Scientific Papers. Series A. Agronomy, Vol. LXI, No. 1, 2018
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

COMPARATIVE STUDY REGARDING THE INFLUENCE OF HERBICIDES ON THE YIELD OF SUNFLOWER CROPS, THE CROPS BEING OBTAINED WITH CONVENTIONAL, CLEARFIELD AND EXPRES SUN TECHNOLOGIES IN THE FIELD CONDITIONS OF MOARA DOMNEASCA

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Abstract

The sunflower is the most important cultivated plant in Romania for production of addible oil by seeds processing. The cultivated areas have increased a lot recently, ranging between 0.7-1 milions hectares. With the increase of the cultivated areas in the past years, the structure of the hybrids has changed very much. The hybrids cultivated by CONVENTIONAL technology decreased at the expense of hybrids resistant to Imazamox herbicide, type IMI, the cultivation technology being named CLEARFIELD and resistant to herbicide Tribenuron-methyl, the cultivation technology being named EXPRESSUN, named by the commercial brands of the herbicides. We may say with no fear of making mistakes that the cultivated area with conventional hybrids is very small, compared to the areas cultivated with the two hybrids resistant to the two herbicides mentioned. This situation leads to the fact that the weeds and their control became one of the most difficult to manage problems in sunflower culture. This is the reason for which we have initiated three years ago a study at the Experimental Didactic Centre from Moara Domneasca for the period 2015-2017, in order to reveal whether there are any differences among the three types of cultures as regards the obtained yields, what is the effect on weed control level and specially if the application of these herbicides in different periods has any influence on post emerging crops (remaining effect) in crop rotation process.

Key words*: hybrids resistant to herbicide*, *Clearfield, Express Sun, Conventional, remaining effect of herbicides.*

INTRODUCTION

One of the most important technological links in sunflower culture is weed control (Şarpe, 1987; Budoi, Penescu, 1996; Popescu et al., 1990; Penescu, Ciontu, 2001; Alonso et al., 1998; Brighenti et al., 2012). The emergence of sunflower hybrids resistant to certain types of herbicides has made this problem of weed control very easy for farmers. The unprecedented expansion of parasitic weeds on the *Orobanche cumana* (broomsrape) root made the surface cultivated sunflower hybrids obtained through the conventional method (without *Orobanche* resistance) to be much more reduced. The links known to be essential in limiting the growth of this weed, such as rotation and crop rotation, were reduced from 6 to 4 years, and in the case of new hybrid cultures resistant to this parasitic weed, even less than 4 years, sometimes 2-3 years. A large number of researchers have studied the efficacy of a large number of simple or combined herbicides in combating weeds in classical sunflower culture technology, giving the farmers at that time the opportunity to have a clean, productive and economical culture (Şarpe et al., 1983; Popescu et al., 1990; Ribeiro, Raiher, 2013; Ciontu et al., 2003). The level of the contamination with weeds, but especially its structure, the large number of weed generations per year, have determined the breeders to obtain hybrids resistant to certain types of herbicides. In our research we aim at studying the influx of three sunflower culture systems, Conventional, Clearfield and Express

Sun, respectively, on the level of weed infestation, its structure, production and the effect on post-emergent crops.

MATERIALS AND METHODS

The experience was carried out in the Experimental Field of the Faculty of Agriculture at Moara Domneasca between 2015 and 2017, on a preluvosoil type of soil with a pH of 6.5, humus content of 2.5, clay content of 35%.

The following hybrids have been studied:

- in the *Conventional* technology, the hybrid *PERFORMER*, created at INCDA Fundulea;
- in the technology *Clearfield*, the *NEOMA* hybrid from Syngenta Company;
- in the technology *Express Sun*, the hybrid *PR64LE19* from Pioneer Company.

The method of setting the experience was that of the subdivided plots. The surface of the experimental plot was 25 m^2 (3.7 x 7.8 m), placed in 4 randomized repetitions.

The herbicides used in the three combat systems were applied at two stages:

- *Optimal stage* 4-6 leaves of the sunflower plants;
- *Late stage* 8-10 leaves of the sunflower plants.

In the *Conventional* technology, the herbicide Modown 4F (bifenox) was used in a dose of 2.0 l/ha and 2.0 + 2.0 l/ha.

The herbicides applied were those used in Romania respectively:

- In the *Clearfield* technology, the Pulsar 40 SG (imazamox) herbicide was used at a rate of 1.2 l/ha and 1.2+1.2 l/ha;
- In the *Express Sun* technology, the Express 50 WG (tribenuron-methyl) herbicide at the dose of 0.030 kg/ha and 0.030 + 0.030 kg/ha, respectively.

To combat the annual monocotyledonous weeds, the Dual Gold 960 EC (s-metholachlor) herbicide was used in all three technological variants at a rate of 1.5 l/ha applied pre-emergence, immediately after sowing. During the vegetation period (post-emergence), for the control of *Sorghum halepense* from rhyzoms, the product Killer Super 5 EC (quisalofop-p-ethyl) was used in the dose of 1.75-2.0 l/ha.

The following indicators were determined prior to harvesting:

- The number of weeds/m^2, their dry weight/m^2 and their structure by species;
- Plant density (plants/m^2);
- Sunflower heads diameter (cm);
- Sunflower head weight (g);
- Grain weight on sunflower head (g);
- TWK (g);
- MH (kg)- hectolitric masse;
- Yield (kg/ha);
- The residual effect of all herbicides on crops from the crop rotation.

In order to establish the statistical significance, the variance analysis method was used.

RESULTS AND DISCUSSIONS

Climate conditions during the research period

The climatic conditions (temperature and precipitation) were approximately normal in the three years of research (2015-2017), as can be seen in Figures 1 and 2, where we present the average of these values.

From the analysis of the climatic conditions, temperature and rainfalls, we can say that all three years of research have been almost normal climatic years, which has led to both weeds and sunflower culture to developed normally.

The deviations from the multi-annual norm of the place were more obvious in the case of the temperatures in August and September + 4.8°C, respectively 4.0°C, and in the case of rainfalls in July and August when a deficit of -44.6 mm was achieved, respectively 14.7 mm.

In these months, an excessive drought happens, but in case of rainfalls we had in March and April positive deviations of +94 mm, 94 mm respectively, above the multi-annual average of the place (Figures 1 and 2).

Weed control

The weed control, presented in Table 1, in the three years of research highlights the following:

- the dominant weed species were the annual dicotyledonous *Xanthium strumarium*: 10.0 pl./m^2, *Hibiscus trionum*: 5.0 pl./m^2, *Chenopodium album*: 4.0 pl./m^2, but the perennial ones also had a great presence: *Cirsium arvense* 4.0 pl./ m^2, *Convolvulus arvensis* 4.0 pl./ m^2 and *Sonchus arvense* 2.0 pl./m^2. We can say that the level of weed contamination was very high;

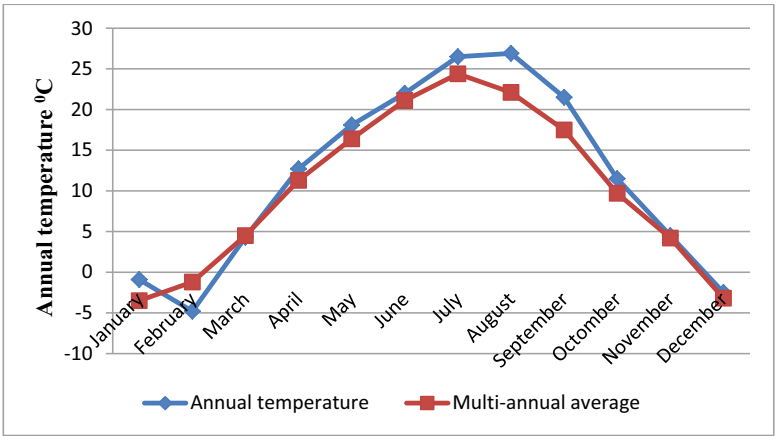


Figure 1. The evolution of average temperatures over the three-year study, compared to the multi-annual average from Moara Domnească (2015-2017 average)

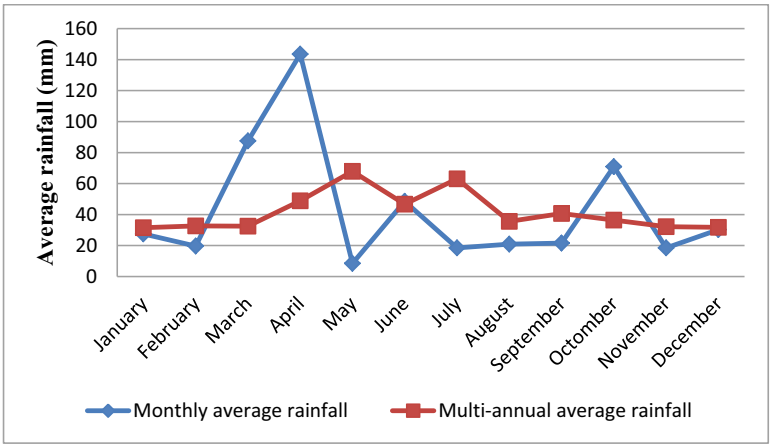


Figure 2. Evolution of the rainfalls, on average over the three years of study, compared to the multi-annual average from Moara Domnească (2015-2017 average)

- the best results in weed control were obtained in *Clearfield* and *Express Sun* technologies, approaching the values of Witness II (Standard II), in which three mechanical cultivations and three manual cultivations and untreated with herbicides were applied (Table 1). Poor weed control values were obtained in the conventional technology, ie the herbicide applied, Modown 4F (bifenox), failed to combat the entire weed spectrum experienced in the three years of experimentation due to the reduced control spectrum (Table 1).

The best values were obtained as follows: The Clearfield system of weed control in the Ist stage distinctly significantly positive, respectively very significantly positive at the dose of imazamox of 2.0 + 2.0 l/ha. And in the Express Sun System, distinctly significantly positive in variant with tribenuron-methyl 0.030 kg/ha, respectively very distinctly significant in the two applications version (0.030 + 0.030 kg/ha). Poor results were obtained in the Conventional version with the bifenox herbicide, the control results being close to the value of Witness I (untreated, unsown) with distinctly significantly negative values in both variants (Table 1). This aspect happened due to the reduced spectrum of Modown (bifenox), both in the variant with one treatment as well as in the one where two

treatments were used repeatedly in both application stages.

Influence of the technological systems used on the productivity indicators

The results obtained during the three years of experimentation on the influence of the three weed control systems on the sunflower productivity elements are presented in Table 2 and highlight the following aspects:

- Very low values were obtained in all the indicators in the variants of Witness I (untreated with herbicides and unsown mechanically or manually), as well as in the variants where the Conventional system was used, the sunflower heads remained small (11.5 cm) for untreated Witness I, and in the variant where the Conventional technology was used, the diameter of the heads remained rather small 15.6 cm, compared to the value of the sown Witness II (24.1 cm);
- This is due to the large number of weeds that developed at free will, even if they were treated with bifenox 2.0 l/ha, resulting in small values of the diameter of the head, the weight of the grains on the head, the weight of the head and MMB (g). In these variants, the heads were small, with small seeds, many of them dried-up;
- Positive values of the productivity indicators obtained in the variants where Clearfield technology was used in which the diameter of the head exceeded 26 cm when applied only once and 27.2 cm when using 2 successive treatments;

Table 1. The weight of dry weeds (kg/ha) obtained before harvesting in the three experimental systems: *Conventional, Clearfield and Express Sun* (Average: 2015-2017), Moara Domeasca

System used	Experimental variants	Dose l,kg/ha	Weed quantity			
			Kg/ha	(%)	Difference kg/ha	Semnification
Stage I (4-6 leaves)						
Conventional	Untreated, unsown Witness	-	4800	Mt.I	4330	000
	Untreated Witness, mechanically and manually sown (3+3)	-	470	Mt.II	Mt.II	Mt.
	Bifenox 4 F	2.0	1200	255	730	000
	Bifenox 4 F + Bifenox 4 F	2.0 + 2.0	850	180	380	0
Clearfield	Untreated, unsown Witness	-	4912	Mt.I	4516	000
	Untreated, sown Witness (3+3)	-	701	Mt.II	Mt.II	Mt
	Imazamox	1.2	220	169	360	**
	Imazamox + Imazamox	1.2 + 1.2	170	176	531	***
Express Sun	Untreated, unsown Witness	-	4790	Mt.I	4465	000
	Untreated, sown Witness (3+3)	-	695	Mt.II	Mt.II	Mt.
	Tribenuron- methyl	0.030	216	169	479	**
	Tribenuron-methyl+ Tribenuron-methyl	0.030+0.030	104	186	591	***
Stage II (8-10 leaves)						
Conventional	Untreated, unsown Witness	-	4910	-	4456	000
	Untreated, sown Witness (3+3)	-	684	Mt.II	Mt.II	Mt
	Bifenox 4 F	2.0	1475	215	791	000
	Bifenox 4 F + Bifenox 4 F	2.0 + 2.0	1205	176	521	00
Clearfield	Untreated, unsown Witness	-	4875	-	4006	000
	Untreated, sown Witness (3+3)	-	876	Mt.II	Mt.II	MtII
	Imazamox	1.2	470	153	-406	*
	Imazamox + Imazamox	1.2 + 1.2	370	142	-506	**
Express Sun	Untreated, unsown Witness	-	4796	-	4398	000
	Untreated, sown Witness (3+3)	-	789	Mt.II	Mt.II	Mt.II
	Tribenuron - methyl	0.030	420	153	369	*
	Tribenuron - methyl+ Tribenuron - methyl	0.030+0.030	378	163	411	*

Dl 5% = 350 kg/ha
Dl 1% = 475 kg/ha
Dl 0.1% = 530 kg/ha

Table 2. Influence of the type of system used to control weeds on the productivity indicators of cultivated sunflower hybrids (Average: 2015-2017), Moara Domneasca

The system used	Experimental variants	Dose l,kg/ha	Density of plants /m^2	Diameter of calatidius (cm)	Weight of calatidius (g)	Grain weight / calatidius (g)	TWK (g)	MH (kg/Hl)
Stage I (4-6 leaves)								
Conventional	Untreated, unsown Witness	Mt.I*	5.3	11.5	82.4	28	27.1	28
	Untreated, sown Witness (3+3)	Mt.II**	5.4	24.6	146.2	45.6	43.0	38
	Bifenox 4 F	2.0	5.6	14.3	143.5	44.1	48.1	40
	Bifenox 4 F + Bifenox 4 F	2.0 + 2.0	5.5	15.6	144.2	44.1	48.2	45
Clearfield	Untreated, unsown Witness	Mt.I	5.5	10.2	86.5	26.0	30.2	30
	Untreated, sown Witness (3+3)	MtII	5.7	24.5	147.5	49.1	56.1	43
	Imazamox	1.2	5.8	26.0	151.2	49.7	55.1	45
	Imazamox + Imazamox	1.2 + 1.2	5.6	27.2	152.4	50.1	43.0	44
Express Sun	Untreated, unsown Witness	Mt.I	5.5	11.2	75.4	25.7	30.1	29
	Untreated, sown Witness (3+3)	Mt.II	5.5	25.1	134.5	49.8	42.5	44
	Tribenuron-methyl	0.030	5.6	26.5	147.5	50.6	54.2	45
	Tribenuron-methyl+ Tribenuron-methyl	0.030+0.030	5.7	26.1	151.2	50.8	57.1	43
Stage II (8-10 leaves)								
Conventional	Untreated, unsown Witness	-	5.4	10.5	74.2	24.1	28.5	24
	Untreated, sown Witness (3+3)	-	5.3	24.7	136.5	48.5	43.2	32
	Bifenox 4 F	2.0	5.4	17.5	128.4	36.2	40.2	35
	Bifenox 4 F + Bifenox 4 F	2.0 + 2.0	5.6	16.4	130.5	39.5	40.1	37
Clearfield	Untreated, unsown Witness	-	5.3	10.4	76.2	24.8	27.9	25
	Untreated, sown Witness (3+3)	-	5.8	25.4	128.5	41.5	43.2	34
	Imazamox	1.2	5.6	26.7	130.4	40.2	40.7	38
	Imazamox + Imazamox	1.2 + 1.2	5.4	28.3	132.5	46.3	41.5	37
Express Sun	Untreated, unsown Witness	-	5.7	10.6	69.5	23.7	29.1	28
	Untreated, sown Witness (3+3)	-	6.0	24.9	127.4	40.5	40.3	34
	Tribenuron-methyl	0.030	5.7	25.9	131.2	40.2	42.7	35
	Tribenuron-methyl+ Tribenuron-methyl	0.030+0.030	5.6	25.4	130.4	39.6	41.9	35

*Mt.I= Witness untreated with herbicides and unsown mechanically or manually (or Standard I);
**Mt.II= Witness untreated with herbicides, mechanically (3) and manually sown (3) (or Standard II).

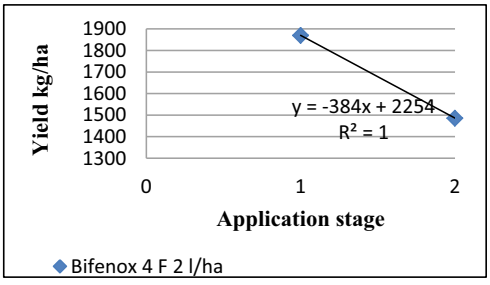
- Good results were also obtained in variants using *Express Sun* technology, values that exceeded the values of the diameter of calatidius in the case of Witness II mechanically and manually sown (3+3), values over 25.0 cm when the Express 50 WG herbicide (tribenuron-methyl) was applied only once and 26.5 cm when two successive treatments were applied. This is due to the almost complete destruction of annual and perennial dicotyledonous weeds, due to the systemic effect of these products, whereas in the case of the manually and mechanically sown standard, the perennial weeds (*Cirsium*, *Sorghum*, *Convolvulus*, *Polygonum*) have been sprouting until the harvest;
- The best values of the other productivity indicators (calatidius weight, grains weight, MMB) were obtained when the herbicides in *Clearfield and Express Sun* technologies were applied in Stage I (optimal stage). The more their application is delayed, the more the values of the productivity indicators worsen. In other words, in the case of sunflower culture it is recommended to use these products when the weeds are mostly grown and do not exceed 4-6 leaves or the height of 4-6 cm, and the sunflower plants are in the 4-6 leaves. The more the

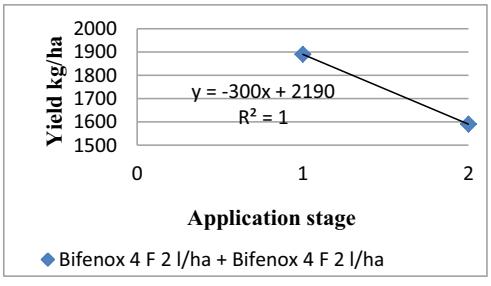
application of herbicides is delayed, the values of the indicators change negatively due to the competitive effect of the weeds with the sunflower plants for the vegetation factors: water, light, nutrients.

Influence of technological systems used to control weeds on sunflower production

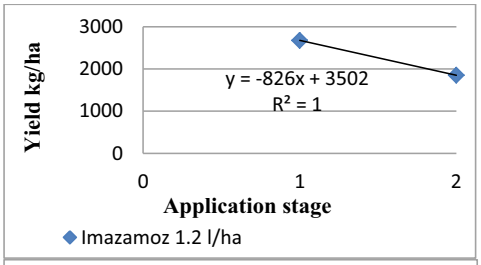
The values of the productions obtained in the three technological systems used for weed control are presented in Table 3 and highlight the fact that the best results were achieved by the *Clearfield* and *Express Sun* technological systems when the herbicides were applied in the first stage (4-6 sunflower leaves). In Clearfield technology at 1.2 l/ha Pulsar 4 SC (imazamox) dose, the production was 2676 kg/ha, and when 2 treatments were applied, the production was 2958 kg/ha.

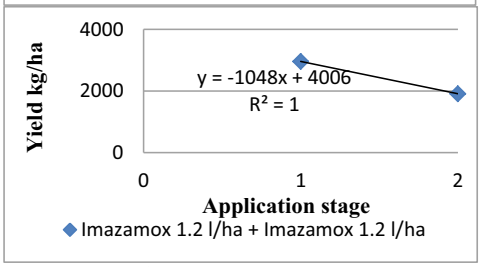
The late application of the herbicide and its application at the 8-10 leaves stage of the sunflower Stage II, 8-10 leaves, the production was reduced to 76% of the untreated Witness II value. In the variant with Conventional technology, it increased to 104% with *Clearfield* technology and 109% in the *Express Sun* technology variant, compared to the value of Witness II, manually and mechanically sown (3+3).



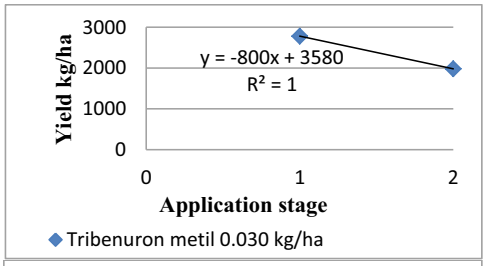


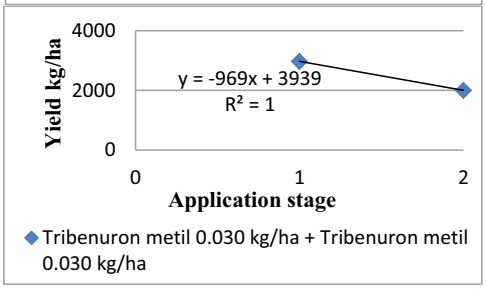
Figures 3, 4. The regression function for bifenox





Figures 5, 6. The regression function for imazamox





Figures 7, 8. The regression function for tribenuron-methyl

Unsatisfactory results were obtained in *Conventional Technology* when using the Modown 4 SC (bifenox) herbicide, which due to the reduced spectrum of control, made the production to remain way below the value of Witness II, sown and far from the productions obtained in the *Clearfield and Express Sun* technological variants. The regression functions (Figures 3, 4, 5, 6, 7, 8) between weed control technology and the application stage clearly shows that the best productions are obtained when these herbicides are applied in the Stage I (4-6 leaves of sunflower plants and 4-6 cm the height of the weeds).

Table 3. Influence of the type of system used to control weeds on sunflower yield (Average: 2015-2017), Moara Domneasca

System used	Experimental variants	Dose l,kg/ha	Yield			
			Kg/ha	%	Difference kg/ha	Semnifica -tion
Stage I (4-6 leaves)						
Conventional	Untreated, unsown Witness	-	1150	46	- 1325	000
	Untreated, sown Witness (3+3)	-	2475	100	Mt.II	Mt.II
	Bifenox 4 F	2.0	1870	75	- 605	000
	Bifenox 4 F + Bifenox 4 F	2.0 + 2.0	1890	76	- 585	000
Clearfield	Untreated, unsown Witness	-	1175	45	- 1395	000
	Untreated, sown Witness (3+3)	-	2570	100	Mt.II	Mt.II
	Imazamox	1.2	2796	109	226	*
	Imazamox + Imazamox	1.2 + 1.2	2958	115	388	**
Express Sun	Untreated, unsown Witness	-	1245	48	- 1315	000
	Untreated, sown Witness (3+3)	-	2560	100	Mt.II	Mt.II
	Tribenuron-metil	0.030	2780	109	220	*
	Tribenuron-methyl + Tribenuron-methyl	0.030+0.030	2970	116	410	**
Stage II (8-10 leaves)						
Conventional	Untreated, unsown Witness	-	1170	46	- 1320	000
	Untreated, sown Witness (3+3)	-	2490	100	Mt.II	Mt.II
	Bifenox 4 F	2.0	1486	60	- 1004	000
	Bifenox 4 F + Bifenox 4 F	2.0 + 2.0	1590	64	- 900	000
Clearfield	Untreated, unsown Witness	-	1148	46	- 1338	000
	Untreated, sown Witness (3+3)	-	2486	100	Mt.II	Mt.II
	Imazamox	1.2	2250	90	- 236	0
	Imazamox + Imazamox	1.2 + 1.2	2350	94	- 136	
Express Sun	Untreated, unsown Witness	-	1178	47	- 1320	000
	Untreated, sown Witness (3+3)	-	2498	100	Mt.II	Mt.II
	Tribenuron -methyl	0.030	2210	88	- 288	0
	Tribenuron -methyl+ Tribenuron- methyl	0.030+0.030	2201	888	- 297	0
Dl.5%=198kg/ha	Dl.1%=310 kg/ha		Dl.0.01%=415 kg.ha			

The residual effect of herbicides applied in the three sunflower weed control systems

Every autumn, after the sunflower, on the same site, after the preparation of the land for sowing (25-28 cm, 2 works with a disc harrow and a work with the combiner), autumn wheat was sown. In the *Conventional and Express Sun* technical variants, no phytotoxicity phenomena were observed, regarding the remaining effect of herbicides on wheat cultures. In other words, both the herbicide Modown and the herbicide Express, both for the single application and for the two successive treatments variants, in both application stages, no phytotoxic phenomena were observed in wheat plants either in the autumn immediately after sunrise, neither at the end of autumn nor spring. In variants where the *Clearfield technology* was used with the herbicide Pulsar 40SC (imazamox), in Stage I (4-6 sunflower leaves), a phytotoxic effect of 10-15% at a dose of 1.2 l/ha was noticed that is, 10-15% of the wheat plants were perished, the crops were hollow, the plants were yellow or white, and in the case of two successive treatments (1,2 + 1,2 l/ha), the phytotoxic effect was quite obvious, 35% at the one application dose and 40-45% more perished wheat plants when the products were applied in Stage II.

As such, when using Clearfield technology, after sunflower, it is recommended that no grainy cereals (wheat, barley, barley) to be sown in autumn, neither oats in spring. Due to the residual effect of the Pulsar 40 SC (imazamox) herbicide, especially on soils with little organic matter, pH less than 6.5 and high content of clay (over 35%).

CONCLUSIONS

The results obtained during the three years of experimentation 2015-2017, under the Experimental Field at Moara Domneasca of the

Faculty of Agriculture allow us to draw the following conclusions:

1. The best effect in weed control is achieved with *Clearfield and Express Sun technologies*. A weak effect in weed control has been achieved in *Conventional technology*, and it will be used only where it is possible to complete the weed control also with 1-2 mechanical hoes.

2. The best results on the productivity indicators were obtained in the *Clearfield and Express Sun* variants. Weak results were recorded in the *Conventional Technology* variant due to the reduced weed control spectrum of the Modown 4 F herbicide (bifenox).

3. Very good production results were obtained in the *Clearfield and Express Sun* technology variants when the herbicides were applied in Stage I (Optimal stage), 4 sunflower leaves and 4-6 cm weed height. Delaying the application of herbicides makes weeds grow very much, compete with sunflower plants and become very difficult to combat due to the highly developed root system and their size (in some cases over 15 cm high).

5. Following the *Clearfield technology*, it is imperative that the next plant be either leguminous or maize, given the residual effect of the imazamox herbicide.

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