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The Effect of Sowing Time on Phytopathogenic Characteristics and Yield of Sunflower Hybrids

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***Abstract*—**The field research was carried out at the Látókép AGTC KIT research area of the University of Debrecen in Eastern-Hungary, on the area of the aeolain loess of the Hajdúság. We examined the effects of the sowing time on the phytopathogenic characteristics and yield production by applying various fertilizer treatments on two different sunflower genotypes (NK Ferti, PR64H42) in 2012 and 2013. We applied three different sowing times (early, optimal, late) and two different treatment levels of fungicides (control = no fungicides applied, double fungicide protection).

During our investigations, the studied cropyears were of different sowing time optimum in terms of yield amount (2012: early, 2013: average). By Pearson's correlation analysis, we have found that delaying the sowing time pronouncedly decreased the extent of infection in both crop years (*Diaporthe*: r=0.663**, r=0.681**, *Sclerotinia*: r=0.465**, r=0.622**). The fungicide treatment not only decreased the extent of infection, but had yield increasing effect too (2012: r=0.498**, 2013: r=0.603**). In 2012, delaying of the sowing time increased (r=0.600**), but in 2013, it decreased (r= 0.356*) the yield amount.

***Keywords*—**Fungicide treatment, genotypes, sowing time, yield, sunflower.

I. Introduction

SUNFLOWER (*Helianthus annus* L.) is the most important oil plant of Hungary, which is produced in a significant extent compared to the European production [1]. In domestic sunflower production proper hybrid selection, seeding technology (sowing time, plant density) and plant protection are crucial cultivation techniques [2]. Planting time and the hybrid have a great effect on the amount of yield [3]. Early sowing has a beneficial effect on yield results [4]. However, if occurred that the latter sowing had a positive influence on yield result [5]. In certain crop years, the diseases of sunflower are the most important elements of crop safety [6]. The average and dry crop years' effect yield amount almost identically. Fungal infection impairing the crop does not appear in drought, while besides average precipitation it appears only to a small extent, therefore the role of the primary determinant of yield – the disease – becomes negligible [7]. During a cooler crop year of lesser precipitation, lower yields can be achieved, due to the more frequent appearance of the stalk and flower diseases [8]. During a dry crop year, due to the lower level of diseases, the yield excess caused by the fungicide treatments is only moderate (100-300 kg ha^{-1}), compared to the chemical control. On the contrary, during a crop year of favorable water supply and high amount of precipitation, the fungicide treatments can result in 100-900 kg/ha yield excesses [9].

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II. Materials and Methods

The research was set up on chernozem soil with lime patches at the Látókép AGTC KIT research area of the University of Debrecen. The research area is located in Eastern-Hungary, 15 km far from Debrecen, on the area of the aeolain loess of the Hajdúság. Soil of the research area is of good agricultural condition, medium hard and loamy with medium humus content and neutrality. Water supplies of the soil are favorable and it has good water retention and conductivity.

We examined the effects of the sowing time on the phytopathogenic characteristics and yield production by applying various fertilizer treatments on two different sunflower genotypes (NK Ferti, PR64H42) in 2012 and 2013. NK Ferti is hybrid with a high oleic acid content and conventional weed control and PR64H42 is Express® tolerant hybrid with a high oleic acid content. Parcells of the research were set up in four repetitions. Previous crops were winter wheat in 2012, maize in 2013. The applied sowing times are recorded in Table I. The number of seedlings at the time of sowing was 95,000ha^{-1} and was later optimized to a plant density of 55,000ha^{-1}. Plants received uniform agrotechnical treatments applied generally in practice. Two different levels of fungicide treatments were used. Besides the control stand (no treatment applied) we set up a double-treated one for which we used fungicide Pictor (substances: boscalid and dimoxistrobin) in a dose of 0.5l ha^{-1} two times (at the time of the 8-10-leaf stages and blooming). The dates of harvesting are also in Table I, harvesting was made with a Sampo parcel harvester, installed with a special adapter.

Phytopathogenic data of the hybrids were recorded in four repetitions. The table contains the average of the repetitions. During the recordings, fifteen plants of average maturity were chosen in each parcel. During the researches we determined the degree of infections (%) in the critical phenophases of the crop year for the most important phytopathogenics (*Sclerotinia sclerotiorum, Diaporthe helianthi*).

At harvest we measured the raw plant and its moisture content. We standardized the results to an 8% content.

TABLE I
APPLIED SOWING AND HARVESTING TIME (2012 - 2013)

Crop year	Early sowing time	Average sowing time	Late sowing time
		Sowing time	
2012	23.03.2012.	10.04.2012.	05.05.2012.
2013	17.04.2013.	25.04.2013.	08.05.2013.
		Harvesting time	
2012	10.09.2012.		19.09.2012.
2013	09.09.2013.		29.09.2013.

The weather of 2012 (Table II) was unfavorable for the sunflower's early vegetative and generative development and its yield production. Due to dry April (20.7mm rainfall compared to the long term average of 42.4mm), the initiative development of the sunflower plants lagged behind the average. Besides significant rainfalls in May (71.9mm) and June (91.7mm), temperature above the average (June: 20.9°C, July: 23.3°C) was also favorable. Average precipitation in July (65.3mm compared to the long term average of 65.7mm) could only partially satisfy the water demand of the huge vegetative stands. Sunflower stands could only partially tolerate the unfavorable and warm flowering and fertilization period. Extremely dry (4.1mm) and hot (22.5°C) August weather had an adverse effect on achene filling processes.

TABLE II
THE AMOUNT OF RAINFALL AND MOISTER TEMPERATURE DURING THE INVESTIGATED CROP-YEARS (2012 - 2013)

	Months	30 year's average	2012	Difference	2013	Difference
Precipitation (mm)	April	42,4	20,7	-21,7	48,0	5,6
	May	58,8	71,9	13,1	68,7	9,9
	June	79,5	91,7	12,2	30,8	-48,7
	July	65,7	65,3	-0,4	15,6	-50,1
	August	60,7	4,1	-56,6	32,2	-28,5
	Totally	307,1	253,7	-53,4	195,3	-111,8
Temperature (°C)	April	10,7	11,7	1,0	12,0	1,3
	May	15,8	16,4	0,6	16,6	0,8
	June	18,8	20,9	2,1	19,6	0,8
	July	20,3	23,3	3,0	21,2	0,9
	August	19,6	22,5	2,9	21,5	1,9
	Average	17,0	19,0	1,9	18,2	1,1

2013 weather conditions significantly challenged the adaptation capability of sunflower hybrids. April and May weather conditions – apart from some short periods – were ideal for the vegetative development of stocks. Sunflower plants with excellent stages of development and significant vegetative sink were able to tolerate the dry (June: 30.8mm, July: 15.6mm, August: 32.2mm) and hot (June: 19.6°C, July: 21.2°C, August: 21.5°C) period from the middle of June till the end of August. The flowering and fertilization of stocks as well as the development and filling of achenes were sufficient. Smaller, but continuous rainfalls prior to the harvesting period set the stock back from drying and hindered harvest.

For the calculation and illustration of the experimental results, we have used Microsoft Excel, SPSS 19.0 statistical software. The data were analyzed by bifactorial variance analysis and Pearson's correlation analysis.

III. RESULTS AND DISCUSSION

During our studies, the crop year of 2012 was characterized by relatively higher extent of infection than that of 2013 since the precipitation amount in 2013 was below that of the previous crop year by 58.4mm (Table III). The *Sclerotinia* infections were low in both crop years due to the fact that the precipitation in both studied crop years was below the multi-year average. In 2012, the *Sclerotinia* infection varied between 2.4 and 9.7%, while in 2013 it was in the range of 0.2-3.2%, depending on the hybrid, the sowing time and the treatment. The *Diaporthe* infections were more pronounced in both of the crop years, 15.0-77.0% in 2012 and 12.0-48.0% in 2013, depending on the hybrid, the sowing time and the fungicide treatment.

During our studies, the delaying of the sowing time decreased the infection of the pathogens, but this decrease was not significant in every case. In the case of *Sclerotinia*, in 2012, significant difference was found only between the early and late sowing times (in NK Neoma and PR64H42 hybrids) and between the average and late sowing times (PR64H42). On the contrary, in the crop year of 2013, on the control plots, the extent of infection was significantly lower due to the delaying of the sowing time in every case, except of the PR64H42 hybrid, between the early and average sowing times. In the case of the doubly treated plots, the extent of infection characteristic to the late sowing time was significantly lower than that characteristic to the early sowing time. In the case of the *Diaporthe* infection, in the hybrid NK Ferti, the extent of infections corresponding to the late sowing time were significantly lower than those of the early sowing time in every case (in both crop years and treatments). In the case of the PR64H42 hybrid, the sowing time influenced the extent of infection to a more considerable extent. In the case of this hybrid, shifting the sowing time significantly decreased the pathological pressure of the pathogen in almost every case (both crop years, both hybrids, both treatments).

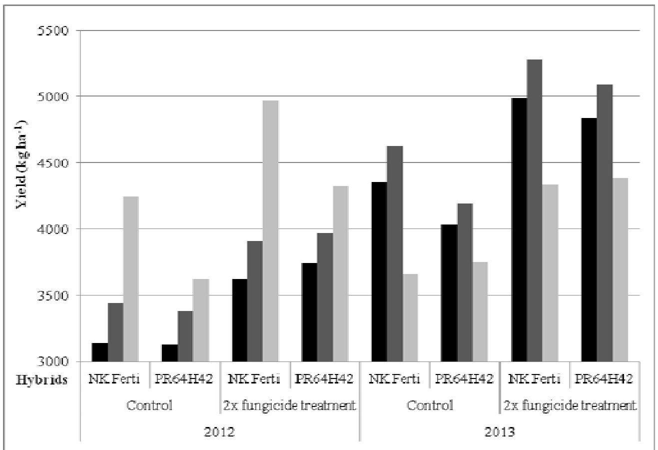
During our experiment, the fungicide treatment decisively lowered the pathogen infections. As an effect of the treatment, the doubly fungicide treated plots were characterized by a significantly lower infection than the control ones. In the average of the hybrids and sowing times, the *Diaporthe* infection decreased by 39.9% in 2012, while by 31.4% in 2013, as an effect of the fungicide treatments. In the case of *Sclerotinia*, the doubly treated plots were characterized by lower infections – by 49.3% in 2012 and by 53.8% in 2013 – in the averages of the hybrids and sowing times.

TABLE III
THE EFFECT OF SOWING TIME ON THE INFECTION OF THE SUNFLOWER (2012-2013)

Hybrid			NK Ferti		PR64H42	
Crop year	Fungicid treatment (B)	Sowing time (A)	Sclerotinia (%)	Diaporthe (%)	Sclerotinia (%)	Diaporthe (%)
2012	Control	Early	9,7	56	9,4	77
		Average	8,1	54	9,5	67
		Late	4,2	39	4,5	25
	Double fungicid treatment	Early	4,2	39	4,2	49
		Average	4,0	34	4,3	34
		Late	2,4	21	2,9	15
	SD5%	Sowing time (A)	4,0	15,5	3,6	13,4
		Fungicid treatment (B)	1,7	2,8	1,5	4,8
		Interaction (A x B)	3,0	4,9	2,5	8,4
2013	Control	Early	3,2	48	1,5	43
		Average	2,1	40	1,2	31
		Late	0,8	29	0,5	19
	Double fungicid treatment	Early	1,7	34	0,8	29
		Average	1,0	28	0,4	21
		Late	0,4	21	0,2	12
	SD5%	Sowing time (A)	0,8	12,5	0,6	9,4
		Fungicid treatment (B)	0,1	5,4	0,2	4,0
		Interaction (A x B)	0,2	9,3	0,3	7,0

The yield results of the crop year of 2012 were below those of the crop year of 2013, due to the canicular days in August. The yield amount varied between 3126 and 4970kg ha^{-1} in 2012, depending on the hybrid, the sowing time and the treatment. Depending on the hybrid, the sowing time and the treatment, the yield amounts in 2013 were between 3662 and 5282kg ha^{-1}. Significant difference between the yield results of the different sowing times was found only in the case of the hybrid NK Ferti. In the case of this hybrid and late sowing time, we have achieved significantly higher yields compared to the early and average sowing times, either on the control or on the doubly treated plots. In 2013, the late sowing time significantly decreased the yield in both treatment levels, compared to the optimal (average) sowing time.

During our investigation, the sowing time influenced not solely the extent of infection but the yield too. With respect to the yield amount, the studied crop years possessed different sowing time optimums. In the crop year of 2012, the late sowing times were the optimal ones in the cases of both hybrids and treatment levels (control: NK Ferti: 4242kg ha^{-1}, PR64H42: 3619kg ha^{-1}; doubly treated: NK Ferti: 4970kg ha^{-1}, PR64H42: 4326kg ha^{-1}); while in 2013, the highest yield results were measured in the case of the average sowing time in both hybrids and both treatment levels (control: NK Ferti: 4621kg ha^{-1}, PR64H42: 4196kg ha^{-1}; doubly treated: NK Ferti: 5282kg ha^{-1}, PR64H42: 5090kg ha^{-1}). The fungicide treatment resulted in significant yield increase in every case (both crop years, both hybrids). In the averages of the hybrids, the highest yield increases were experienced in the cases of the late (718kg ha^{-1}) and average sowing times (778kg ha^{-1}) in 2012 and 2013, respectively. In the averages of the sowing times, the yield increasing effect of the fungicide treatment was higher in the case of the PR64H42 hybrid (2012: NK Ferti: 559kg ha^{-1}, PR64H42: 637kg ha^{-1}; 2013: NK Ferti: 655kg ha^{-1}, PR64H42: 777kg ha^{-1}). In the averages of the hybrids and sowing times, the yield increasing effect of the fungicide treatment was 598kg ha^{-1} in 2012 and 716kg ha^{-1} in 2013 (Fig. 1).



Crop year		2012		2013	
SD5%	Parameters	NK Ferti	PR64H42	NK Ferti	PR64H42
	Planting time (A)	578,9	907,3	731,1	1001,9
	Fungicid treatment (B)	235,8	389,5	298,9	430,1
	Interaction (A x B)	408,5	674,6	517,8	745,0

Fig. 1 The effect of sowing time on the yield of sunflower hybrids (2012-2013)

We applied Pearsons's correlation to determine the degree and course of the relationships between the examined hybrids, agrotechnical factors (i.e. planting time, fungicide treatment), yield and phytopathogenic infections (*Sclerotinia, Diaporthe*). As shown in Table IV, values of correlations below 0.3 were considered small, values between 0.3-0.5 were medium, values between 0.5-0.7 were strong and correlations above 0.7 were considered very strong.

TABLE IV
CORRELATION BETWEEN THE ANALYZED PARAMETERS (2012 - 2013)

Crop year	Parameters	*Sclerotinia*	*Diaporthe*	Yield
	Hybrid	0.062	0.107	-0.161
2012	Sowing time	-0.465(**)	-0.663(**)	0.600(**)
	Fungicide treatment	-0.658(**)	-0.564(**)	0.498(**)
	Hybrid	-0.441(**)	-0.343(*)	-0.134
2013	Sowing time	-0.622(**)	-0.681(**)	-0.356(*)
	Fungicide treatment	-0.460(**)	-0.495(**)	0.603(**)

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

In 2013, we have experienced opposite, weak interaction between the hybrid and the studied pathogens (r=0.441**, r=0.343*). However, in 2012, there was no significant connection between the hybrid and the pathogens. The delaying of the sowing time decisively decreased the extents of infection in both crop years in the case of the studied pathogens. We have found opposite, medium correlation between *Diaporthe* and the sowing time in both crop years (r=0.663**, r=0.681**). However, the sowing time could lower the *Sclerotinia* infection in 2012 to lesser extent than in 2013 (r=0.465**, r=0.622**). The fungicide treatment decreased the infection of the studied pathogens to a greater extent in 2012 (r=0.658**, r=0.564**) than in the next crop year (r=0.460**, r=0.495**). The sowing time and the fungicide treatment affected the yield too. The fungicide treatment decreased the yield in both crop years, which was confirmed by the positive medium (r=0.498**) and tight (r=0.603**) correlations between the two factors. In 2012, the delaying of the sowing time increased yield amount to a great extent (r=0.600**), while in 2013 it decreased the yield (r=0.356*).

IV. CONCLUSION

During our investigation, the delaying of the sowing time decreased pathogenic infection, although the decrease was not significant in every case. In our experiment, the double fungicide treatment significantly decreased the extent of infection in the cases of both hybrids in both crop years. The yield amounts of 2012 were below those of 2013, due to the relatively higher infection and the canicular days in August. Significant difference between the yield results of the different sowing times was found only in the case of the hybrid NK Ferti. With respect to the yield amount, the studied crop years performed different sowing time optimums. In 2012, the late sowing time was optimal, while in 2013, the highest yield amounts were measured in the case of the average sowing time. The fungicide treatment resulted in significant yield increase in every case (both crop years, both hybrids). In the averages of the hybrids and sowing times, the fungicide treatment caused the yield increase of 598kg ha^{-1} in 2012, while that of 716kg ha^{-1} in 2013.

By Pearson's correlation analysis, we have found that delaying the sowing time pronouncedly decreased the extent of infection in both crop years (*Diaporthe*: r=0.663**, r=0.681**, *Sclerotinia*: r=0.465**, r=0.622**). The fungicide treatment not only decreased the extent of infection, but had yield increasing effect too (2012: r=0.498**, 2013: r=0.603**). In 2012, delaying of the sowing time increased (r=0.600**), but in 2013, it decreased (r= 0.356*) the yield amount.

REFERENCES

[1] Treitz M., *"Napraforgó hibridek rezisztencia-vizsgálata a Diaporthe helianthi (Muntanola-Cvetkovic et al.) kórokozó gombával szemben." Doktori értekezés,* Keszthely, 2003
[2] Zsombik L., *"A napraforgó termesztésének helyzete, a hybrid megválasztás fontosabb kérdései"* Agrárágazat. 2006. 7. 1. 22 – 24 p..
[3] Allam, A. Y. - El-Nagar, G. R. – Galal, A. H., "*Response of two sunflower hybrids to planting dates and densities."* Acta Agronomica Hungarica. 2003. 51. 1. 25-35.
[4] F. Harper, R. C. Fergusson, *"The effects of bitumen mulch and sowing date on the establishment and yield of oil-seed sunflower (Helianthus annuus L.)"* Journal of Agricultural Sciences 1979. vol. 93. no. 1. 171-180.
[5] J. Surovcík, "*Yield reaction of sunflower (Helianthus annuus) to sowing time and weed treatment"* Vedecké Práce Výskumného Ústavu Rastlinnej Výroby Piešt'any. 30. Piešt'any: VýskumnýÚstav Rastlinnej Výroby Pieš'tany. 2001. 97-102.
[6] Zsombik L. – Szabó A. (2007): "*A napraforgó növényvédelmének fontosabb szempontjai."* Agrárágazat. 2007. 8. 4. 28-30. p 6.
[7] Ruzsányi L., Csajbók J., "*Termésstabilitás és az évjárat kölcsönhatása a fontosabb szántóföldi növényeinknél."* Agrártudományi Közlemények = Acta Agraria Debreceniensis. 2001. 2. sz. 41-46. p.
[8] Szabó A. – Pepó P., "*Effect of agrotechnical and meteorological factors on yield formation in sunflower production."* Cereal Research Communications. 2005. 33. 1. 49-52.
[9] Pepó P., "*A napraforgó növényvédelme."* Magyar mezőgazdaság. 2010. 22-25. p.

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