed after the measurement time 28.04., however, in a slighter extent (Fig. 1).

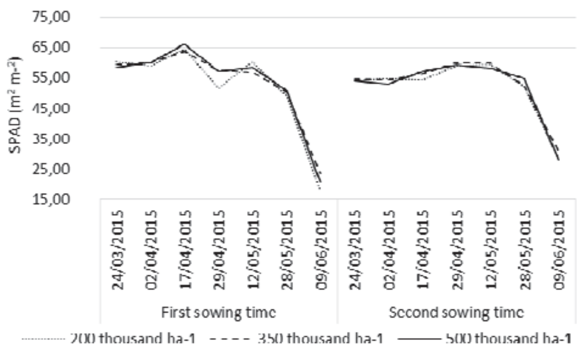

Fig. 1 The effects of sowing time and the plant density on the winter oilseed rape's chlorophyll content dynamics (Debrecen, 2015)

Regarding the measurement data of the first sowing time it can be stated that there is a linear relationship between plant number and LAI values (Fig. 2): the higher plant density was applied, the higher LAI values were measured.

Based on the results of the second sowing time this relationship could not be observed in all measurement times due to the incomplete emerging, but the highest leaf area index values were measured in case of both sowing times in case of the plant density of 500 thousand plants ha^{-1} (4.22 m^2 m^{-2}; 3.33 m^2 m^{-2}). The present experimental results proved that LAI values showed continuously decreasing tendency after reaching the maximum values on 28.05 in case of both the first and the second applied sowing times.

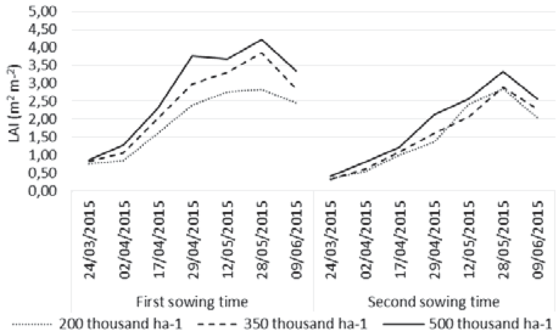

Fig. 2 The effects of sowing time and the plant density on the winter oilseed rape's LAI dynamics (Debrecen, 2015)

In the crop year 2015/2016 the effect of the application of three different plant density values, and yet three different sowing times were studied on LAI and SPAD values of populations of the hybrid Arkaso. It can be stated that in case of all three sowing times increasing chlorophyll content values were measured until the measurement time 11.04., while after that continuous decrease could be observed.

In case of the measured SPAD values of the first sowing time (Fig. 3) rapeseed populations no significant difference was found between the populations of the plant densities 350 and 500 thousand plants ha^{-1}, while the population of 200 thousand plants ha^{-1} showed lower chlorophyll content values. After the measurement time 26.04. the results of the populations with plant density 350 thousand plants ha^{-1} were similar to that of 200 thousand plants ha^{-1}. Thus, it can be stated that at the end of the vegetation the population of 500 thousand plants ha^{-1} showed the highest measured results, just like in case of the first sowing time: the highest value (67.84) was measured in case of this applied plant density.

No significant difference was found either in case of the second sowing time between the densities 350 and 500 thousand plants ha^{-1}, except for the third measurement time when we found difference (2.94) in the measured values. Higher chlorophyll content value was registered in the measurement time 26.04. in the population of the plant density 200 thousand plants ha^{-1} (60.50.) than in case of the application of the two other applied plant densities and closer to the end of the vegetation period similar decreasing values were measured.

Regarding the SPAD values registered for the third sowing time it can be stated that in case of the rapeseed populations of the densities 350 and 200 thousand plants ha^{-1} higher values were measured than in case of the of 500 thousand plants ha^{-1}, however in the period between 11.04. and 24.04. this tendency proved to be reverse.

It is clear that in case of the first and the third sowing times (Fig. 4) the highest leaf area index values were measured in case of the plant density of 500 thousand plants ha^{-1} (4.69; 4.29), while in case of the second sowing time in case of the density of 200 thousand plants ha^{-1} (4.28). The present experimental results proved that in case of both the first and the second sowing time LAI values reached the maximum on 24.05. and then showed decreasing tendency, while in case of the third sowing time maximum value was measured one measurement time earlier and then continuous decrease was observed.

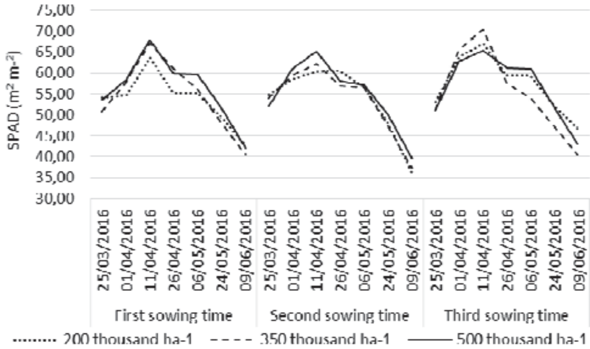

Fig. 3 The effects of sowing time and the plant density on the winter oilseed rape's chlorophyll content dynamics (Debrecen, 2016)

Based on the measurement data of the three-sowing time it can be stated that there is a linear relationship between plant number and LAI: the higher plant density is applied, the higher LAI values were measured.

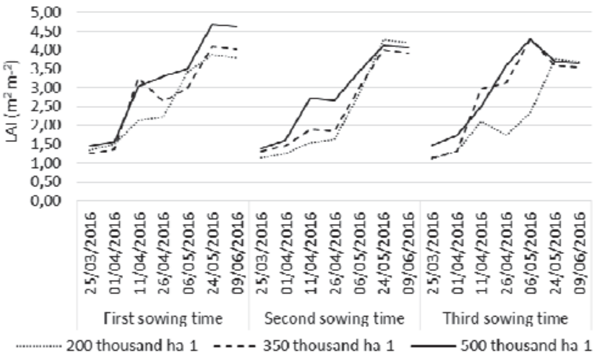

Fig. 4 The effects of sowing time and the plant density on the winter oilseed rape's LAI dynamics (Debrecen, 2016)

Correlation analysis results of the data of the crop year 2014/2015 are shown in the Table II. Strong negative (r=-0.884) relationship can be stated between sowing time and yield amounts that is confirmed by the higher harvested yield results of the first sowing time populations in contrast to those of the second sowing time. Similar medium (r=-0.662; -0.436; -0.472) and tight (r=-0.861; -0.724; -0.821; -0.751) negative correlation can be found between leaf area index and sowing time: the later sowing was executed, the lower leaf area index values were measured. This statement is valid for chlorophyll content values as well (r=-0.824; -0.784; -0.829). However, the opposite was observed in case of the last measurement time, because due to the younger population higher chlorophyll content was measured in case of the later sowing time; this relationship proved to be tight positive (r=0.735).

Strong negative correlation (r=-0.900) can be stated between sowing time and oil yield which can be explained by the relationship between sowing time and yield amounts mentioned before. The higher yield amount of the first sowing time resulted in higher oil yield than that lower yield amount of the second sowing time. In case of the application of higher plant densities higher leaf area index values were measured that is confirmed by medium positive significant relationship in four cases.

No significant relationship was stated between plant density and chlorophyll content, just as between plant density and oil yield. At the beginning of the vegetation period tight positive (r=0.820; 0.724; 0.833; 0.795) while at the end medium positive (r=0.560; 0.686; 0.497) correlation was found between yield amount and leaf area index: the higher leaf area index values were measured, the higher yield amount was realized. At the beginning of the vegetation period strong and medium positive, while at the end of it medium negative correlation was confirmed between yield amount and chlorophyll content. Strong positive (r=0.995) relationship was found between yield and oil yield: parallel to increasing yield amounts oil yields increased as well.

TABLE II
CORRELATION BETWEEN THE ANALYSED PARAMETERS (DEBRECEN, 2014/2015)

	Yield	LAI 1	LAI 2	LAI 3	LAI 4	LAI 5	LAI 6	LAI 7
Sowing time	-0,884 (**)	-0,861 (**)	-0,724 (**)	-0,821 (**)	-0,751 (**)	-0,662 (**)	-0,436 (*)	-0,472 (*)
Plant density	0,246	0,154	0,493 (*)	0,345	0,488 (*)	0,284	0,54 (**)	0,467 (*)
Yield	1	0,82 (**)	0,724 (**)	0,833 (**)	0,795 (**)	0,56 (**)	0,686 (**)	0,497 (*)
	SPAD 1	SPAD 2	SPAD 3	SPAD 4	SPAD 5	SPAD 6	SPAD 7	Oil yield
Sowing time	-0,824 (**)	-0,784 (**)	-0,829 (**)	0,529 (**)	0,088	0,401	0,735 (**)	-0,9 (**)
Plant density	-0,129	-0,042	0,163	0,306	-0,188	0,241	0,084	0,207
Yield	0,604 (**)	0,613 (**)	0,844 (**)	-0,318	-0,172	-0,21	-0,679 (**)	0,995 (**)

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Based on the results of the Pearson correlation analysis (Table III) loose positive (r=0.327) relationship can be stated between the crop year and sowing time, while the observed strong positive correlation (r=0.785) between crop year and yield amount represents the relationship between the results of the lower crop year 2015, just as the more favourable 2016. Loose positive (r=0.352) relationship between crop year and leaf area index could be observed in one measurement time, while medium positive (r=0.641; 0.614; 0.488) in three measurement times and strong positive in two times that confirms the favourable effect of crop year on leaf area size.

The relationship between crop year and chlorophyll content showed continuously increasing tendency during the vegetation development: in one measurement time medium negative (r=-0.563) correlation – that confirms the stronger determining effect of the crop year at the beginning of the vegetation – in case of one measurement time loose positive (r=0.329), once medium positive (r=0.472), just as strong positive correlation could be observed. It can be stated that the crop year affected the measured results in a positive way at the end of the vegetation period.

No significant relationship was stated between sowing time and leaf area index values, while chlorophyll content reacted to the applied 3 sowing times with a medium negative (r=-0.456) correlation in the first measurement time, while later in two measurements loose positive and in the last sampling time medium negative correlation was found. Treatments of the later sowing time showed higher chlorophyll content values in the last measurement time. No significant relationship between plant density and chlorophyll content could be confirmed, but regarding the leaf area loose positive correlation was found in four measurement times and once medium positive (r=0.538) relationship was stated.

Loose positive relationship was found in one measurement time between yield amount and leaf area index, while in three measurement times medium positive and in three times tight positive (r=0.710; 0.718; 0.780) correlations were found that confirms that higher leaf area index values are related to higher yield amounts.

TABLE III
CORRELATION BETWEEN THE ANALYSED PARAMETERS (DEBRECEN, 2014/2015; 2015/2016)

	Sowing time	Yield	LAI 1	LAI 2	LAI 3	LAI 4	LAI 5	LAI 6
Cropyear	0,327 (*)	0,758 (**)	0,7 (**)	0,641 (**)	0,614 (**)	0,084	0,352 (**)	0,488 (**)
Sowing time	1	-0,12	0,047	0,081	-0,05	-0,14	0,072	-0,17
Plant density		0,09	0,144	0,269 (*)	0,371 (**)	0,538 (**)	0,383 (**)	0,295 (*)
Yield			0,687 (**)	0,629 (**)	0,71 (**)	0,35 (**)	0,445 (**)	0,718 (**)
	LAI 7	SPAD 1	SPAD 2	SPAD 3	SPAD 4	SPAD 5	SPAD 6	SPAD 7
Cropyear	0,763 (**)	-0,56 (**)	0,329 (*)	0,472 (**)	0,212	-0,25	-0,14	0,831 (**)
Sowing time	-0,002	-0,46 (**)	0,34 (**)	0,001	0,284 (*)	0,034	0,023	0,434 (**)
Plant density	0,197	-0,17	0,07	0,179	0,245	0,107	0,085	0,011
Yield	0,78 (**)	-0,22	0,365 (**)	0,657 (**)	-0,01	-0,27 (*)	-0,09	0,491 (**)

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

IV. CONCLUSION

In the crop year 2014/2015 the effect of three different plant densities, just as of two sowing times was studied on the LAI- and SPAD-values of the rapeseed hybrid Arkaso.

Regarding the measurement data of the first sowing time it can be stated that there is a linear relationship between plant number and LAI values (Fig. 2): the higher plant density was applied, the higher LAI values were measured. In the crop year 2015/2016 the effect of the application of three different plant density values, and yet three different sowing times were studied on LAI and SPAD values of populations of the hybrid Arkaso. It can be stated that in case of all three sowing times increasing chlorophyll content values were measured until the measurement time 11.04., while after that continuous decrease could be observed. Based on the measurement data of the three-sowing time (Fig. 4) it can be stated that there is a linear relationship between plant number and LAI: the higher plant density is applied; the higher LAI values were measured.

Strong negative (r=-0.884) relationship can be stated between sowing time and yield amounts that is confirmed by the higher harvested yield results of the first sowing time populations in contrast to those of the second sowing time. Strong negative correlation (r=-0.900) can be stated between sowing time and oil yield which can be explained by the relationship between sowing time and yield amounts mentioned before. In case of the application of higher plant densities higher leaf area index values were measured. No significant relationship was stated between plant density and chlorophyll content, just as between plant density and oil yield. Strong positive (r=0.995) relationship was found between yield and oil yield: parallel to increasing yield amounts oil yields increased as well. The observed strong positive correlation (r=0.785) between crop year and yield amount represents the relationship between the results of the lower crop year 2015, just as the more favourable 2016.

It can be stated that the crop year affected the measured SPAD results in a positive way at the end of the vegetation period. No significant relationship between plant density and chlorophyll content could be confirmed. Higher leaf area index values are related to higher yield amounts.

References

[1] Amar, S. - Becker, H. C. – Möllers, C. (2008): Genetic variation and Genotype x Environment Interactions of Phytosterol Content in Three Doubled Haploid Populations of Winter Rapeseed. Crop Science, 48: 1000-1006.

[2] Izsáki, Z. – Lázár, L. (2004): Szántóföldi növények vetőmagtermesztése és kereskedelme. Mezőgazda Kiadó. Budapest, 479.

[3] Pepó, P. (2012): Kockázatok a repcetermesztésben. Agrofórum, 23, 12–20.

[4] Pepó P. (2013): Effect of nuriment supply and sowing time on the yield and pathologichal traits of winter oilseed rape. Acta Agronomica Hungarica, 61 (3), 195–205 (2013)

[5] Pepó P.-Vincze É. (2015): Fertilization and sowing time as the environmental risk factors in winter oilseed rape (Brassica napus var. napus f. biennis L.) production. Analele Universităţii din Oradea, Fascicula Protecţia Mediului, Vol. XXV, 2015, Anul 20, 61-68; ISSN 1224-6255

[6] Péti L.-né, Tihanyi F.: 1978. A repce termésátlagát befolyásoló tényezők vizsgálata regressziószámításokkal. Gazdálkodás. Gazdálkodás 1978. 22 (12), 25-28.

[7] Risnoveanu, L., Buzdugan, L. (2011): Some aspects the influence of sowing time of winter oilseed rape production in the conditions north-east Baragan. Lucrari Stiintifice, Universitatea de Stiinte Agricole Si Medicina Veterinara "Ion Ionescu de la Brad" Iasi. Seria Agronomie, 54, 163–169.

[8] Sharafizadeh, M., Gholizadeh, M. R. E., Aryannia, N., Razaz, M. (2012): Effect of planting date and planting pattern on quality and quantity of canola hybrid seed (Hayola 401). Adv. Environ. Biol., 6, 2184–2189.

[9] Sváb J. (1981) Biometriai módszerek a kutatásban. Mezőgazdasági Kiadó. 171-179.