FERTILIZATION AND SOWING TIME AS THE ENVIRONMENTAL RISK FACTORS IN WINTER OILSEED RAPE (*Brassica napus* var. napus f. biennis L.) PRODUCTION

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Abstract

We have investigated the fertilizer response of oilseed rape on the chernozem soil in Eastern Hungary. Our research results proved that oilseed rape is has high fertilizer (N+PK) demand. In the experiments, N = 210 kg ha^{-1} +PK proved to be the optimal fertilizer dose. The yield increasing effect of fertilization was 800 to 1300 kg ha^{-1}, depending on the cropyear. The maximum yield (5000 kg ha^{-1}) was obtained in the cropyear of the less infection. The results of our studies confirmed that the hybrid rape was of excellent adaptivity to the sowing time; due to this fact, the yield decrease was minimal (0-270 kg ha^{-1}) in the middle September sowing time compared to the late August one. According to the results of the Pearson's correlation analysis, strong correlation (0.6-0.9**) was found between the spring precipitation and temperature and the most important diseases (Sclerotinia, Alternaria, Peronospora, Phoma) of oilseed rape. The sowing time had more significant effect on the LAI oilseed rape and moderated effect on the relative chlorophyll content (SPAD).*

Key words: oilseed rape, fertilization, sowing time, yield, diseases, LAI, SPAD

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.

Oilseed rape is a field crop that needs large and harmonic NPK supply (*Kádár* and *Márton* 2007, *Pospišil* et al. 2008). The optimal NPK dose was significantly influenced by the soil traits (*Máthé-Gáspár* et al. 2007, *Máthé-Gáspár* et al. 2008). According to the differences of the genotype and the agro-ecological factors, *Gulzar Ahmad* et al. (2011) found N = 120 kg ha^{-1}, while *Boelcke* et al. (1991) N = 240 kg ha^{-1} fertilizer doses as the most favourable ones for the yield of oilseed rape. In their experiment not only the yield maximum was realised but the yield stability was also the most favourable. *Rathke* et al. (2006) emphasized the importance of numerous factors (crop rotation, fertilizer doses, fertilizer splitting, genotype) in the N utilization of oilseed rape.

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* (2011) found the interval between 5 and 10 September as the optimal sowing time.

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 (*Pepó* 2012).

MATERIAL AND METHOD

Our experiments were setup on calcareous chernozem soil in the Hajdúság, 15 km from Debrecen. The soil of the experiment is characterized by favourable physical, chemical and biological traits. The humus content of the calcareous chernozem soil of the experiment is 2.76%, its AL soluble P_2O_5 value is 133 mg kg^{-1}, its AL soluble K_2O value is 240 mg kg^{-1}. The soil has favourable water management traits. 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 applied fertilizer doses and N splitting are listed in *Table 1*.

Table 1.

The fertilizer doses in the long-term experiment (Debrecen, 2010-2012 years)

Fertilizer treatments	N kg ha^{-1}				P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	Note
	autumn	end of winter	spring	total			
1	0	0	0	0	48	108	
2	40	60	40	140	48	108	
3	40	100	70	210	48	108	
4	40	100	70	210	48	108	sulfur+foliar fertilizer

The experiment design was set as split-plot, in four replicates. Plot areas were 36 m^2.

RESULTS AND DISSCUSIONS

During the three-year-long experiment, we have investigated the most important leaf, stalk and pod diseases of oilseed rape (*Table 2*). The precipitation amount during the most important spring period (April-May-June) in terms of the appearance of diseases, significantly influenced the infection. Especially the differences between the values of Sclerotinia infection were considerable among the cropyears. During the spring of 2010, the Sclerotinia infection varied between 3.0 and 11.0%, between 0.2 and 0.8% in 2011, while between 1.1 and 2.1% in 2012, respectively. The

Sclerotinia infection was closely related to the precipitation fell in April, May and June. The highest Sclerotinia infection rate was measured in 2010 (302.2 mm precipitation in April, May and June), while that was significantly lower in 2012 (184.3 mm) and 2011 (89.9 mm). In the case of the most important leaf diseases, similar tendencies were found, but the differences among the cropyears were not that pronounced. The Peronospora infection varied between 11 and 26% in 2010, between 9 and 15% in 2011 and between 11 and 22% in 2012, respectively. The values of the Phoma infection were as follows: 2010: 10-24%, 2011: 5-11%, 2012: 9-19%. The most important pod disease, the Alternaria infection was the highest in the rainy spring of 2010 (10-21%), while the lowest in the dry 2011 (3-6%). In 2012, it varied between 5 and 14%.

Table 2.

Effect of fertilizer and sowing time on the diseases of oilseed rape
(Debrecen, chernozem soil, 2010-2012 years)

Sowing time / Fertilization treatments	2009/2010				2010/2011				2011/2012			
	Sclerotinia	Alternaria	Peronospora	Phoma	Sclerotinia	Alternaria	Peronospora	Phoma	Sclerotinia	Alternaria	Peronospora	Phoma
Sowing in August												
1	3.0	10	16	11	0.2	5	11	8	1.1	7	12	11
2	8.0	16	22	20	0.5	5	13	9	1.4	8	15	13
3	10.0	19	25	23	0.4	6	15	9	1.4	12	18	15
4	11.0	21	26	24	0.6	6	15	11	2.2	14	22	19
Sowing in September	-											
1	5.0	10	11	10	0.5	4	9	5	1.4	5	11	9
2	8.0	14	20	16	0.7	3	10	5	1.4	8	14	12
3	9.0	17	23	19	0.8	5	10	7	1.9	10	17	17
4	9.0	18	22	21	0.3	5	12	8	2.1	10	21	18
$LSD_{5\%}$	2.0	4	6	5	0.2	2	2	2	0.4	3	4	4

As an effect of the increasing fertilizer doses, the infection values of the diseases significantly increased, while between the sowing times of August and September, there were no significant differences between the infection values.

The results of our traditional, non-long-term experiments confirmed the favourable natural nutrient fertility of the chernozem soil. In the case of appropriate phosphorus and potassium supply (P_2O_5 = 48 kg ha^{-1} and K_2O = 108 kg ha^{-1}), the yield of oilseed rape varied between 3010 and 3102 kg ha^{-1} in 2010, between 4157 and 4218 kg ha^{-1} in 2011, while between 3139 and 3722 kg ha^{-1} in 2012, respectively, without nitrogen fertilizer, depending on sowing time (*Table 3*). The sowing time did not effect yields significantly in

2010 and 2011, but we did not found significant differences in the case of all fertilizer levels in 2012 between the sowing times. In a traditional experiment, the maximum yield surplus achieved by N fertilization was 1300 kg ha^{-1} in 2010, 800 kg ha^{-1} in 2011, and 1000 kg ha^{-1} in 2012, respectively. The maximum yields were obtained in August sowing time during all three years (2010: 4390 kg ha^{-1}, 2011: 4950 kg ha^{-1}, 2012: 4311 kg ha^{-1}). According to the results of our experiments, although the increasing fertilizer doses increased the infection of different diseases, the higher N doses resulted in higher yields.

Table 3.

Effect of fertilization and sowing time on the yields of oilseed rape
(Debrecen, chernozem soil, 2010-2012 years)

Sowing time / Fertilization treatments	2009/2010		2010/2011		2011/2012	
	Yield kg ha^{-1}	Yield surplus kg ha^{-1}	Yield kg ha^{-1}	Yield surplus kg ha^{-1}	Yield kg ha^{-1}	Yield surplus kg ha^{-1}
Sowing in August	3102	0	4157	0	3722	0
1	3932	830	4714	557	4181	459
2	4361	1259	4950	793	4311	589
3	4390	1288	4796	639	4140	418
4						
Sowing in September	3010	0	4218	0	3139	0
1	3709	699	42642	424	3875	736
2	4241	1231	4996	778	4042	903
3	4273	1263	4654	436	4111	972
4						
$LSD_{5\%}$	516	-	508	-	547	-

The data of the Pearson's correlation analysis (*Tables 4* and *5*) confirmed that due to the favourable nutrient management features of the chernozem soil, medium and tight correlation was detected between the fertilization and the yield of oilseed rape both in the case of the August (0.609*) and September sowings (0.602*). Among the meteorological factors, the yields were primarily negatively influenced by the temperature of March-June (-0.638* and -0.683*, respectively), i.e. lower yield belonged to the higher temperature. We have found unambiguous and tight correlation between the weather factors and oilseed rape diseases. Especially tight, positive correlation was detected between the precipitation and temperature of the spring months (March-June) and the infection values measured at both sowing times (August and September). The correlation coefficient values varied between 0.638* and 0.943* in the case of Sclerotinia, between 0.761** and 0.889** in the case of Alternaria, between

0.652* and 0.742** in the case of Peronospora, while between 0.701* and 0.797** in the case of Phoma infection with the March-June precipitation and March-June temperature values.

Table 4.

Evaluation of meteorological parameters, yield and infections of diseases by Pearson correlation analyses in winter rape
(Debrecen, sowing time in August, chernozem soil, 2010-2012 years)

	Fertilization	Rainfall in Aug.-Febr.	Mean temp. in Aug.-Febr.	Rainfall in March-June	Mean temp. in March-June	Rainfall in Aug.-June	Mean temp. in Aug.-June
Fertilization	1	0.000	0.000	0.000	0.000	0.000	0.000
Yield	0.609*	0.276	-0.450	-0.546	-0.638*	-0.215	-0.631*
Sclerotinia	0.281	0.244	0.884**	0.871**	0.649*	0.777**	0.743**
Alternaria	0.451	-0.30	0.780**	0.831**	0.761**	0.575	0.810**
Peronospora	0.614*	0.025	0.709**	0.742**	0.652*	0.546	0.704*
Phoma	0.528	-0.098	0.687*	0.750**	0.725**	0.474	0.759**

Table 5.

Evaluation of meteorological parameters, yield and infections of diseases by Pearson correlation analyses in winter rape
(Debrecen, sowing time in September, chernozem soil, 2010-2012 years)

	Fertilization	Rainfall in Aug.-Febr.	Mean temp. in Aug.-Febr.	Rainfall in March-June	Mean temp. in March-June	Rainfall in Aug.-June	Mean temp. in Aug.-June
Fertilization	1	0.000	0.000	0.000	0.000	0.000	0.000
Yield	0.602*	0.479	-0.379	-0.508	-0.683*	-0.044	-0.651*
Sclerotinia	0.171	0.150	0.953**	0.943**	0.710**	0.795**	0.810**
Alternaria	0.376	-0.074	0.847**	0.889**	0.785**	0.602*	0.846**
Peronospora	0.576	-0.257	0.590*	0.670*	0.700*	0.316	0.715**
Phoma	0.539	-0.388	0.589*	0.701*	0.797**	0.249	0.794**

Our scientific results of 2014/2015 cropyear proved that the sowing time influenced the LAI values and their dynamics in spring time. Early sowing time (August) had quicker leaf surface development comparing with the sowing time of October. The LAI values were 1.05 m^2 m^{-2} and 0.60 m^2 m^{-2} in 02 April measuring time, respectively (*Table 6*). These differences remained until early June (in 09 June the LAI values were 2.85 m^2 m^{-2} and 2.28 m^2 m^{-2}, respectively). The maximum LAI (LAI_{max}) values were obtained in late May (in 28 May the LAI_{max} values were 3.85 m^2 m^{-2} and 2.88 m^2 m^{-2}, respectively). The higher LAI values and better LAI dynamics resulted bigger yield in early (August) sowing time. The yields of oilseed rape were 4590 kg ha^{-1} in August sowing time and 3954 kg ha^{-1} in October sowing time, respectively.

Table 6.

Effect of sowing time on the leaf area index (LAI) and yield of winter oilseed rape
(Debrecen, 2015)

Dates	Sowing time (22.08. 2014)	Sowing time (01.10. 2014)
	m^2 m^{-2}	
24.03. 2015	0.82	0.32
02.04. 2015	1.05	0.60
17.04. 2015	2.03	1.08
29.04. 2015	2.98	1.59
12.05. 2015	3.30	2.06
28.05. 2015	3.85	2.88
09.06. 2015	2.85	2.28
Yield (kg ha^{-1})	4590	3954

The photosynthetic capacity of oilseed rape is determined by surface of leaves (LAI) and its dynamics and the chlorophyll content and its dynamics, too. The results of relative chlorophyll contents (SPAD value) were very stable during the spring and early summer of 2015 year in both sowing time (*Table 7*). The SPAD values varied between 50.4-63.8 in March-April-May. The relative chlorophyll content dropped down in the early maturity phenophase. The SPAD values were 23.6 (August sowing time) and 30.9 (October sowing time) in 09 June measurement time, respectively.

Table 7.

Effect of sowing time on the relative chlorophyll content (SPAD) and yield of winter oilseed rape
(Debrecen, 2015)

Dates	Sowing time (22.08. 2014)	Sowing time (01.10. 2014)
	m^2 m^{-2}	
24.03. 2015	59.4	54.6
02.04. 2015	60.0	54.2
17.04. 2015	63.8	56.4
29.04. 2015	57.4	60.1
12.05. 2015	56.9	59.8
28.05. 2015	50.4	52.4
09.06. 2015	23.6	30.9
Yield (kg ha^{-1})	4590	3954

CONCLUSIONS

Our oilseed rape experiments conducted on chernozem soil in different cropyears confirmed that the cropyear influenced the yield of oilseed rape due to the autumn germination and stock settlement and the differences between the infection of the diseases occurring during spring. Our experimental results confirmed that the infection of leaf, stalk and pod diseases were determined by the weather of the spring period (April-May-

June) and the amount of precipitation. In the case of the rainy spring weather (302 mm precipitation in April-May-June), the Sclerotinia infection was especially high (3.0-11.0%). As an effect of the lower precipitation in spring, in 2012 (184 mm) we have found the varied between Sclerotinia infection 1.1-2.1%, while in 2011 (90 mm) 0.2-0.8%, respectively. Same tendencies but lesser differences were found in the cases of the Peronospora, Phoma and Alternaria infections. The increasing N fertilizer doses significantly, while the sowing time (lower infection in the August sowing) non-significantly influenced the infection values of oilseed rape.

The most favourable yields were achieved in 2011, the year of the lower infections. The maximum yield was obtained in the case of the N = 210 kg ha^{-1} +PK treatment (5000 kg ha^{-1}).

Although in each year, comparing the late August and middle September sowing times, the August one was more favourable, the yield decreasement was only minimal in the middle September one (0-270 kg ha^{-1} depending on the cropyear). While in the experiments of *Risnoveanu* and *Buzdugen* (2011), the optimal sowing time interval was relatively narrow (5 to 10 September), in our studies we obtained comparatively broad optimum sowing time interval (25 August-15 September).

The results of the Pearson's correlation analyses confirmed that the correlation between fertilization and the yield of oilseed rape was medium (0.6*). The weather factors, especially the precipitation and temperature of the spring-early summer months (March-June) were in strong positive correlation (0.6*-0.9**) with the Sclerotinia, Alternaria, Peronospora and Phoma infections.

Our scientific results proved that the sowing time modified the leaf area index (LAI) and its dynamics relative chlorophyll content (SPAD) values. The higher LAI values resulted higher yields in the early (August) sowing time (4590 kg ha^{-1}) comparing with the late (October) sowing time (3954 kg ha^{-1}).

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