EFFECTS OF THE NUTRIENT SUPPLY AND SOWING TIME ON THE YIELD AND THE PHYTOPATHOLOGICAL TRAITS OF WINTER OILSEED RAPE (*BRASSICA NAPUS* VAR. NAPUS F. BIENNIS L.) ON CHERNOZEM SOIL

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Abstract: We have studied the fertilizer response of oilseed rape on the chernozem soil in Eastern Hungary in a three-year experiment (years of 2009/2010, 2010/2011, 2011/2012) in two sowing times (end of August, middle of September). Our research results proved that oilseed rape 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 excellent natural nutrient providing ability of chernozem soil was confirmed by the high yield level (3000-4200 kg ha^{-1}) of the control treatment (N = 0 kg ha^{-1} +PK). According to our studies, as an effect of the increasing N doses, the specific fertilization yield surplus of oilseed rape declined (from 19-27 kg/1 kg NPK to 11-12 kg/1 kg NPK). On the other hand, fertilization improved the water utilization efficiency (WUE) of oilseed rape in the experimental years (from 4-8 kg/1 mm precipitation + irrigation water to 11-14 kg/1 mm precipitation + irrigation water). The results of our studies confirmed that the hybrid rape had of excellent adaptation 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.

Keywords: oilseed rape, fertilization, sowing time, yield, diseases

Introduction

The demand for vegetable oils has been constantly growing both in the world and in Hungary during the last decades. This was partially the consequence of the growing demand of population for food and partially for the broadening usage of vegetable oils by the industry. A new kind of demand is the production of biodiesel among the renewable energy sources; its most important base material is currently rape oil. 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. During the past years, oilseed rape production appeared also on such areas, in farms, which previously have not cultivated this plant. In the past years, the Hungarian variety/hybrid portfolio significantly changed; nowadays new types of hybrids (e.g. semidwarf, IMI, etc.) appeared, whose production technological demands considerably differ from the agrotechnical needs of the older genotypes. 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. According to the studies of *Sieling* and *Christen* (1997), the increase of the N doses from 80 kg ha^{-1} to 200 kg ha^{-1} increased the yield from 3.21 t ha^{-1} to 3.84 t ha^{-1}. They have found that the distribution of the N doses did not affect the yield amount

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of oilseed rape. In their studies summarizing the results of several experiments, *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, *Risnoreanu* and *Buzdugan* (2011) found the interval between 5 and 10 September as the optimal sowing time. In the studies of *Sharafizadeh* et al. (2012), the sowing time significantly influenced the yield of oilseed rape.

In Hungarian research, we can found only limited amounts of experimental data in connection with the nutrient supply and sowing time of oilseed rape (*Pepó* 2012). Results of pathology studies are almost entirely missing; therefore, we started a research project investigating the individual effects of fertilization and sowing time and their interactions in winter oilseed rape in three different cropyears.

Materials and methods

Our experiments were setup on calcareous chernozem soil in the Hajdúság, 15 km from Debrecen, in three different cropyears (2009/2010; 2010/2011; 2011/2012). 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 disponable water.

In the experimental years, the fore-crop was winter wheat. Soil preparation was conducted by disc, mulch tiller (loosening) and germinator. In the experimental years, weed control, regulator and insecticide use were done uniformly. In the experimental years, protection against diseases was performed at the beginning of flowering (200.0 g l^{-1} boscalid + 200.0 g l^{-1} dimoxistrobin [0.5 l ha^{-1}]). Before harvest, we made pod sticking and stock desiccation. Harvest was performed at the end of June-beginning of July, depending on the cropyear.

We applied traditional row distance (24 cm) for the sowing of the experiment. The hybrid used in the experiment was Rohan, which we sowed with germ number of 350 thousand per hectare. During the experiment, we applied two sowing dates (August and September):

Cropyear of 2009/2010
26/08/2009 and 10/09/2009

Cropyear of 2010/2011
27/08/2010 and 14/09/2010

Cropyear of 2011/2012
25/08/2011 and 14/09/2011

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

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The phosphorus and potassium doses during the tillage works were applied by 0:8:18 complex fertilizer. The application of nitrogen was conducted in the form of NH_4NO_3.

During the vegetation period of winter rape we determined the infections of Peronospora (*Peronospora parasitica*) and Phoma (*Leptophaeria maculans*, anamorph: *Phoma lingam*) as the leaf diseases. We detected the infected leaf area (%) on 15-15 crops in each plots. The stalk disease was Sclerotinia (*Sclerotinia sclerotiorum*). If the infection area of stem by Sclerotinia was over 20% we stated as an infected plant (15-15 plants plot^{-1}). The pod disease was Alternaria (*Leptoshaeria napi*, amorf: *Alternaria brassicae*). If the infected number of pods was over 20% we took as an infected plant (15-15 plant plot^{-1}). All phytosamitary measurement were carried out in four replications.

The experiment design originally was split-split-plot. The factors of experiment were: fertilization (4 treatments), sowing time (2 treatments) and plant density (3 treatments). We publish the results of plant density of 350 thousand ha^{-1} (the others were 200 thousand ha^{-1} and 500 thousand ha^{-1}). We used four replicates. The main plots (fertilization) were 216 m^2, the sub-plots (sowing time) were 108 m^2 and the sub-sub-plots (plant density) were 36 m^2. So we used the two-factor variance analysis and correlation analysis by Pearson for statistical analysis our experimental data (split-plot experiment design). During the evaluation of experimental treatments, we have used the yields per 1 kg NPK active ingredient and 1 mm precipitation + irrigation water (WUE = Water Use Efficiency).

For the characterization of the weather of the experimental years, we list the monthly precipitation and temperature data of the whole vegetation period (August to June) in *Tables 2* and *3*. The weather of the experimental years significantly differed from each other. These differences were especially pronounced in the case of the weather conditions at the end of summer-autumn.

There were also differences between the weather of the spring and early summer months. We demonstrate the effects of the meteorological factors in the experimental results section in details. In the case of oilseed rape, the basic criteria of the comparability of the experiments are the adequate plant number and stock homogeneity. In favour of achieving these, we performed irrigation in the years of unfavourable late summer-autumn weather by linear irrigation equipment providing precise

Table 2. Monthly precipitation in the vegetation period of rape (mm) (Debrecen, 2010-2012 years)

Years	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Febr.	March	Apr.	May	June
2009/2010	11.3	21.7	79.3	78.3	54.9	48.8	58.6	14.4	89.9	111.4	100.9
2010/2011	98.3	98.4	22.8	52.9	104.2	19.2	16.8	35.1	15.6	52.3	22.0
2011/2012	42.7	6.2	18.1	0	71.1	28.0	17.8	1.4	20.7	71.9	91.7
Average of 30 years	60.7	38.0	30.8	45.2	43.5	37.0	30.2	33.5	42.4	58.8	79.5

Table 3. Monthly average temperature in the vegetation period of rape (^{o}C) (Debrecen, 2010-2012 years)

Years	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Febr.	March	Apr.	May	June
2009/2010	22.6	18.9	11.4	7.6	2.3	-1.1	0.5	7.6	11.6	16.6	19.7
2010/2011	19.0	14.1	6.9	7.7	-1.7	-1.2	-2.5	5.0	12.2	16.4	20.8
2011/2012	21.4	18.0	8.6	0.6	1.5	-0.6	-5.7	6.3	11.7	16.4	20.9
Average of 30 years	19.6	15.8	10.3	4.5	-0.2	-2.6	0.2	5.0	10.7	15.8	18.7

Table 4. Irrigation system in the vegetation period of oilseed rape (Debrecen, 2010-2012 years)

Years	Planting in August (irrigation time and water, mm)	Planting in September (irrigation time and water, mm)
2009/2010	31/08/2009 – 20 mm 25/09/2009 – 20 mm	25/09/2009 – 20 mm
2010/2011	-	-
2011/2012	24/08/2011 – 25 mm 31/08/2011 – 15 mm 02/09/2011 – 15 mm 14/09/2011 – 15 mm	14/09/2011 – 15 mm 21/09/2011 – 20 mm 28/09/2011 – 20 mm

water application. The irrigation system of the different experimental years are listed in *Table 4*.

The experimental years were significantly different considering the weather at the end of summer-autumn. The August and September of the 2009/2010 cropyear were dry (11.3 mm and 21.7 mm), which made the application of the 40 mm and 20 mm irrigation water reasonable. From October, a favourable rainy weather began to take place, which was proved by the precipitation of the autumn-winter months (August-February, 352.9 mm) that exceeded the 30-year average (285.4 mm). This rainy weather persisted during the spring and early summer (March-June) of 2010 (316.6 mm precipitation, compared to the multi-year average of 214.2 mm).

The weather of the cropyear of 2010/2011 was completely different. Due to the late summer-autumn precipitation of favourable amount and distribution (412.6 mm rainfall in August-February, exceeding the multi-year average by 127.2 mm), there was no need for irrigation. Although the precipitation of the spring-early summer months (125.8 mm between March and June, 88.4 mm below the multi-year average) was low, the autumn and winter precipitation stored in the chernozem soil provided adequate water reservoire for the development and crop formation of the rape stocks.

The highest water shortage of late summer-winter took place in the cropyear of 2011/2012. The precipitation fell between August and February (183.9 mm) was 101.5 mm lower than the multi-year average. In favour of the appropriate development of plant stocks in autumn, we have to apply a sum of 70 mm irrigation water (in four occasions) in the August sowing, while a total of 55 mm in three occasions in the September sowing. The precipitation of the spring-early summer months (March-June, 185.7 mm) was close to the multi-year average of 214.2 mm. The water supply was especially favourable in May (71.9 mm) and June (91.7 mm) favouring for pod development and seed filling.

The aim of our experiments was to determine the influence of increasing N fertilizer doses and different sowing times on the pathological traits and yield of oilseed rape in different cropyears.

Results

During the three-year-long experiment, we have investigated the most important leaf, stalk and pod diseases of oilseed rape (*Table 5*). 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

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Table 5. Effect of fertilizer and sowing time on the diseases of oilseed rape
(Debrecen, chernozem soil, 2010-2012 years)

Treatments Fertilizers (A) Sowing time (B)	2009/2010				2010/2011				2011/2012			
	Sclerotinia	Alternaria	Peronospora	Phoma	Sclerotinia	Alternaria	Peronospora	Phoma	Sclerotinia	Alternaria	Peronospora	Phoma
	infection%											
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
$LSD_{5\%}$ (A)	**1.2**	**2**	**2**	**1**	**0.1**	**1**	**1**	**1**	**0.2**	**2**	**1**	**2**
$LSD_{5\%}$ (B)	**0.9**	**1**	**3**	**2**	**0.1**	**1**	**1**	**1**	**0.1**	**1**	**2**	**1**
$LSD_{5\%}$ (AxB)	**2.0**	**4**	**6**	**5**	**0.2**	**2**	**2**	**2**	**0.4**	**3**	**4**	**4**

(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%.

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 6*). 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. The application of nitrogen fertilizer increased yield up to the dose of N = 210 kg ha^{-1} +PK. The adequate sulphur content (favourable humus content) and sulphur providing ability of the chernozem soil was confirmed by the fact that there were no significant differences between N = 210 kg ha^{-1} +PK (3rd treatment) and N = 210 kg ha^{-1} +PK+sulphur (4th treatment). 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

Table 6. Effect of fertilization and sowing time on the yields of oilseed rape (Debrecen, chernozem soil, 2010-2012 years)

Treatments Fertilizers (A) Sowing time (B)	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						
1	3102	0	4157	0	3722	0
2	3932	830	4714	557	4181	459
3	4361	1259	4950	793	4311	589
4	4390	1288	4796	639	4140	418
Sowing in September						
1	3010	0	4218	0	3139	0
2	3709	699	42642	424	3875	736
3	4241	1231	4996	778	4042	903
4	4273	1263	4654	436	4111	972
$LSD_{5\%}$ (A)	**210**	**-**	**196**	**-**	**154**	**-**
$LSD_{5\%}$ (B)	**168**	**-**	**243**	**-**	**268**	**-**
$LSD_{5\%}$ (C)	**516**	**-**	**508**	**-**	**547**	**-**

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}). The difference between the two sowing times was the lowest in 2011, the most favourable cropyear for the vegetative and generative development of oilseed rape (46 kg ha^{-1}), but slight differences were found in 2010 (117 kg ha^{-1}) and 2012 (269 kg ha^{-1}) too. This confirmed that in the case of the applied oilseed rape hybrid, the optimal sowing interval is very wide (from the end of August to the middle of September). 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. In 2011, when the leaf, stalk and pod infections were the lowest, we have achieved the highest yield (~5000 kg ha^{-1}) among the three studied cropyears.

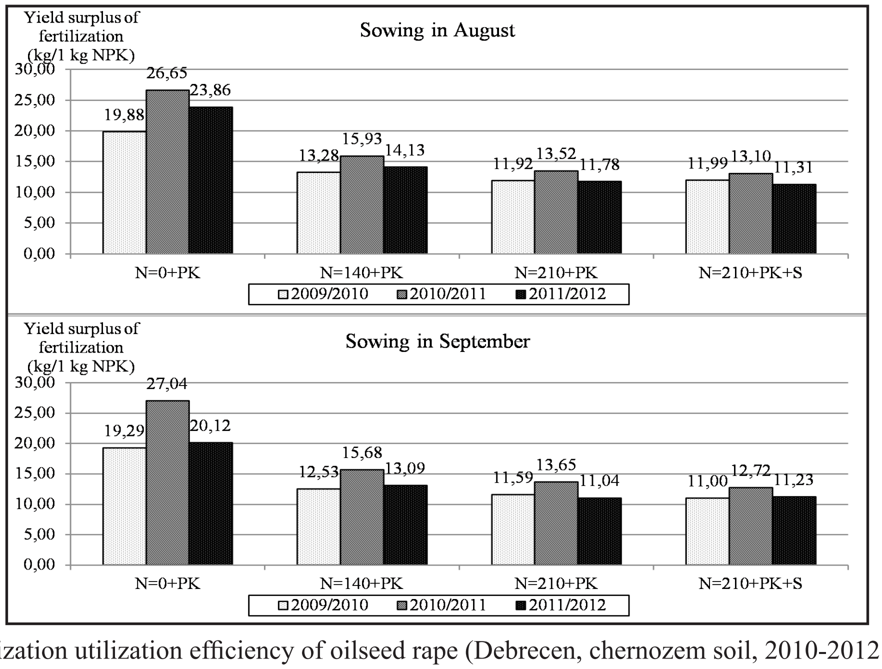

Figure 1. Fertilization utilization efficiency of oilseed rape (Debrecen, chernozem soil, 2010-2012 years)

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In the experiment, we characterized the efficiency of fertilization by yield per 1 kg NPK fertilizer (*Figure 1*). Our research results confirmed that the increasing N doses resulted in decreasing efficiency. In the case of the control (1st treatment, N = 0 kg ha^{-1}) 19.29-27.40 kg/1 kg NPK, while in the case of the highest N dose (3rd treatment, N = 210 kg ha^{-1}) 11.04-13.65 kg/1 kg NPK was the efficiency of fertilization despite the yield maximums were achieved in the case of the latter treatment (N = 210 kg ha^{-1}) in both sowing times, all three experimental years.

We have experienced considerable difference between the cropyears in terms of water utilization (*Figure 2*). During the calculation of water utilization, the precipitation fell during the vegetation period and the amount of applied irrigation water during the given sowing time were considered jointly. The worst water utilization was found in the year of the highest precipitation and infection (2010, 4.37-6.20 kg/1 mm precipitation + irrigation water, respectively). There were no significant differences found between the water utilization values of 2011 and 2012 (2011: 7.72-9.28 kg, 2012: 7.39-9.81 kg/1 mm precipitation + irrigation water). We have not found significant difference between the two sowing times in terms of water utilization. As an effect of the increasing N doses, the water utilization of oilseed rape improved.

The data of the Pearson's correlation analysis (*Tables 7* and *8*) 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*

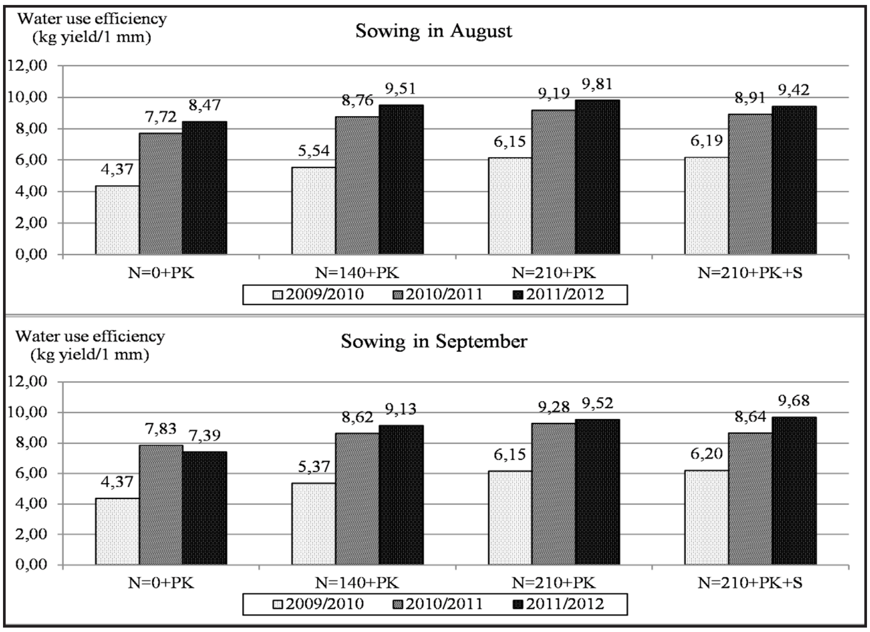

Figure 2. Effect of fertilization and sowing time on the water use efficiency of oilseed rape (Debrecen, chernozem soil, 2010-2012 years)

Table 7. 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^{NS}	-0.450^{NS}	-0.546^{NS}	-0.638*	-0.215^{NS}	-0.631*
Sclerotinia	0.281^{NS}	0.244^{NS}	0.884**	0.871**	0.649*	0.777**	0.743**
Alternaria	0.451^{NS}	-0.30^{NS}	0.780**	0.831**	0.761**	0.575^{NS}	0.810**
Peronospora	0.614*	0.025^{NS}	0.709**	0.742**	0.652*	0.546^{NS}	0.704*
Phoma	0.528^{NS}	-0.098^{NS}	0.687*	0.750**	0.725**	0.474^{NS}	0.759**

**Correlation on LSD1% level; Correlation on LSD5% level; ^{NS} Non significant

Table 8. 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^{NS}	-0.379	-0.508^{NS}	-0.683*	-0.044^{NS}	-0.651*
Sclerotinia	0.171^{NS}	0.150^{NS}	0.953**	0.943**	0.710**	0.795**	0.810**
Alternaria	0.376^{NS}	-0.074^{NS}	0.847**	0.889**	0.785**	0.602*	0.846**
Peronospora	0.576^{NS}	-0.257	0.590*	0.670*	0.700*	0.316^{NS}	0.715**
Phoma	0.539^{NS}	-0.388	0.589*	0.701*	0.797**	0.249^{NS}	0.794**

**Correlation on LSD1% level; Correlation on LSD5% level; ^{NS} Non significant

and 0.797** in the case of Phoma infection with the March-June precipitation and March-June temperature values.

Discussion

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. The unfavourable effects of the dry late summer-autumn weather were compensated by irrigation during the autumn periods of the 2009/2010 and 2011/2012 cropyears. Therefore, in all three experimental years, complete, homogenous stocks developed making the precise comparison and evaluation of the experimental results possible.

Due to the favourable autumn weather of the 2010/2011 cropyear, no irrigation was conducted. 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}), which confirmed the high nutrient demand of oilseed rape. With its widespread, intensive rootsystem, oilseed rape could utilize

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the natural nutrient supply of the chernozem soil to a great extent. In the case of the P + K fertilizer treatment, the yield was between 3000 and 4200 kg ha^{-1}, while in the N = 210 kg ha^{-1} +PK treatment, it varied between 4000 and 5000 kg ha^{-1}. As an effect of sulphur fertilization, the yield of oilseed rape did not changed, this proved that the chernozem soil could provide the high sulphur demand of rape. As an effect of the increasing N doses, the specific fertilization yield surplus of rape decreased (in the case of N = 0 kg ha^{-1} +PK treatment 19-27 kg/1 kg NPK, in the N = 210 kg ha^{-1} +PK treatment 11-12 kg/1 kg NPK). Our studies confirmed that N fertilization conversely improved the water utilization of oilseed rape in all three experimental years (in the case of the N = 0 kg ha^{-1} +PK treatment 4-8 kg/1 mm precipitation + irrigation water, in the case of the N = 210 kg ha^{-1} +PK treatment 11-14 kg/1 mm precipitation + irrigation water).

According to the data of our research – under irrigated circumstances –, the hybrid oilseed rape has favourable adaptive capacity to the different sowing times. 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). Similarly to the experiments of *Boelcke* et al. (1991) (optimal N = 240 kg ha^{-1}), our research results confirmed the high nutrient demand of oilseed rape (in our experiments the optimum was N = 240 kg ha^{-1}). Due to the traditional, non-long-term experiment, the yield increasing effect of fertilization varied between 800 and 1300 kg ha^{-1}, depending on the cropyear. These values considerably exceeded the yield increase obtained by *Sieling* and *Christen* (1997) in their studies. 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) in the case of the hybrid of new genotype (Rohan). There was moderate yield difference (0-270 kg ha^{-1}) between the August and September sowing times in the studied cropyears.

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.

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