The effect of crop protection and agrotechnical factors on sunflower in the Hajdúság region

Szabó András – Fülöp Lajos Dóka

Institute of Crop Science, Faculty of Agricultural and Food Sciences and Environmental Management, Centre for Agricultural and Applied Economic Sciences, University of Debrecen, H-4032 Debrecen Böszörményi str. 138.,e-mail:szabo@agr.unideb.hu

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Summary

Extreme weather conditions are becoming more and more frequent in the crop years, thus increase the risk of sunflower production. The objective of researches into plant production is to minimize these effects as much as possible. In this sense, the optimization of agrotechnological factors is of high importance. Within these factors, the appropriate crop technology (sowing time, crop density) and optimized, rational crop protection technologies are important, especially in the highly sensitive sunflower cultures. The effect of sowing time, crop density, and fungicide treatments on the yield of sunflower hybrids was analysed in different crop years in 2008 and 2009. In each case, the infection was highest with the early sowing time and at the highest crop density level (65000 ha^{-1}). When one fungicide treatment was applied, the rate of infection decreased compared to the control treatment. The further decrease of the infection rate was less after the second fungicide treatment.

In the humid year of 2008 the crop yield was the highest at 45000 ha^{-1} crop density level in the control treatment and at 55000 crop ha^{-1} crop density level when fungicides were applied. In the draughty year of 2009 the maximum yield was gained at 55000 ha^{-1} crop density level in the control treatment and at 65000 crop ha^{-1} when fungicides were applied. In 2008 and 2009 as regards the crop yield, the difference between the optimal and minimal crop density levels was higher in the fungicide treatments than in the control treatment (in 2008: control: 517 kg ha^{-1}; one application of fungicides: 865 kg ha^{-1}; two applications of fungicides: 842 kg ha^{-1}), (in 2009: control: 577 kg ha^{-1}; one application of fungicides: 761 kg ha^{-1}; two applications of fungicides: 905 kg ha^{-1}).

In each and every case, the first treatment with fungicides was more effective than the second. In 2008, the highest yield was obtained with the third, late sowing time in each fungicide treatment. The differences between the crop yields with different sowing times was less than in 2009, when the results of the second treatment exceeded those of the first and third treatment in each case.

INTRODUCTION, REVIEW OF SCIENTIFIC LITERATURE

The success of sunflower production is significantly influenced by the effects of the crop year and the agrotechnical factors. We have no influence on climatic factors however, their effect can significantly be reduced by sound agrotechnology. Using the right cropping technology and crop protection methods suitable for the hybrid, the land area and the crop year decreases the yield loss caused by diseases, increases the crop yield and improves the quality. The critical factor of sunflower production is the excessive vulnerability of hybrids to infections caused by fungi. The negative effect of stalk and head infections caused by different diseases was lower in draughty years than in humid years. Even today, the climatic conditions of the crop year cannot be predicted; however, the infection rate and the yield loss caused by the unfavourable weather can significantly be reduced by adequate and well-timed crop protection technologies. Recently, the crop yields have been varying significantly, weather extremes (uneven distribution of precipitation during the crop year, draughty periods, low temperature) were rather frequent and thus increased the risk of production.

Crop density is a major agrotechnological factor in sunflower production. Using the optimal crop density level enhances the yield potential of the hybrids.

Increasing crop density (above 50-55 thousand/ha) increases the costs and decreases the crop yield (Pepó et al. 2002). Besides the climatic conditions, the crop yields and the yield safety are also influenced by the water supply and water management of the soil (Birkás et al., 2006). Within the biological optimum, the yield potential was significantly influenced by the sowing time and the crop density level (Zsombik, 2007).

The yield potential of sunflower hybrids is highly influenced by the different agrotechnical and climatic factors applied in different crop years (for e.g. crop density, sowing time, etc.) (Borbélyné et al. 2007, Zsombik 2006).

Pepó and Szabó (2005) analysed the effects of agrotechnological factors at different crop density levels in sunflower. The results showed that in humid, cold crop years the yield was lower due to the higher degree of infection by stalk and head diseases. The optimal crop density level varied with the hybrids proving that in humid, cold years the optimal crop density level is determined by the resistance of the plant against stalk and head diseases. In dry years, since the spread of diseases is slower, the infection rate was lower, which was reflected in the yields and the oil yield as well. The agroclimatic factors have the most significant influence on the crop yield, while the effect of the hybrid composition was moderate. The emergence and intensity of diseases is significantly influenced by the hybrid composition, as well as the agroclimatic factors in the crop year (temperature, distribution and amount of precipitation) (Branimir et al., 2008).

The precipitation in the vegetation period has a significant influence on the emergence of the diseases as well as on the crop yield. If soil conditions are favourable, sunflower can utilize the precipitation accumulated before the vegetation period, the highest yield can be obtained in dry crop years (Borbélyné et al., 2007). Today the most critical factor of production technology is crop protection. Not only the weed control measures but also the prevention of diseases needs wide-range expertise. Today, the success lies in prevention and in the integrated application of chemical and agrotechnological methods. Besides the use of effective pesticides other factors, such as crop rotation, optimal nutrient supply, sound soil cultivation, optimal sowing time and crop density, control of weeds and volunteer weeds, cultivation of plant residues in the soil are of equal importance to obtain weed-free and healthy sunflower cultures. Out of the various pathogens of sunflower the most dangerous ones are powdery mildew (Plasmophara halstedii), Diaporthe stem canker (Diaporthe helianthi), white mould (Sclerotinia sclerotiorum) and grey mould (Botrytis cinerea). The origin of these diseases is the infected soil, and the disease development is conduced by temperate weather or high temperature together with humid weather conditions (Goór és Kissné, 1999).

Material and methods

The experiment was carried out at the Látókép Plant Cultivation Research Site of the Debrecen University. The site is about 15 km from Debrecen, near the route 33 on the loess ridge of the Hajdúság region. Its physical characteristics are that of semi-compacted clay category, the plasticity index of Arany is 43.

Examining the water management features of the soil we found that they are favourable, as characteristic of chernozem soils. According to the Várallyay classification it is ranked in category IV i.e. it has good water management and water storing capacity.

Crop density was set manually after the emergance of the young plant. Harvesting was done by Sampo parcel harvester applied with a special adapter. The raw yield and moisture content was measures at harvesting. The crop yields weer standardized at 8 % moisture content. In both years two hybrids were examined (2008: NK Delfi, PR64D82; 2009: Petunia, NK Kondi).

The design of the experiment was random-block, it was conducted in 4 repetitions. Three different sowing times were used (in 2008.: *1st sowing time:* 2008 29 March.; *2nd sowing time:* 2008 09 April; *3rd sowing time:* 2008 04 May; in 2009: *1st sowing time:* 2009 31 March.; *2nd sowing time:* 2009 18 April.; *3rd sowing time:* 2009 05 May) at four different theoretical crop density levels (35000-65000 crop ha^{-1}) with 10000 crop ha^{-1} stages. Fungicide treatment was applied at the 8-leaf stage on plots where fungicide treatment was applied once, and at the 8-leaf-stage and the flowering stages on plots with two fungicide treatments. The applied pesticides were Pictor (0,5 l ha^{-1}) in 2008 and Tanos (0,4 kg ha^{-1}) in 2009. We have reported the fenological, fenometrical, agronomical and pathological features of hybrids in four repetitions.

In 2008, the amount of precipitation was high, at the same time the weather was cold, which had a negative effect on sunflower hybrids. The amount of precipitation in the cropping season (441.7 mm) was much higher than the 30 year average (307.1 mm), while the average temperature increased the 30 year average by 1 °C. In each month in the cropping season the amount of precipitation was high, in June and July it even increased 140 mm.

In 2009, the precipitation in the cropping season was only third of the previous year’s (147.1 mm) and around half of the 30 year average. The distribution of the precipitation was very uneven. The amount of precipitation was significant in June (96.6 mm), however, in each month of the cropping season the amount of rainfall was very low. The amount of rain was 126.6 mm in the first quarter of the cropping season, which counted for 85 % of the amount fell in the vegetation period. In 2009 the average temperature of the cropping season was 1.6 °C higher than in the previous year, and it was 2.6 °C higher than the 30 year average. The average temperature in the first three months of the vegetation period (April, May, July) was 1.1 °C higher than the same value in 2008, while the average temperature of the first two months (July, August) was 2.5 °C higher than in 2008 (table 1-2.).

Table 1.

The amount of rainfall in the examined years
(Debrecen-Látókép, 2007-2009.)

2007-2008 (mm)											
october	november	december	january	february	may	april	may	june	july	august	Total
71,4	40,9	29,8	26,4	4,6	41,7	74,9	47,6	140,1	144,9	34,2	656,5
214,8						441,7					
						262,6			179,1		
2008-2009 (mm)											
october	november	december	january	february	may	april	may	june	july	august	Total
16,1	19,8	52,2	29,5	44	41,6	9,9	20,1	96,6	9,2	11,3	350,3
203,2						147,1					
						126,6			20,5		

Table 2.

The temperature profile int he examined years
(Debrecen-Látókép, 2007-2009.)

2007-2008 (°C)					
april	may	june	july	august	Average
11,4	16,8	20,6	20,4	20,6	18,0
18,0					
16,3			20,5		
2008-2009 (°C)					
april	may	june	july	august	Average
14,9	17,4	19,8	23,4	22,6	19,6
19,6					
17,4			23,0		

EVALUATION OF THE RESULTS

We have examined the effect of sowing time, crop density and different fungicide treatments on the infection and yield of sunflower hybrids.

As a result of the differences between the cropping seasons, our results showed significant differences in the agrotechnical and crop protection technologies in the two examined years. As a result of the different sowing times, crop density levels and fungicide treatments, the infection by Diaporthe and Sclerotinia, as well as by head diseases was different. In each case, the infection by head diseases, Diaporthe and Slerotinia was highest with the 1st sowing time and at the highest crop density level. The infection rates decreased with the 2nd and 3rd sowing times. The humid and cold year of 2008 was favourable for the spread of fungal diseases, therefore, the infection rates were higher. On the control plots where fungicides were not applied, the infection by Diaporthe, Sclerotinia and head diseases was highest on the average of the crop density level and the sowing times (48 %, 6.5 %, 30.8 %). One application of fungicides decreased the average infection rate of Diaporthe, Sclerotinia and head diseases by 9.0 %, 2.8 %, and 9.5 %, respectively. The second fungicide treatment further decreased the Sclerotinia and head diseases, but the decrease was less than that was between the non-treated and the once-treated plots (5.7 %, 1.5 %). The infection by Diaporthe decreased by 12%. On the average of the hybrids and the treatments in the experiment, the infection rate by Diaporthe, Sclerotinia and head diseases was 38%, 4.1 %, 22.6%, respectively (Table 3).

Table 3.

Infection rates in different crop protection and cultivation technologies on the average of the hybrids in 2008
(Debrecen-Látókép, 2008)

Fungicide treatment	Sowing time	Head diseases (%)	Sclerotinia (%)	Diaporthe (%)
Control	1. sowing time	41,7	9,6	57
	2. sowing time	31,8	6,5	54
	3. sowing time	18,8	3,3	34
	Average	***30,8***	***6,5***	***48***
	LSD5%	***3,9***	***0,9***	***6***
Once treated	1. sowing time	28,2	5,4	49
	2. sowing time	22,2	3,6	41
	3. sowing time	13,6	2,3	26
	Average	***21,3***	***3,7***	***39***
	LSD5%	***5,2***	***0,9***	***5***
Twice treated	1. sowing time	19,9	2,7	32

	2. sowing time	17,4	2,2	30
	3. sowing time	9,5	1,7	20
	Average	***15,6***	***2,2***	***27***
	LSD5%	***4,3***	***0,8***	***7***
Fungicide treatment	**Plant Density**	**Head diseases (%)**	**Sclerotinia (%)**	**Diaporthe (%)**
control	**35000 plant hectar^{-1}**	24,1	3,4	37
	45000 plant hectar^{-1}	27,5	4,9	39
	55000 plant hectar^{-1}	34,7	8,0	57
	65000 plant hectar^{-1}	36,8	9,7	60
	Average	***30,8***	***6,5***	***48***
	LSD5%	***3,9***	***0,9***	***6***
Once treated	**35000 plant hectar^{-1}**	15,8	1,9	31
	45000 plant hectar^{-1}	18,9	2,6	33
	55000 plant hectar^{-1}	24,3	4,8	45
	65000 plant hectar^{-1}	26,4	5,7	47
	Average	***21,3***	***3,7***	***39***
	LSD5%	***5,2***	***0,9***	***5***
Twice treated	**35000 plant hectar^{-1}**	10,3	0,9	23
	45000 plant hectar^{-1}	12,8	1,8	25
	55000 plant hectar^{-1}	18,6	2,7	29
	65000 plant hectar^{-1}	20,8	3,2	31
	Average	***15,6***	***2,2***	***27***
	LSD5%	***4,3***	***0,8***	***7***
Average of treatments		***22,6***	***4,1***	***38,0***

The dry weather in 2009 decreased the formation and spread of diseases, therefore, the infection rate of the examined pathological factors was lower. On the average of the hybrids and the treatments, the infection by Diaporthe, Sclerotinia and head diseases was 17%, 1.4% and 12 %, respectively. As a result of the lower infection pressure, the effect of the fungicide treatments was less than in the previous year in case of all diseases. One application of fungicides decreased the infection by only 6 %, 0.7 %, 3.7 % respectively. The second fungicide treatment resulted in further decrease of the infection rate (4 %, 0.3 %, and 3.3 %, respectively). As the number of treatments increased, the infection rate decreased at a lower degree (Table 4).

Table 4.

Infection rates in different crop protection and cultivation technologies on the average of the hybrids in 2009 (Debrecen-Látókép, 2009)

Fungicide treatment	**Sowing time**	**Head diseases (%)**	**Sclerotinia (%)**	**Diaporthe (%)**
Control	**1. sowing time**	24,5	3,2	40
	2. sowing time	16,5	2,1	21
	3. sowing time	5,8	0,8	8
	Average	***15,6***	***2,0***	***23***
	LSD5%	***6,1***	***0,4***	***6***
Once treated	**1. sowing time**	18,2	1,9	30
	2. sowing time	12,7	1,4	16
	3. sowing time	4,8	0,6	6
	Average	***11,9***	***1,3***	***17***
	LSD5%	***5,4***	***0,7***	***5***
Twice treated	**1. sowing time**	13,3	1,3	21
	2. sowing time	9,5	1,0	12
	3. sowing time	3,1	0,6	5
	Average	***8,6***	***1,0***	***13***
	LSD5%	***2,9***	***0,5***	***7***
Fungicide treatment	**Plant Density**	**Head diseases (%)**	**Sclerotinia (%)**	**Diaporthe (%)**
control	**35000 plant hectar^{-1}**	10,5	1,4	18
	45000 plant hectar^{-1}	14,1	1,9	21
	55000 plant hectar^{-1}	15,3	2,1	22
	65000 plant hectar^{-1}	22,5	2,8	32
	Average	***15,6***	***2,0***	***23***
	LSD5%	***6,1***	***0,4***	***6***
Once treated	**35000 plant hectar^{-1}**	7,8	0,8	14

	45000 plant hectar^{-1}	9,9	1,1	16
	55000 plant hectar^{-1}	13,0	1,5	17
	65000 plant hectar^{-1}	17,0	1,8	23
	Average	***11,9***	***1,3***	***17***
	LSD5%	***5,4***	***0,7***	***5***
Twice treated	**35000 plant hectar^{-1}**	5,6	0,7	10
	45000 plant hectar^{-1}	7,2	0,9	12
	55000 plant hectar^{-1}	9,4	1,1	13
	65000 plant hectar^{-1}	12,3	1,2	16
	Average	***8,6***	***1,0***	***13***
	LSD5%	***2,9***	***0,5***	***7***
Average of treatments		***12,0***	***1,4***	***17***

The agrotechnological factors, the crop protection technologies, as well as the crop year significantly influenced the crop yield and yield safety. Examining the effect of sowing times in 2008, we found that the later the sowing was done, the higher the yield was. On the average of the treatments the yields with the 1st, 2nd and 3rd sowing times were 4543 kg ha^{-1}, 4560 kg ha^{-1}, and 4820 kg ha^{-1}, respectively. The highest average yield was obtained on plots where fungicides were applied twice with all three sowing times (4818 kg ha^{-1}, 4750 kg ha^{-1}, 5051 kg ha^{-1}). The yield difference between the 1st and 2nd sowing times was minimal (17 kg ha^{-1}), the yield increase between the first and third sowing times was higher (273 kg ha^{-1}). In the control treatments (no fungicides applied) the yield difference between the three sowing times on the average of the crop density was lower than in the treatments where fungicides were applied (the difference between the 1st and 3rd sowing time is 169 kg ha^{-1}). The yield increase was the highest in the treatment where fungicide was applied once on the average of the crop density levels (the difference between the 1st and 3rd sowing time is 426 kg ha^{-1}). The second fungicide treatment resulted smaller yield increase.. The fungicide treatments increased the effects of the sowing times as well. With the first sowing time, on the average of the crop density levels the yield increase caused by the first fungicide treatment was 398 kg ha^{-1} compared to the control plot, while the yield increasing effect of the second treatment was 213 kg ha^{-1} , compared to the plot that was only treated with fungicides once. With the 2nd and 3rd sowing times compared to the control plot, the yield increase was singificant in the stands where fungicides were applied once (655 kg ha^{-1}, 522 kg ha^{-1}) and minor in the stands with a second fungicide treatment (29 kg ha^{-1}, 20 kg ha^{-1}).

The optimal crop density levels were 55 thousand ha^{-1} with the first sowing time and 45 thousand in the second and third sowing times on the average of the sowing times. In both treatments (one or two application of fungicides) with all three sowing times, the maximum yield was obtained at 55000 plant ha^{-1} on the average of the sowing times. In 2008 the difference between the optimal and minimal crop density levels was higher in case of the treated cultures that on the control plots (control: 517 kg ha^{-1}; one treatment: 865 kg ha^{-1}; two treatments: 842 kg ha^{-1}) (Table 5).

Table 5.

Crop yields in different crop protection and cultivation technologies on the average of the hybrids in 2008 (Debrecen-Látókép, 2008)

Fungicide treatment	Plant Density	1. sowing time	2. sowing time	3. sowing time	*Average*
Control	**35000 plant hectar^{-1}**	4008	3935	4082	***4008***
	45000 plant hectar^{-1}	4419	4582	4575	***4525***
	55000 plant hectar^{-1}	4451	4379	4506	***4445***
	65000 plant hectar^{-1}	3950	3940	4342	***4077***
Average		***4207***	***4209***	***4376***	***4264***
LSD5%		***321***	***256***	***396***	
Once treated	**35000 plant hectar^{-1}**	4213	4155	4480	***4282***
	45000 plant hectar^{-1}	4675	4916	5182	***4924***
	55000 plant hectar^{-1}	4938	5115	5388	***5147***
	65000 plant hectar^{-1}	4596	4699	5076	***4790***
Average		***4605***	***4721***	***5031***	***4786***
LSD5%		***279***	***310***	***276***	
Twice treated	**35000 plant hectar^{-1}**	4361	4268	4549	***4392***
	45000 plant hectar^{-1}	4839	4895	5114	***4949***
	55000 plant hectar^{-1}	5137	5061	5504	***5234***
	65000 plant hectar^{-1}	4936	4775	5040	***4917***
Average		***4818***	***4750***	***5051***	***4873***
LSD5%		***379***	***271***	***311***	
Average of treatments		***4543***	***4560***	***4820***	***4641***

In 2009, the highest yield (5090 kg ha^{-1}) was obtained with the 2nd sowing time on the average of the treatments. Both the earlier and the later sowing time caused yield loss (3731 kg ha^{-1}, 4741 kg ha^{-1}). The same tendency was experienced on the average of the crop density levels in all three treatments (control, one treatment, two treatments). Compared to the 1st sowing time, the yield increase with the 2nd sowing time ranged between 1333 kg ha^{-1} – 1383 kg ha^{-1}. Compared to the 2nd sowing time, the yield decrease with the 3rd sowing time ranged between 328 kg ha^{-1} and 354 kg ha^{-1}. On the average of the sowing times and crop density levels, the highest yield (4747 kg ha^{-1}) was obtained on the plot where fungicides were applied twice and it was lowest (4247 kg ha^{-1}) in the control stands. Due to the lower infection rate the yield increasing effect of the single fungicide application was lower than in the humid cropyear of 2008 (314 kg ha^{-1}, 316 kg ha^{-1}, 324 kg ha^{-1}) on the average of the crop density levels, but the effect of the 2nd fungicide treatment was significant with the 2nd and 3rd sowing times. Due to the effects of the cropping years, the maximum yield was realized at 55 thousand ha^{-1} with all three sowing times in the control treatment, at 65 thousand ha^{-1} with the 1st and 2nd sowing times on plots treated once and at 55 thousand ha^{-1} with the 3rd sowing time. On plots where fungicides were applied twice, the optimal crop density level was 65 thousand ha^{-1} with all three sowing times. In 2009, the difference between the optimal and minimal crop density levels in the fungicide treatments on the average of the sowing times was higher than in the control group (control: 577 kg ha^{-1}; one treatment: 761 kg ha^{-1}; second treatment: 905 kg ha^{-1}). The yield was the highest at 65 thousand ha^{-1} crop density level with the 2nd sowing time with two fungicide applications (Table 6).

Table 6.

Crop yields in different crop protection and cultivation technologies on the average of the hybrids in 2009 (Debrecen-Látókép, 2009)

Fungicide treatment	Plant Density	1. sowing time	2. sowing time	3. sowing time	*Average*
control	**35000 plant $hectar^{-1}$**	3120	4546	4181	*3949*
	45000 plant $hectar^{-1}$	3439	4787	4476	*4234*
	55000 plant $hectar^{-1}$	3760	5086	4731	*4526*
	65000 plant $hectar^{-1}$	3552	4786	4504	*4280*
Average		***3468***	***4801***	***4473***	***4247***
LSD5%		***402***	***402***	***402***	
Once treated	**35000 plant $hectar^{-1}$**	3336	4635	4374	*4115*
	45000 plant $hectar^{-1}$	3666	5006	4716	*4462*
	55000 plant $hectar^{-1}$	3984	5433	5079	*4832*
	65000 plant $hectar^{-1}$	4143	5499	4987	*4876*
Average		***3782***	***5143***	***4789***	***4571***
LSD5%		***426***	***426***	***426***	
Twice treated	**35000 plant $hectar^{-1}$**	3356	4813	4504	*4224*
	45000 plant $hectar^{-1}$	3861	5182	4940	*4661*
	55000 plant $hectar^{-1}$	4187	5580	5160	*4976*
	65000 plant $hectar^{-1}$	4372	5732	5285	*5129*
Average		***3944***	***5327***	***4972***	***4747***
LSD5%		***415***	***415***	***415***	
Average of treatments		***3731***	***5090***	***4744***	***4522***

CONCLUSIONS

Based on the average values of the examined two years, we found that the crop year, the crop density, the sowing time and the fungicide treatments are in interaction and thus strenghten or weaken the influence of one another. Table 1 and 2 reveils that in humid years the maximum yield can be obtained at lower crop density levels (45000-55000 ha^{-1}) while in dry cropyears higher crop density levels can be used (55000-65000 ha^{-1}). The application of fungicides allows of using higher crop density levels. In 2008 the yield of the control plots was highest at 45000 ha^{-1} while in plots with one or two fungicide application it was 55000 ha^{-1} . The tendency was the same in 2009 with the difference that on the control plots the maximum yield was obtained at 55000 ha^{-1} (4526 kg ha^{-1}) crop density level, while on the treated plots it was (4876 kg ha^{-1}, 5129 kg ha^{-1}). In 2008-2009, as regards the crop yields, the difference between the optimal and minimal crop density levels was higher on the average of the sowing times than in the control treatment (2008: control: 517 kg ha^{-1}; one treatment: 865 kg ha^{-1}; second treatment: 842 kg ha^{-1}), (2009: control: 577 kg ha^{-1}; one treatment: 761 kg ha^{-1}; second treatment: 905 kg ha^{-1}). However, the efficiency of the fungicide treatments is different. In humid cropyears the effect of one application of fungicides is better than in dry cropyears. The modifying effect of fungicide treatments on the yield varied with the different sowing times as well. In 2008 on the avereage of the sowing times, compared to the control treatment, the yield increase of the first fungicide treatment was 522 kg ha^{-1} on plots with one application, and only 87 kg ha^{-1} on plots with two applications. In 2009 the average yield increase caused by one fungicide application was lower (324 kg ha^{-1}). Thanks to the substantial amount of precipitation in June, the further yield increase on the plots with two fungicide treatments was higher than in the previous year. In 2008 due to the high amount of rainfall the different sowing times caused no significant differences in the yields. This year the yield average was highest with the 3rd sowing time on plots with two fungicide treatments. Due to the draught in April, in 2009 the yield of the 1st sowing time was well below that of the 2nd and 3rd sowing times. The highest yield was obtained with the 2nd sowing time. The average yield increase was 1383 kg ha^{-1}. Compared to the 2nd sowing time, the yield reduction was 355 kg ha^{-1} with the 3rd sowing time. In 2009, these yields were significantly lower (17 kg ha^{-1}, 259 kg ha^{-1}) (Figure 1-2).

Figure 1.: **Crop yields in different crop protection and cultivation technologies on the average of the hybrids in 2008 (Debrecen-Látókép, 2008)**

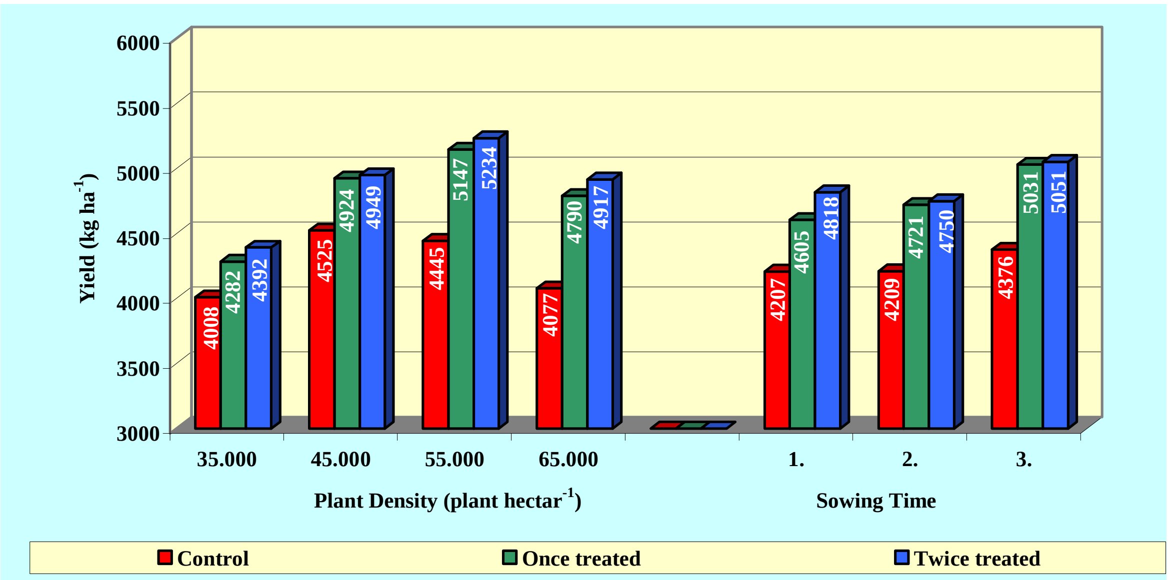
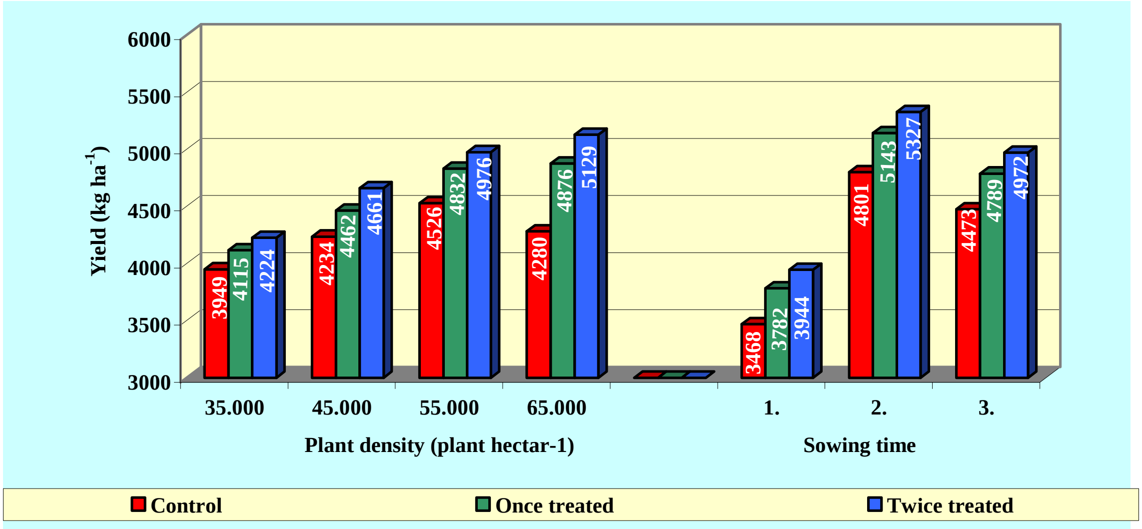


Figure 2.: **Crop yields in different crop protection and cultivation technologies on the average of the hybrids in 2009 (Debrecen-Látókép, 2009)**



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