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THE ROLE OF PHOTOSYNTHESIS IN CHOOSING OPTIMAL AGRO-TECHNICAL FACTORS OF AUTUMN CANOLA PRODUCTION

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Abstract. *We measure plant physiological parameters in Hybridrock winter oilseed rape hybrid: relative chlorophyll content (SPAD) measurements at seven different date (25.03; 01.04; 11.04; 26.04; 06.05; 24.05; 09.06.2016) in our experiment. The experiment has been set up in the University of Debrecen Látóképi Experimental Station in three different sowing times (I 28.08.2015, II. 12.09.2015and III. 23.09.2015), three different plant density 200, 350 and 500 thousand ha^{-1}, four replication of the same nutrient supply with using a line spacing of 45 cm. In the experiment the fore crop was winter wheat. The highest yield in the early sowing time was 5475 kg ha-1 (high plant density); the average sowing time was 4485 kg ha-1 (medium plant density) and the late sowing time 4104 kg ha-1 (high plant density). We concluded that the photosynthetic capacity of rape is significantly influenced by the sowing time. On the basis of the Pearson correlation analysis there was significant negative correlation between the sowing time and yield of the hybrid.*

Keywords: winter oilseed rape, yield, LAI, SPAD, PHC

1. Introduction

Oilseed rape is the third most important cultivated oil plant all over the world while second in Hungary after sunflower. Its cultivation area has been increasing since 1990; currently it varies between 200 and 250 thousand ha. Among the technological elements, the appropriate nutrient supply and the optimal sowing time are of especial importance in the oilseed rape production [2]. The optimal selection of the sowing time of oilseed rape is very important for the germination, the development of homogenous stocks and over-wintering. In their experiments, Risnoveanu and Buzdugan [4] found the interval between 5 and 10 September as the optimal sowing time. In the studies of Sharafizadeh et al. [5] the sowing time significantly influenced the yield of oilseed rape. The growth status can be controlled the optimal seeding time and in addition plant density. Péti and Tihany [3] between sowing date and plant density r = 0.3 to 0.45 correlation was found. In the domestic research, we can found only limited amounts of experimental data in connection with the nutrient supply and sowing time of oilseed rape [1].

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2. 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 of the experiment 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 Hybridrock hybrid. Three different sowing times (early sowing date: August 28, average: September 12, late: September 23.) were sown in the experimental year (2015). Three different plant densities were set in this year: 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. We harvested the experimental plots with a SAMPO plot combine harvester.

In the crop year 2015/2016 altogether 694.6 mm precipitation fell during the vegetation of rapeseed (1.08.2015. - 30.06.2016.). This amount was about one and a half times higher than the several years' average value (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 really 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 value (30.8 mm), and the monthly average temperature value (10.0 ˚C) was similar to the several years' average value (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.

Table 12) Amount of precipitation (mm) and temperature (˚C) values 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 (^{O}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

For the statistical evaluation of the experiment, we used SPSS 13.0 for Windows and Microsoft Excel 2010 programs. The statistical evaluation, the bifactorial variance analysis and correlation analysis were done according to Sváb [6], 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.

3. Results and discussion

The photosynthetic capacity (Ph.C.) is calculated by the formula bellow using the max. SPAD values, max. leaf area (LAI) values and max. yield:

$$Ph.C. = \left(\frac{Yield_{max}}{LAI_{max}} * \frac{Yield_{max}}{SPAD_{max}}\right)/1000$$

The Ph.C. calculation was done with the average of the hybrid at three sowing time and with all three plant density (Table 2.). Based on the results we concluded that the photosynthetic capacity of rape is significantly influenced by the sowing time. The early sowing time (122, 107, 103) had a significantly higher Ph.C. value than the average sowing time (87, 69, 65) and the late sowing time (77, 47, 59). Yield of the low, medium and high plant density plots was 5160 kg ha^{-1}, 5415 kg ha^{-1}, 5475 kg ha^{-1}; 4389 kg ha^{-1}, 4485 kg ha^{-1}, 4387 kg ha^{-1} and 4044 kg ha^{-1}, 3408 kg ha^{-1}, 4104 kg ha^{-1} in the early, average and late sowing date.

Table 13) Effect of sowing time and plant density on the photosynthetic capacity of rape (Debrecen, 2016)

Sowing time:	Plant density: (th ha^{-1})	Yield (kg ha^{-1}):	SPAD max:	Date: (d/m)	LAI max:	Date: (d/m)	Ph.C.:
Early	200	5160	55,24	06.05	3,95	06.05	122
(August 28.)	350	5415	63,27	06.05	4,34	06.05	107
	500	5475	63,6	04.26	4,58	04.26	103
Average	200	4389	65,63	04.26	3,37	04.26	87
(September 12.)	350	4485	67,79	04.26	4,31	04.26	69
	500	4387	60,1	04.26	4,92	04.26	65
Late	200	4044	59,5	06.05	3,57	04.26	77
(September 23.)	350	3408	62,97	04.26	3,95	04.26	47
	500	4104	63,04	04.26	4,51	04.26	59

During the correlation measurement (Table 3.), we concluded that there was tight negative correlation (r=-0,942) between the sowing time and the yield. There was tight negative correlation (r=-0,754) between the sowing time and LAI max value. The tight positive correlation (r=0,796) between the yield and LAI max value as well as the medium positive correlation (r=0,681) between the photosynthetic activity and yield confirmed that the efficiency of photosynthesis and the size of leaf area have a crucial influence on the yield of rape.

Table 14) Correlation measurement between sowing time and plant density, photosynthetic capacity and yield using the Pearson Correlation (Debrecen, 2016)

	Sowing time	Plant density	Yield	SPAD max	LAI max	Ph.C.
Sowing time	1	0	-,942**	-0,191	-,754*	-0,646
Plant density	0	1	0,078	0,047	0,372	-0,252
Yield	-,942**	0,078	1	0,173	,796*	,681*

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

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

On the basis of the Pearson correlation analysis (Table 4.) there was significant negative correlation (r=-0,849) between the sowing time and yield of the hybrid. Medium negative correlation (r=-0,602; -0,401) can be noted between 06/05, 24/05, 04.17at the measurement dates between the sowing time and leaf area index values. With one measurement date medium positive (r=0,411) and one measurement date (r=0,355) there was loose positive correlation between the sowing time and chlorophyll content values (Table 5.). With two measurement

dates (11/04, 26/04) the results showed tight positive (r=0,742, 0,782) and one measurement date (09/06) medium positive correlation (0,480). between the plant density and leaf area index values. There was medium positive correlation (r=0,626) at the measurement date of 06/05 and medium positive correlation (r=0,347) at 24/05 between the yield and the leaf area index values. Findings showed that there was medium and loose positve correlation (r=-0,411, 0,355) between the sowing time and chlorophyll content values at the first two measurement dates. Between the yield and chlorophyll content values there was medium (r=0,481) and loose (r=0,382) negative correlation at the dates of 25/03, 01/04.

Table 15) Correlation between the analyzed parameters (Debrecen, 2016)

				LAI measurement dates (2016)						
Parameters	**Sowing time**	**Plant density**	**Yield**	**25/03**	**01/04**	**11/04**	**26/04**	**06/05**	**24/05**	**09/06**
Sowing time	1	0	-,849**	-0,114	-0,095	-0,082	0,004	-0,602**	-,401*	-0,082
Plant density	0	1	0,07	0,236	0,241	,742**	,782**	0,3	0,269	,480**
Yield	-0,849**	0,07	1	0,109	0,085	0,046	-0,041	0,626**	0,347*	0,098

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

Table 16) Correlation between the analyzed parameters (Debrecen, 2016)

				SPAD measurement dates (2016)						
Parameters	**Sowing time**	**Plant density**	**Yield**	**25/03**	**01/04**	**11/04**	**26/04**	**06/05**	**24/05**	**09/06**
Sowing time	1	0	-,849**	,411*	,355*	0,132	-0,024	0,094	0,076	0,028
Plant density	0	1	0,07	0,152	0,158	0,222	0,233	0,151	0,194	-0,097
Yield	-,849**	0,07	1	-,481**	-,382*	-0,108	0,008	-0,129	-0,117	-0,007

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

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

Conclusions

Based on the results we concluded that the photosynthetic capacity of rape is significantly influenced by the sowing time. The early sowing time had a significantly higher Ph.C. value than the average sowing time and the late sowing time. Yield of the low, medium and high plant density plots was 5160 kg ha^{-1}, 5415 kg ha^{-1}, 5475 kg ha^{-1}; 4389 kg ha^{-1}, 4485 kg ha^{-1}, 4387 kg ha^{-1} and 4044 kg ha^{-1}, 3408 kg ha^{-1}, 4104 kg ha^{-1} in the early, average and late sowing date.During the correlation measurement, we concluded that there was tight negative correlation between the sowing time and the yield as well as between the sowing time and LAI max value. The tight positive correlation between the yield and LAI max value as well as the medium positive correlation between the photosynthetic

activity and yield confirmed that the efficiency of photosynthesis and the size of leaf area have a crucial influence on the yield of rape. On the basis of the Pearson correlation analysis there was significant negative correlation (r=-0,849) between the sowing time and yield of the hybrid. Medium negative correlation can be noted between the sowing time and leaf area index values. Medium positive and loose positive correlation was between the sowing time and chlorophyll content values. The results showed tight positive and medium positive correlation between the plant density and leaf area index values. There was medium positive correlation and medium positive correlation between the yield and the leaf area index values. Findings showed that there was medium and loose positve correlation between the sowing time and chlorophyll content values. Between the yield and chlorophyll content values there was medium and loose negative correlation.

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