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Effects of Sowing Time on Yield and Oil Content of Different Sunflower Genotypes in Years with Different Water Supply

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***Abstract*—**We examined the effects of the sowing time on the yield production and oil content of the sunflower hybrids in 2010 and 2012. The crop year and the sowing time had both a strong impact on the yield, on the oil- content and yield. By delaying the sowing time both the yield crop result and the oil yield increased. In 2010 in terms of crop yield and oil yield results PR64H42 was the best, in 2012 NK Neoma, in all three sowing times. The oil content of the hybrids was better in 2010. The highest oil content was recorded at early sowing time. We found out that the hybrid had a stronger impact in 2010 on both crop yield result and on oil content than in 2012. The sowing time played a bigger role regarding yield results in 2012. In addition the sowing time influenced oil content development highly.

***Keywords*—**Genotypes, oil content, sowing time, sunflower, yield.

I. Introduction

AFTER cereals oilseeds are the second largest field crop group in the world. Among oil seeds in Hungary sunflower is most frequently grown (550,000ha) [1]. In Hungary, sunflower has very significant role in the production of vegetable oil [2]. Sunflower is extremely sensitive to vintage [3]. This means that our extreme weather conditions these days bear a higher and higher risk in sunflower growing. That is why the optimization of agro-industrial factors gets a more and more important role (sowing technology, sowing time and plant density) [4]. Weather circumstances have an important effect on yield [5], the oil content and oil yield [6]. Oil content depends mainly on the hybrid (69.6%) but vintage (10.3%) and sowing time (6.8%) are also important factors. However oil yield is mainly influenced by the vintage (58.8%), sowing times (12.9%) and hybrid (10.7%) are less important factors [7]. Sowing time does not only influence the oil content but the yield as well. The highest seed yield (4.47t ha^{-1}) was obtained at the early sowing date and the highest oil % (45.32) at the late sowing time [8]. Early sowing has a beneficial effect on yield results, the oil content [9], [10] and the oil yield [11] as well. However if occurred that the latter sowing had a positive influence on yield result [12]. The maximum yield (4717kg ha^{-1}) was obtained in the case of the mid-April sowing date in the average of hybrids. Both earlier or later sowing dates led to yield reduction (3712kg ha^{-1}, 4228kg ha^{-1}) [13].

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II. Materials and Methods

The research was set up on chernozem soil with lime patches at the Látókép AGTC MÉK research area of the University of Debrecen. The research area is located in Eastern-Hungary, 15km 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.

In a specific experiment (dispense with fungicide) we searched the effects of sowing time on sunflower yield, oil content and oil yield in 2010 and 2012. In the experiment we used three different hybrids (NK Neoma, NK Ferti, PR64H42). Hybrid NK Neoma is an imidazolin resistant, traditional oil sunflower while, 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. In 2010 and 2012, previous crops were winter wheat. The sowing times are recorded in Table I.

TABLE I
Applied Sowing and Harvesting Time (Debrecen, 2010, 2012)

Crop year	Early sowing time	Average sowing	Late sowing time
	Sowing time		
2010	26.03.2010.	09.04.2010.	03.05.2010.
2012	23.03.2012.	10.04.2012.	05.05.2012.
	Harvesting time		
2010		14.09.2010.	
2012		10.09.2012.	19.09.2012.

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. The dates of harvesting are also in Table I, harvesting was made with a Sampo parcel harvester, installed with a special adapter. At harvest we measured the raw plant and its moisture content. We standardized the yield results and oil content to an 8.0% moister content.

The crop year of 2010 was an extreme wet one, because the amount of precipitation was over 80mm in each month, which means an extraordinary deviation from the average values

(difference: 184.6mm). The average temperature in the vegetation period was 17.8°C, which is 0.8°C higher than the last 30 years' average. This extremely humid period favors the appearance and spread of pathogens, so our stands were highly infected.

The weather of 2012 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 (see Table II).

TABLE II
THE AMOUNT OF RAINFALL AND TEMPERATURE DURING IN THE INVESTIGATED CROP-YEARS (DEBRECEN, 2010, 2012)

Precipitation (mm)					
Months	30 year's average	2010	Difference	2012	Difference
April	42.4	83.9	41.5	20.7	-21.7
May	58.8	111.4	52.6	71.9	13.1
June	79.5	100.9	21.4	91.7	12.2
July	65.7	97.2	31.5	65.3	-0.4
August	60.7	98.3	37.6	4.1	-56.6
Totally	**307.1**	**491.7**	**184.6**	**253.7**	**-53.4**
Temperature (°C)					
Months	30 year's average	2010	Difference	2012	Difference
April	10.7	11.6	0.9	11.7	1.0
May	15.8	16.6	0.8	16.4	0.6
June	18.8	19.7	0.9	20.9	2.1
July	20.3	22.0	1.7	23.3	3.0
August	19.6	19.0	-0.6	22.5	2.9
Average	**17.0**	**17.8**	**0.7**	**19.0**	**1.9**

III. RESULTS AND DISCUSSION

The yield crop determines the oil yield result, so the parameters of these two showed a very similar tendency during our examination. During our experiment the rearing year had a high impact on the yield crop, so on the oil yield as well. The humid weather of 2010 favored the appearance and spread of fungal infections. Due to this the yield crop of 2010 was 17.2% less than in 2012 in terms of hybrids' and sowing times' average. Concerning the two years yield crop results the biggest difference appeared in the late sowing time. In terms of hybrids' and sowing times' average the crop yield results were 24.1% less in 2010 than in 2012. In 2010 we recorded lower yield results and oil yields both at NK Neoma and NK Ferti than in 2012. Instead, hybrid PR64H42 showed almost the same yield results in early and late sowing times (early: 3150kg ha^{-1} and 3126kg ha^{-1}; late: 3506kg ha^{-1} and 3619kg ha^{-1}), and oil yields (early: 1424kg ha^{-1} and 1378kg ha^{-1}; late: 1503kg ha^{-1} and 1479kg ha^{-1}) in rearing year. At average sowing time we reached the best results in 2010 at both parameters (yield crop result: 4487kg ha^{-1}, oil yield: 1971kg ha^{-1}).

Besides vintage, the sowing time had a strong impact on the yield crop and the oil yield results. By extending of the sowing time both yield crop results (except of hybrid PR64H42 in 2010) and oil yield results (except of hybrid PR 64H42) grew. These differences however were not significant. In case of hybrid PR64H42 we measured the best oil yield results in both years at average sowing time (2010: 1971kg ha^{-1}, 2012: 1505kg ha^{-1}). The lowest crop yield results were recorded at early sowing time in both years and at all three hybrids. The NK Neoma (2010: 2953kg ha^{-1}, 2012: 4772kg ha^{-1}) and the NK Ferti (2010: 3134kg ha^{-1}, 2012: 424kg ha^{-1}) hybrids optimal sowing time was the late sowing time. In case of hybrid PR64H42 we found that the optimal sowing time in 2012 was the late (3619kg ha^{-1}), however in 2010 the average sowing time (4487kg ha^{-1}).

Effect of sowing time was influenced by the rearing year's weather conditions. In case of hybrid NK Neoma applying the early sowing time instead of the optimal sowing time, showed a yield decrease of almost the same rate (2010: 22.8%; 2012: 22.2%). In case of hybrids NK Ferti and PR64H42 the change from optimal to another sowing time showed different degrees of yield results' decrease. Hybrid PR64H42 showed a higher decrease in yield results in 2010 when not applying the optimal sowing time (2012: 29.8%, 2012: 13.6%).

Examining all three sowing times we found out that in regard of oil yield and crop yield results the weakest hybrid in 2010 was NK Neoma (average sowing times yield crop result: 2608kg ha^{-1}, oil yield: 1188kg ha^{-1}), in 2012 the weakest hybrid was PR64H42 (average sowing times yield crop result: 3375kg ha^{-1}, oil yield: 1454kg ha^{-1}). On the contrary in regard of oil yield and crop yield results the best hybrid was PR64H42 in 2010 (average sowing times yield crop result: 3714kg ha^{-1}, oil yield: 1833kg ha^{-1}), and NK Neoma in 2012 (average sowing times yield crop result: 4152kg ha^{-1}, oil yield: 1683kg ha^{-1}) in all three sowing times.

According to our experiments, similar to the crop yield results and oil yield results, the oil content was different in the two rearing years. Unlike the crop yield results, the oil content of the hybrids was better in 2010 (except in case of averages sowing time at hybrid PR64H42), which is explicable by the extreme heat at the time of achene filling. In 2010 – depending on hybrid and sowing time – the oil content difference was between 42.9 – 46.5%, while in 2012 the difference was only between 39.6 – 44.5%. In case of hybrids' and sowing times' average oil content was 7.5% weaker in 2012 than in 2010.

Sowing time did not only influence the crop yield result but also the degree of oil content, however the oil content change due to the sowing time was not always significant. In 2010 we measured the best oil content at all three hybrids at early sowing time (NK Neoma: 46.5%, NK Ferti: 46.4%, PR64H42: 45.2%). In 2012 early sowing time brought the best oil content

results in early sowing time in case of hybrids NK Neoma (41.5%) and NK Ferti (42.9%), while in case of hybrid PR64H42 the optimal result was measured at average sowing time (44.5%). Significant differences between the oil content of hybrids in 2010 were measured at late sowing time: between NK Neoma (45.5%) and PR64H42 (42.9%), as well as between NK Ferti (45.4%) and PR64H42 (42.9%). In 2012 at average sowing time a significant difference in the oil content results were measured between NK Neoma (39.6%) and PR64H42 (44.5%) (see Table III).

TABLE III
THE EFFECT OF SOWING TIME ON THE YIELD, OIL CONTENT AND OIL YIELD OF THE SUNFLOWER (DEBRECEN, 2010, 2012)

Crop year		2010			2012		
Hybrids	Sowing time	Yield (kg ha^{-1})	Oil yield (kg ha^{-1})	Oil content (%)	Yield (kg ha^{-1})	Oil yield (kg ha^{-1})	Oil content (%)
	Early	2281	1061	46.5	3712	1541	41.5
NK Neoma	Average	2590	1160	44.8	3972	1573	39.6
	Late	2953	1343	45.5	4772	1933	40.5
Average of sowing time		**2608**	**1188**	**45.6**	**4152**	**1683**	**40.5**
	Early	2675	1241	46.4	3142	1347	42.9
NK Ferti	Average	2873	1293	45.0	3437	1414	41.1
	Late	3134	1423	45.4	4242	1712	40.4
Average of sowing time		**2894**	**1319**	**45.6**	**3607**	**1491**	**41.5**
	Early	3150	1424	45.2	3126	1378	44.1
PR64H42	Average	4487	1971	43.9	3381	1505	44.5
	Late	3506	1503	42.9	3619	1479	40.9
Average of sowing time		**3714**	**1633**	**44.0**	**3375**	**1454**	**43.2**
$LSD_{5\%}$ (Hybrids)		390.5	233.5	1.8	531.3	244.9	3.1
$LSD_{5\%}$ (Sowing time)		167.2	113.7	0.7	259.4	119.6	1.0
$LSD_{5\%}$ (Interaction)		289.5	197.0	1.2	449.3	207.1	1.7

We applied Pearsons's correlation to determine the degree and course of the relationships between the examined hybrids, sowing time, yield and oil content. 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.

From the study results we found out that the hybrid had a stronger impact on both crop yield result (very strong positive correlation: r=0.725**) and on oil content (strong, opposite correlation: r=0.557**) in 2010, than in 2012 (strong, opposite correlation: r=0.534**; r=0.458**). Sowing time played a bigger role in 2012 in terms of the yield results, which is proven by the strong relationship between the two factors (r=0.608**). In addition the sowing time influenced the development of oil content in both rearing years, as we found a strong connection between them in 2010 (r=0.510**) and a middle strong in 2012 (r=0.458**).

TABLE IV
CORRELATION BETWEEN THE ANALYZED PARAMETERS (DEBRECEN, 2010, 2012)

Crop year	Factors	Yeald	Oil content
2010	Hybrid	0.725(**)	-0.557(*)
	Sowing time	0.325	-0.510(*)
2012	Hybrid	-0.534(**)	-0.458(**)
	Sowing time	0.608(**)	0.533(**)

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

IV. CONCLUSION

In our experiment the rearing year and the sowing time had both a strong impact on the yield crop result, on the oil content and on the oil yield. The amount of yield crop defines the rate of oil yield, so the changing of these two factors shows very similar tendencies and parameters. In terms of yield crop and oil yield results 2012 was a better year for NK Neoma and NK Ferti, and 2010 for PR64H42. By delaying the sowing time both the yield crop result (except PR64H42 in 2010) and the oil yield (except PR64H42) increased. In 2010 in terms of crop yield and oil yield results hybrid PR64H42 was the best, in 2012 NK Neoma, in all three sowing times. In the achene filling period with a very warm weather of 2012 the oil content of the hybrids was better in 2010 from the two rearing years (except PR64H42 in average sowing time). The highest oil content was recorded at early sowing time (except hybrid PR64H42 in 2012). With the help of Pearson-correlation we found out that the hybrid had a stronger impact in 2010 on both crop yield result (r=0.725**) and on oil content (r=-0.557**) than in 2012 (r=-0.534**, r=-0.458**). The sowing time played a bigger role regarding yield results in 2012 (r=0.608**). In addition the sowing time influenced oil content development highly in both rearing years (r=-0.510*, r=-0.458**).

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