THE EFFECT OF GENOTYPE AND CROPYEAR ON THE YIELD AND THE PHYTOPATHOLOGICAL TRAITS OF SUNFLOWER (*Helianthus annus* L.)

Péter PEPÓ – Adrienn NOVÁK

Institute of Crop Scoience of Agricultural and Food Sciences of Environmental Management, Centre of Agricultural Sciences, University of Debrecen, 138. Böszörményi út, Debrecen H-4032, Hungary
e-mail: novak@agr.unideb.hu

Abstract
The yield and the phytopathological traits of seven sunflower hybrids were studied in two crop protection models with different input levels (extensive=without fungicide treatments, mid-tech=-two fungicide treatments) on chernozem soil in two different years (2012 and 2013). The experimental results proved that the level of infection by Diaporthe (64% in the extensive model, 38% in the mid-tech model as an average of the hybrids), Phoma (53.5% and 34.0%), Sclerotinia (8.4% and 4.6%), Alternaria (76.4% and 48.7%) in the more wet year of 2012. When the precipitation before the season (294 mm from December until March) had filled up the water stock of the chernozem soil and the vegetation period had been dry (79 mm rain during the months of June, July and August), the degree of infection was considerably lower (infection by Diaporthe: 37% in the extensive model and 25% in the mid-tech model, infection by Phoma: 28.5% and 17.4%, infection by Sclerotinia: 1.5% and 0.7%, infection by Alternaria: 35.8% and 22.2% in 2013 as an average of the hybrids). Due to the higher disease infection in 2012, the yield of the hybrids ranged between 3300 – 4200 kg ha^{-1} and between 3900 – 4900 kg ha^{-1} in the extensive (control) model and mid-tech model (two fungicide treatments), respectively. In the more favourable year of 2013 (as regards the weather and the disease infection), the yields of the hybrids varied between 4200 – 5200 kg ha^{-1} in the extensive and between 5000 – 6000 kg ha^{-1} in the mid-tech crop protection model.

Keywords: fungicide treatment, genotype, phytopathological traits, sunflower, yield

Introduction

Sunflower (*Helianthus annus* L.) is the most important oil crop of Hungary, the amount of production is high even when considered at a European level (Treitz, 2003). Nowadays, the extreme weather conditions are increasing the risk of sunflower production. The favourable soil conditions can compensate for the unfavourable effects of the season lack or unfavourable distribution of precipitation (Mijić et al, 2012). However, in order to reduce the unfavourable weather effects as much as possible, the agrotechnical factors need to be optimized (Szabó, 2011). The hybrid selection, the proper sowing technology (sowing date, plant density) and optimized and rational crop protection are of special importance (Szabó, 2012).

The different climate (Borbély and Lesznyák, 2006; Bedő, 2003) and agrotechnical factors (sowing date, plant density etc.) have a strong impact on the yield of sunflower hybrids in the different years (Zsombik, 2006). There is a strong, significant correlation between the climate conditions and the yield (Cerny et al., 2013). The sunflower hybrids respond differently to the changes in the environmental conditions. Those hybrids are regarded less stable which respond to the changes in the environmental conditions with a higher yield fluctuation, while those which can better compensate for the extreme effects of the year are considered stable (Szabó, 2008).

When the weather is cold and wet, lower yields can be expected due to the higher infection by stem and head diseases (Borbély et al., 2007; Szabó and Pepó, 2005), as the yield of sunflower is strongly influenced by the fungal diseases (Mukhtar, 2009). The level and intensity of disease infection in sunflower stands are dependent upon the hybrid selection as there are great differences between the genotypes in their susceptibility to diseases (Borbélyné et al., 2002). The occurrence and spread of diseases are mainly determined by the agroclimatic conditions of the season (temperature, distribution and amount of

DOI: 10.18380/SZIE.COLUM.2014.1.2.101

precipitation (Branimir et al., 2008). According to Ruzsányi and Csajbók (2001), an average and a dry year have similar effects on the yield. A damaging fungal infection does not occur in a dry year and is only of moderate level in a year with average precipitation, thereby, the role of the primary yield-determining factor (disease) becomes negligible. The yield can be increased by protection against fungal pathogens (Szabó, 2013). In a dry year, the yield increasement due to the fungicide treatments as compared to the control was only moderate due to the low disease levels (100-300 kg ha^{-1}). As opposed to this, the fungicide treatments resulted in a yield increment of 100-900 kg ha^{-1} in a rainy year with favourable water supply (Pepó, 2010).

Materials and methods

A field experiment was set up at the experimental farm of the University of Debrecen, Centre of Agricultural Science at Látókép on calcareous chernozem soil. The experimental site is located in Eastern-Hungary, 15 km from Debrecen along the main road No. 33 in the loess region of Hajdúság (N 47°33', E 21°27'). The experimental soil is of good culture-state, medium-hard loam. The soil has good water management characteristics, it has a good water conducting and water-holding capacity.

The yield and the phytopathological characteristics of seven sunflower hybrids of different genetic background were studied in two crop protection models of different intensity (extensive model = no fungicide treatment, mid-tech model = two fungicide treatments) in two different years (2012 and 2013). The tested sunflower hybrids were the followings: NK Neoma (early ripening, low oleic acid [LO], Clearfield ® [IMI]), NK Ferti (early ripening, high oleic acid [HO], normal herbicid tolerant [N]), Tutti (mid-early ripening, HO, N), P64H42 (early ripening, HO, Express-tolerant [E]), P64HE39 (early maturity, HO, N), P63LE13 (early ripening, LO, E), and SY Revelio (early ripening, HO, IMI,).

The experiment was set up in four repetitions in a randomized block design (plot size: 15.2 m^{-2}). The forecrops were winter wheat in 2012 and maize in 2013. Sowing was performed with a seed number of 95 000 ha^{-1} on 10 April in 2012 and 25 April in 2013. After emergence, a plant density of 55 00 plants ha^{-1} was set. The hybrids were treated with the agrotechnique generally applied in the practice. In the mid-tech treatment, fungicides were applied twice (first treatment at the state of 8-10 pair of leaves (BBCH18 – BBCH19), second treatment at the beginning of blooming (BBCH61) (Pictor in a dosage of 0.5 l ha^{-1}, active ingredients: boscalid + dimoxystrobin). The experiment was harvested on 10 September 2012 and 9 September 2013 using a Sampo plot combine harvester with a special adapter.

Table 1. The amount of rainfall and temperature during the investigated crop-years
(Debrecen, October, 2011. – September, 2013.)

Months	Oct.	Nov.	Dec.	Jan.	Feb.	Marc.	Apr.	May.	Jun.	Jul.	Aug.	
						Precipitation (mm)						**Totally**
30 year's average	30.8	45.2	43.5	37.0	30.2	33.5	42.4	58.8	79.5	65.7	60.7	527.3
2012	18.1	0.0	71.1	28.0	17.8	1.4	20.7	71.9	91.7	65.3	4.1	390.1
Difference	-12.7	-45.2	27.6	-9.0	-12.4	-32.1	-21.7	13.1	12.2	-0.4	-56.6	-137.2
2013	22.4	16.6	65.8	38.7	52.9	136.3	48.0	68.7	30.8	15.6	32.2	528.0
Difference	-8.4	-28.6	22.3	1.7	22.7	102.8	5.6	9.9	-48.7	-50.1	-28.5	0.7
						Temperature (°C)						**Average**
30 year's average	10.3	4.5	-0.2	-2.6	0.2	5	10.7	15.8	18.7	20.3	19.6	9.3
2012	8.6	0.6	1.5	-0.6	-5.7	6.3	11.7	16.4	20.9	23.3	22.5	9.6
Difference	-1.7	-3.9	1.7	2.0	-5.9	1.3	1.0	0.6	2.2	3.0	2.9	0.3
2013	11.1	7.2	-1.2	-1.0	2.3	2.9	12.0	16.6	19.6	21.2	21.5	10.2
Difference	0.8	2.7	-1.0	1.6	2.1	-2.1	1.3	0.8	0.9	0.9	1.9	0.9

 DOI: 10.18380/SZIE.COLUM.2014.1.2.101

In the critical phenophases, the percentage of disease infection was determined for the major phytopathogens (*Diaporthe helianthi, Phoma macdonaldii, Sclerotinia sclerotiorum, Alternaria helianthi*). The phytopathological data of the hybrids were recorded in four repetitions. In the assessments, 15 plants of average development were selected on each plot. In the case of the stem and head diseases, the level of infection was determined as the percentage of the infected plants. If the disease symptoms were obvious on the studied plant, it was considered infected. The infection was determined as the percentage of infected plants from the 15 selected plants. In the case of leaf diseases, the level of infection was determined as a percentage of the leaf area. At harvest the raw yield of plots and their moisture content were measured. The yields were standardized for a moisture content of 8.0 %.

The meteorological data of the experimental years are included in Table 1. The weather of 2012 was unfavourable for the sunflower's early vegetative and generative development and its yield production. Due to dry April (20.7 mm rainfall compared to the long term average of 42.4 mm), the initiative development of the sunflower plants lagged behind the average. Besides significant rainfalls in May (71.9 mm) and June (91.7 mm), temperature above the average (June: 20.9 °C, July: 23.3 °C) was also favourable. Average precipitation in July (65.3 mm compared to the long term average of 65.7 mm) could only partially satisfy the water demand of the huge vegetative stands. Sunflower stands could only partially tolerate the unfavourable and warm flowering and fertilization period. Extremely dry (4.1 mm) and hot (22.5 °C) August weather had an adverse effect on achene filling processes.

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: 30.8 mm, July: 15.6 mm, August: 32.2 mm) 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.

Results and discussion

Considerable changes have been occurring in Hungarian sunflower production for the past 10-15 years. One of the most important factors in generating these changes was the cardinal change in the biological bases. The number of domestic, registered hybrids has tripled, nowadays it is around 100. The quality transformation was even more significant than the quantitative change, as a consequence of which the yielding capacity of sunflower hybrids considerably increased, for the exploitation of which a more intensive mid-tech agrotechnique of higher input level is needed as compared to the earlier extensive and low-input production technologies. Consequently, the new hybrids created by breeding require the application of more intensive production technology elements with special regards to fertilization, sowing technology and crop protection. For the latter, the proper application of fungicides is of special importance.

Seven sunflower hybrids of different genetic backgrounds were studied in two crop protection models of different intensity (extensive model = no fungicide treatment, mid-tech model = two fungicide treatments [first treatment at the stage of 8-10 pair of leaves - BBCH18/BBCH19, second treatment at the beginning of flowering - BBCH61]) in two different years (2012 and 2013). The weather was totally different in the two years, the effect of which was manifested both in the phytopathological characteristics and in the yield in the studied genotypes. In the months preceding the season of 2012 (from

Table 2. The effect of crop year, genotypes and fungicide treatment on the yield of sunflower (Debrecen, chernozem soil, 2012- 2013.)

Hybrids (A)	Fungicide treatment (B)	2012. year (kg ha^{-1})	2013. year (kg ha^{-1})	Difference in yield (kg ha^{-1})
NK Neoma	control	3972	4237	265
	fungicide 2x	4550	5103	553
P 63 LE 13	control	4240	4686	446
	fungicide 2x	4907	5639	732
NK Ferti	control	3437	4621	1184
	fungicide 2x	3910	5282	1372
Tutti	control	3605	5218	1613
	fungicide 2x	4260	5970	1710
SY Revelio	control	3619	4490	871
	fungicide 2x	4196	5004	808
P 64 HE 39	control	3336	4382	1046
	fungicide 2x	4061	5184	1123
PR 64 H 42	control	3381	4196	815
	fungicide 2x	3968	5090	1122
Average	**control**	**3656**	**4547**	**891**
	fungicide 2x	**4265**	**5325**	**1060**
$LSD_{5\%}$	Hybrid (A)	1158	969	
	Fungicide treatment (B)	203	250	
	Interaction (A x B)	537	663	

the beginning of December until the end of March), the amount of precipitation was very low (118.3 mm). The amount of precipitation during the season was higher (253.7 mm) but its distribution was unfavourable (71.9 mm in May, 91.7 mm in June, 65.3 mm in July). The precipitation from May until the end of June created favourable microclimate conditions for the relatively early occurrence of the leaf, stem and head diseases of sunflower and for the development of a significant infection. The average temperature of June, July and August was considerably, 2.2 – 3.0 ^{o}C higher than the 30-year average which was unfavourable for the yield formation. These factors had a negative influence on the fertilization, seed development and seed filling of sunflower. As a result of these effects, the yield of the sunflower hybrids varied between 3300 and 4900 kg ha^{-1} in 2012.

The weather and phytopathological conditions of 2013 and the preceding period were totally different from those of 2012. The amount of precipitation from December 2012 until March 2013 (293.7 mm) was very favourable, it enabled the fill-up of the water stock of the chernozem soil. With its enormous root system, sunflower is able to utilize the significant available water stock of the chernozem soil. The amount of precipitation (195.3 mm) in the vegetation period of 2013 (April-August) was considerably lower than in 2012. Consequently, the sunflower diseases occurred later in 2013 and their spread was moderate in the stands. The water supply of sunflower on the whole was more favourable in 2013 (489.0 mm between December 2012 and August 2013) than in 2012 (372.0 mm). The monthly mean temperature of the critical months also had a favourable effect on the fertilization and seed development in 2013 (the mean monthly temperatures of June, July and August were moderately 0.9 – 1.9 ^{o}C higher than the 30-year average). The joint effect of these positive factors was that the yields of the sunflower genotypes were much more favourable in 2013 than in 2012, they varied between 4200 and 6000 kg ha^{-1} (Table 2).

When studying the different fungicide models separately (Table 2), it can be stated that the average yield of the hybrids was 3656 kg ha^{-1} in 2012 and 4547 kg ha^{-1} in 2013 in the extensive model, which increased considerably in the mid-tech model in both years (4265 kg ha^{-1} in 2012

 DOI: 10.18380/SZIE.COLUM.2014.1.2.101

Table 3. The effect of crop year, genotypes and fungicide treatment on the lodging and phytopathological traits of sunflower (average of hybrids) (Debrecen, chernozem soil, 2012- 2013.)

Crop year		2012. year		2013. year	
Disease	Fungicide treatment	Average	Min. - Max.	Average	Min. - Max.
Lodging %	control	18,8	14,4 - 26,3	8,9	7,2 - 10,8
	fungicide 2x	10,4	8,2 - 16,1	4,5	2,9 - 6,3
Diaporthe helianthi %	control	64	58 - 74	37	30 - 42
	fungicide 2x	38	32 - 49	25	21 - 28
Phoma macdonaldii %	control	53,5	43,8 - 61,2	28,5	25,0 - 32,8
	fungicide 2x	34	27,3 - 40,3	17,4	12,2 - 20,6
Sclerotinia sclerotiorum %	control	8,4	7,3 - 9,5	1,5	1,1 - 2,1
	fungicide 2x	4,6	4,0 - 5,9	0,7	0,4 - 1,1
Alternaria helianthi %	control	76,4	67,9 - 84,6	35,8	31,0 - 41,3
	fungicide 2x	48,7	41,8 - 56,8	22,2	18,9 - 27,2

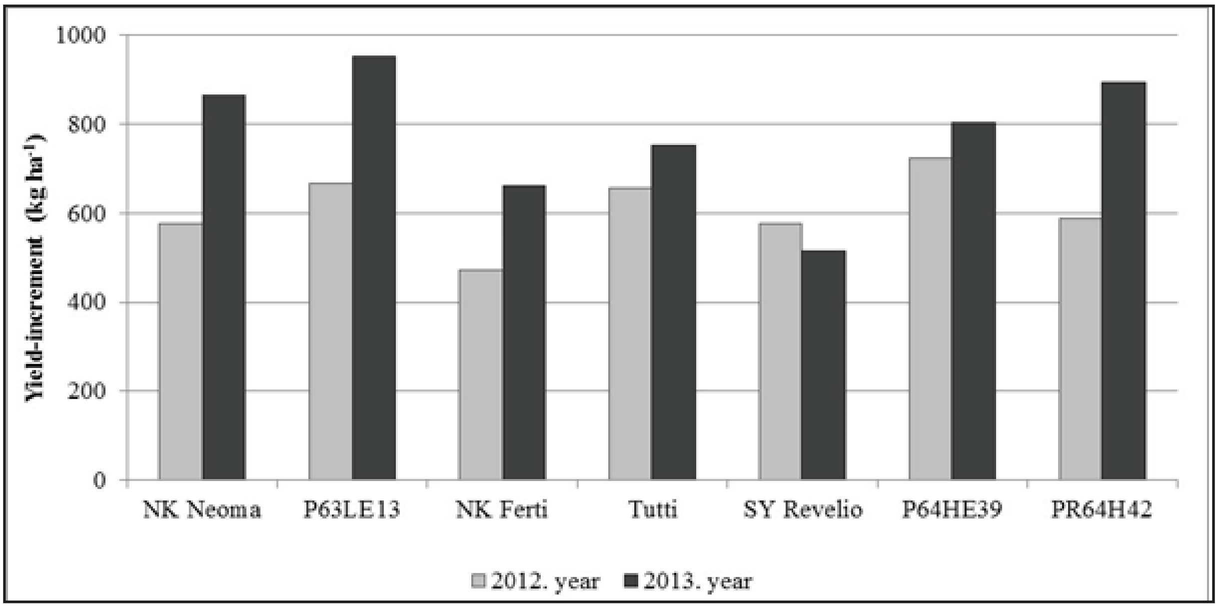
and 5325 kg ha^{-1} in 2013). The sunflower hybrids differed in their adaptation to the different years. In both fungicide models, the highest difference in yield between the two years was found for the hybrid Tutti (1613 kg ha^{-1} in the extensive and 1710 kg ha^{-1} in the mid-tech model), that is the adaptation ability of the hybrid was low. In the favourable years of 2013, the hybrid Tutti gave the highest yield of the tested hybrid sortiment (5970 kg ha^{-1}). The lowest difference in yield between the years was found in the case of NK Neoma (265 kg ha^{-1} and 553 kg ha^{-1}) and P63LE13 (446 kg ha^{-1} and 732 kg ha^{-1}) , which indicated a good adaptation ability of the hybrids. In addition to their good adaptation ability, these hybrids gave a higher than average yield in the mid-tech model. In the mid-tech model, the yields of NK Neoma and P63LE13 were 4550 kg ha^{-1} and 4907 kg ha^{-1} in 2012 and 5103 kg ha^{-1} and 5639 kg ha^{-1} in 2013, respectively.

The experimental results showed that the differences between the potential yield of the different sunflower hybrids were manifested strongly in the untreated control (extensive model). In both years, the smallest yields without fungicide treatment were obtained for the hybrids PR64H42 (3381 kg ha^{-1} in 2012 and 4196 kg ha^{-1} in 2013) and P64HE39 (3336 kg ha^{-1} and 4382 kg ha^{-1}) (Table 2). In both years, the highest yields were obtained in the mid-tech model. From among the tested hybrids, the highest yields were measured for P63LE13 (4907 kg ha^{-1}) and NK Neoma (4550 kg ha^{-1}) in 2012, while Tutti (5970 kg ha^{-1}) and P63LE13 (5639 kg ha^{-1}) gave the highest yields in 2013.

In the two experimental years, the major stem, leaf and head diseases of sunflower were studied (Table 3). The disease infection levels had a strong effect on the lodging and consequently on the yield loss. The lodging and infection data clearly represent the differences between the weather of 2012 and 2013.

Table 3 contains the average, minimum and maximum lodging and infection data of the tested seven hybrids. In the control treatment in the extensive model, the degree of lodging was 18.8% in 2012 and 8.9% in 2013, while the disease infection values were as follows: infection by Diaporthe 64% and 37%; infection by Phoma 53.5% and 28.5%; infection by Sclerotinia 8.4% and 1.5%; infection by Alternaria 76.4% and 35.8%. The two fungicide treatments applied in the mid-tech model considerably reduced the degree of infection in both years, as a result of which lodging was also diminished. In the mid-tech technology, the degree of lodging was 10.4% in 2012 and 4.5% in 2013. The disease infection levels in the mid-tech model in 2012 and 2013 were as follows: infection by Diaporthe: 38% and 25%; infection by Phoma: 34.0% and 17.4%; infection by Sclerotinia: 4.6% and 0.7%; infection by Alternaria: 48.7% and

Figure 1. The yield-increment of the mid-tech fungicide plant protection model at the different sunflower hybrids (Debrecen, chernozem soil, 2012- 2013.)



22.2% as an average of the tested hybrids. The minimum and maximum lodging and disease infection data for 2012 and 2013 presented in Table 3 proved that there are great differences between the hybrids in both the extensive model and the mid-tech fungicide model, that is the genotypes has different phytopathological tolerance.

The experimental data (Figure 1) proved the yield-increasing effect of the mid-tech model as compared with the extensive model for all tested sunflower hybrids in both years (2012 and 2013). As an average of the hybrids, the yield increasement due to the two fungicide treatments (mid-tech model) was 609 kg ha^{-1} in 2012 and 777 kg ha^{-1} in 2013 as compared to the control treatment (extensive model). This means that it is worth applying the mid-tech fungicide model for all sunflower hybrids in years with a higher (2012) and lower infection pressure. The yield increasement of hybrids due to the two fungicide treatments varied between 473 and 725 kg ha^{-1} in 2012 and between 514 and 953 kg ha^{-1} in 2013 depending upon the genotype.

Conclusion

The yield and the phytopathological characteristics of seven sunflower hybrids were studied under favourable agrotechnical conditions on chernozem soil in years with different weather conditions. The year of 2012 was unfavourable as regards the water supply of sunflower and the disease infection. The amount of precipitation before the season (December-March) was low (118.3 mm), while the amount (253.7 mm) and distribution of precipitation in the season (April-August) advanced the occurrence of the leaf, stem and head diseases of sunflower. The temperatures of June, July and August were 2.2 – 3.0 ^{o}C higher than the 30-year average which was unfavourable for yield formation. The weather conditions were favourable in 2013. The significant amount of precipitation from December until March (253.7 mm) increased the water stock of the chernozem soil, which had a positive influence on the vegetative and generative development of sunflower stands. Due to the low amount of precipitation in the season of 2013 (195.3 mm) disease infections were moderate in sunflower. The temperatures of the summer months, which were moderately higher than the 30-year average (by 0.9 – 1.9 ^{o}C) also advanced the yield formation. Due to the different weather conditions in the experimental yields, there were great differences in the yields of the tested hybrids. The yields of the hybrids

 DOI: 10.18380/SZIE.COLUM.2014.1.2.101

varied between 3300 and 4900 kg ha^{-1} in 2012 and between 4200 and 6000 kg ha^{-1} in 2013 depending upon the fungicide treatment. The significant effect of weather during the season on the yield of sunflower was also proved by Borbély et al. (2007), Szabó and Pepó (2005).

The experiment proved that the hybrids differed in their adaptation ability to the weather (and indirectly to the phytopathological) conditions, which was also observed by Mukhtar (2009). The hybrids NK Neoma and P63LE13 showed a good adaptation ability and produced high yields in both years. From among the hybrids, the highest yields were given by P63LE13 (4907 kg ha^{-1}) and NK Neoma (4550 kg ha^{-1}) in 2012 and by Tutti (5970 kg ha^{-1}) and P63LE13 (5639 kg ha^{-1}) in 2013. These results draw attention to the importance of hybrid selection in modern sunflower production. According to the experimental results, the disease infection values and the degree of lodging were considerably higher in the year of 2012 with a wet season and unfavourable distribution of precipitation as compared to the drier year of 2013. In the experiments of Ruzsányi and Csajbók (2001), the primary yield-determining factor was the disease infection level. As a result of this, the yields of the hybrids were 256 – 1613 kg ha^{-1} higher in the control (extensive model) and 553 – 1710 kg ha^{-1} higher in the mid-tech model (two fungicide treatments) in 2013 than in 2012.

The yield-increasement of the mid-tech model as compared to the extensive model was 473 – 725 kg ha^{-1} (609 kg ha^{-1} as an average of the hybrids) in 2012 and 514 – 953 kg ha^{-1} (average: 777 kg ha^{-1}) in 2013. Our results proved that the mid-tech technology model (two fungicide treatments in the season) can be applied with favourable agrotechnical efficiency in different years for all the tested hybrids.

References

Bedő, Z. (2003): Development of crop production technologies for multifunctional agriculture. Acta Agronomica Hungarica. 51. 83–90. DOI: http://dx.doi.org/10.1556/aagr.51.2003.1.11

Borbélyné, HÉ., Csajbók, J., Lesznyák, M. (2007): Relations between the yield of sunflower and the characteristics of the cropyear. Cereal Research Communications. 35:2. 285-288. DOI: http://dx.doi.org/10.1556/crc.35.2007.2.30

Borbélyné, HÉ., Lesznyák, M. (2006): Investigating yield and phenological stages of sunflower varieties in agro-ecological environment. Cereal Research Communications. 34:1. 417-420. DOI: http://dx.doi.org/10.1556/crc.34.2006.1.104

Borbélyné, HÉ., Pepó P., Kutasy, E., Zsombik, L. (2002): Az évjárat hatása különböző napraforgó genotípusok termésére, minőségére és agronómiai jellemzőire. In: Jávor A. (szerk.) Innováció, a tudomány és a gyakorlat egysége az ezredforduló agráriumában: Plenáris ülés. 2002.04.10-11. Debrecen. 257-262.

Branimir, S., Jasenka, C., Ruza, P., Karolina, V. (2008): Influence of climate conditions on grain yield and appearance of white rot (Sclerotinia sclerotiorum) in field experiments with sunflower hybrids. Cereal Research Commuications. 36. 63-66.

Cerny, I., Veverková, A., Mátyás, M., Kovár, M. (2013): Evaluation of year weather conditions and hybrids impact on the sunflower (Helianthus Annuus L.) achene yield and fat content. Journal of Microbiology, Biotechnology and Food Sciences. 2. 1846-1855.

Mijic, A., Liovic, I., Kovacevic, V., Pepó, P. (2012): Impact of weather conditions on variability in sunflower yield over years in eastern parts of Croatia and Hungary. Acta Agronomica Hungarica. 60:4. 397–405. DOI: http://dx.doi.org/10.1556/aagr.60.2012.4.10

Mukhtar, I. (2009) Sunflower Disease And Insect Pests In Pakistan: A Review. African Crop Science Journal. 17:2. 109 - 118 pp. DOI: http://dx.doi.org/10.4314/acsj.v17i2.54204

Pepó, P. (2010): A napraforgó növényvédelme. Magyar mezőgazdaság. 22-25.

Ruzsányi, L., Csajbók, J. (2001): Termésstabilitás és az évjárat kölcsönhatása a fontosabb szántóföldi növényeinknél. Agrártudományi Közlemények. 2. 41-46.

Szabó, A. (2008): Napraforgó hibridek tőszámreakciójának értékelése regresszió- és stabilitásanalízissel. Agrártudományi Közlemények = Acta Agraria Debreceniensis. 32. 101-109.

Szabó, A. (2011): Study of agrotechnical response in sunflower (Helianthus annuus L.) production. Analele Universitatii din Oradea. Fascicula: Protectia Mediului 17 Oradea: University of Oradea Publishing House. 147-154

Szabó, A. (2012): Az integrált napraforgó termesztés néhány kritikus agrotechnikai tényezőjének értékelése. In: Lehoczky É. (szerk) I. Talajtani, Vízgazdálkodási és Növénytermesztési Tudományos Nap: Talaj, víz, növény kapcsolatrendszer a növénytermesztési térben. 2012.11.23., Debrecen. MTA Talajtani és Agrokémiai Kutatóintézet, Budapest. 217-220. 12.

Szabó, A. (2013): Evaluation on the critical agrotechnical factors of the integrated sunflower production on chernozem soil. Növénytermelés. 62:Suppl. 115-118.

Szabó, A., Pepó, P. (2005): Effect of agrotechnical and meteorological factors on yield formation in sunflower production. Cereal Research Communications. 33:1. 49-52. DOI: http://dx.doi.org/10.1556/crc.33.2005.1.11

Treitz M. (2003): Napraforgó hibridek rezisztencia-vizsgálata a Diaporthe helianthi (Muntanola-Cvetkovic et al.) kórokozó gombával szemben. Doktori értekezés. Keszthely

Zsombik, L. (2006): Effect of sowing time on yield and oil content of different sunflower hybrids. Cereal Research Communications. 34:1. 725-728. DOI: http://dx.doi.org/10.1556/crc.34.2006.1.181

 DOI: 10.18380/SZIE.COLUM.2014.1.2.101