

EFFICACY OF HERBICIDES AND THEIR TANK MIXTURES AT SUNFLOWER (*Helianthus annuus* L.)

Grozi DELCHEV

Trakia University, Students' Campus, Stara Zagora, Bulgaria

Corresponding author email: delchevkd@dir.bg

Abstract

The research was conducted during 2012-2014. Under investigation were 4 sunflower hybrids (*Helianthus annuus* L.): hybrid Bacardy (an imitolerant hybrid by ClearField plus technology), hybrid Estiva (an imitolerant hybrid by ClearField technology), hybrid Sumico (a tribenuron-methyl tolerant hybrid by ExpressSun technology) and hybrid Arizona (a hybrid by conventional technology). Factor A included the years of investigation. Factor B, herbicides and tank mixtures, included 20 rates. It includes 3 variants by ClearField plus technology, 5 variants by ClearField technology, 5 variants by ExpressSun technology and 7 variants by conventional technology. Herbicide Pulsar plus by ClearField plus technology and herbicide Listego by ClearField technology, destroy completely all annual and perennial graminaceous and broadleaved weeds in sunflower crops, including *Orobanche cumana* Wall. Herbicide Express by ExpressSun technology, controls all perennial and annual broadleaved weeds. Tank mixture of Express with antigraminaceous herbicide Select super controlled successfully and all annual and perennial weeds. The highest seed yield is obtained at herbicide tank mixture Pulsar plus + Stomp aqua by ClearField plus technology. Tank mixture Listego + Dash + Sharpen by ClearField technology and Express + Trend + Select super by ExpressSun technology also lead to obtaining of high seed yields. Tank mixtures of herbicides Smerch, Pendigan, Wing, Raft, Pledge and Modown with Amalgerol premium by conventional technology have lower yields due to insufficient control of weeds as *Xanthium strumarium* L., *Cirsium arvense* Scop., *Convolvulus arvensis* L. in sunflower crops.

Key words: oil-bearing sunflower, herbicides, tank mixtures, efficacy, selectivity, seed yield.

INTRODUCTION

A large part of oil-bearing sunflower in the world is grown by ClearField and ExpressSun technologies. There are significant areas in Bulgaria where sunflower still is grown by conventional technology. There are many unsolved problems in this technology about controlling of weeds such *Xanthium strumarium* L., *Cirsium arvense* Scop., *Convolvulus arvensis* L., *Orobanche cumana* Wall., which necessitated the introduction of new ExpressSun and ClearField technologies for growing of oil-bearing sunflower (Simić et al., 2012; Brighenti et al., 2012).

During creating situation of increasingly louder and more frequent drought occur serious problems that must be solved (Zand et al., 2009; Suresh & Reddy, 2010; Saskevich et al., 2011). One of these problems is for the efficacy and selectivity, i.e. the behavior of foliar-applied and soil-applied herbicides under these conditions.

It should to consider a number of factors that determine the effective application of these

complex organic compounds. Herbicides will remain in future agriculture efficient tool for control of weeds as part of an integrated weed control in sunflower, which is why there is need for research for optimization of their use (Mitric & Vuckovic, 2008; Jocić et al., 2011; Knežević et al., 2011; Delchev, 2018).

The purpose of this investigation was to establish the efficacy and selectivity of some herbicides, adjuvants, foliar fertilizer Lactofol B, growth regulator Amalgerol premium and their tank mixtures on the oil-bearing sunflower by influence of different meteorological conditions.

MATERIALS AND METHODS

The research was conducted during 2012-2014 on pellic vertisol soil type. Under investigation were 4 sunflower hybrids (*Helianthus annuus* L.): hybrid Bacardy (an imitolerant hybrid by ClearField plus technology), hybrid Estiva (an imitolerant hybrid by ClearField technology), hybrid Sumico (a tribenuron-methyl tolerant hybrid by ExpressSun technology) and hybrid

Arizona (a hybrid by conventional technology). Two factors experiment was conducted under the block method, in 4 repetitions, the size of the crop plot was 15 m². Factor A included the years of investigation. Factor B, herbicides and

tank mixtures, included 20 rates. It includes 3 variants by ClearField plus technology, 5 variants by ClearField technology, 5 variants by ExpressSun technology and 7 variants by conventional technology.

Table 1. Investigated variants

№	Variants	Active substance	Doses
ClearField plus technology - hybrid Bacardy			
1	Check	-	-
2	Pulsar plus	imazamox	1.2 l/ha
3	Pulsar plus + Stomp aqua	imazamox pendimethalin	1.2 l/ha + 2.3 l/ha
ClearField technology - hybrid Estiva			
4	Check	-	-
5	Listego 40	imazamox	1.2 l/ha
6	Listego 40 + Dash HC	imazamox *	1.2 l/ha + 500 ml/ha
7	Listego 40 + Sharpen 33 EC	imazamox pendimethalin	1.2 l/ha + 2.3 l/ha
8	Listego 40 + Dash HC + Sharpen 33 EC	imazamox * pendimethalin	1.2 l/ha + 500 ml/ha + 2.3 l/ha
ExpressSun technology - hybrid Sumico			
9	Check	-	-
10	Express 50 SX + Trend 90	tribenuron-methyl **	40 g/ha + 0.1 %
11	Express 50 SX + Lactofol B	tribenuron-methyl ***	40 g/ha + 8 l/ha
12	Express 50 SX + Trend 90 + Select super 120 EC	tribenuron-methyl ** clethodim	40 g/ha + 0.1 % + 1.6 l/ha
13	Express 50 SX + Lactofol B + Select super 120 EC	tribenuron-methyl *** clethodim	40 g/ha + 8 l/ha + 1.6 l/ha
Conventional technology - hybrid Arizona			
14	Check	-	-
15	Smerch 24 EC + Amalgerol premium	oxifluorfen ****	800 ml/ha + 5 l/ha
16	Pendigan 330 EC + Amalgerol premium	pendimethalin ****	4 l/ha + 5 l/ha
17	Raft 400 SC + Amalgerol premium	oxidiargil ****	800 ml/ha + 5 l/ha
18	Wing P + Amalgerol premium	pendimethalin + dimethenamid ****	4 l/ha + 5 l/ha
19	Pledge 50 WP + Amalgerol premium	flumioxazin ****	80 g/ha + 5 l/ha
20	Modown 4 F + Amalgerol premium	bifenox ****	1.5 l/ha + 5 l/ha

All of variants are treated on herbicide Gardoprim plus gold 500 SC (S-metolachlor + terbuthylazine) - 3.5 l/ha, which is applied after sowing before emergence of the sunflower.

***Lactofol B - nitrogen in amide, ammonium and nitrate forms, easily absorbable phosphorus and potassium, trace elements, amino acids, physiologically active substances, complex agent - lactic acid.

****Amalgerol premium - extract of sea algae, mineral oils, plant extracts, essential oils, macro- and micronutrients.

Active substances of preparations and their doses are shown in Table 1. All of them were treated during 3-4 pair leaves stage of the sunflower.

All of variants are on herbicide Gardoprim plus gold 500 SC (S-metolachlor + terbuthylazine) - 3.5 l/ha, which treated after sowing before emergence of the sunflower. All of herbicides and herbicide tank mixtures were applied in a working solution of 200 l/ha.

It was investigated efficacy and selectivity of herbicides and their tank mixtures. It was established their influence on seed yield. Efficacy of herbicides against weeds was appointed according to 100% scale of EWRS (European Weed Research Society). Selectivity of herbicides to sunflower plants was followed according to the 9-rate scale of EWRS (rating 1 - without damages, rating 9 - crop is completely destroyed). The mathematical processing is done with analysis of variance method.

RESULTS AND DISCUSSIONS

Dominant weeds that determine secondary weeding in the experiment field are annual broadleaved species *Xanthium strumarium* L., *Amaranthus retroflexus* L., *Amaranthus albus* L., *Chenopodium album* L., *Solanum nigrum* L., *Datura stramonium* L., *Abutilon theophrasti* Medic., *Polygonum aviculare* L., a lesser amount *Amaranthus blifoides* W., *Portulaca oleracea* L., *Hibiscum trionum* L., *Tribulus terrestris* L.

Annual grassy weeds are represented by *Echinochloa crus-galli* L., *Panicum sanguinale* L., *Setaria viridis* Beauv., *Setaria glauca* Beauv. In a lesser amount are *Avena fatua* L., *Echinochloa coarctata* Vas., *Setaria verticillata* Beauv.

Perennial species in experiment are broadleaved weeds *Cirsium arvense* Scop. and *Convolvulus arvensis* L. and graminaceous weed *Sorghum halepense* Pers. mainly by seeds.

Herbicides Pulsar plus and Listego destroy completely *Setaria viridis* Beauv., *Setaria glauca* Beauv., *Setaria verticillata* Beauv., *Echinochloa crus-galli* L., *Panicum sanguinale* L., *Amaranthus retroflexus* L., *Amaranthus albus* L., *Amaranthus blifoides* W., *Chenopodium album* L., *Sinapis arvensis* L.,

Solanum nigrum L., *Datura stramonium* L., *Abutilon theophrasti* Medic., *Polygonum aviculare* L., *Portulaca oleracea* L., *Hibiscum trionum* L., *Tribulus terrestris* L. et al. (Table 2). Pulsar plus and Listego fully destroyed and *Xanthium strumarium* L. These herbicides control successfully and perennial weeds - *Sorghum halepense* Pers. from seeds and rhizomes *Cirsium arvense* Scop. and *Convolvulus arvensis* L. (Table 3).

To the herbicide Listego is necessary to add adjuvant Dash for better control of weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L. Herbicide Pulsar Plus does not require adjuvants for the effective control of these weeds. Tank mixtures Pulsar plus + Stomp aqua and Listego + Sharpen ensuring effective control of secondary emerged annual weeds.

Pulsar plus and Listego fully control and *Orobanche cumana* Wall. This weed grows with the sunflower hybrids Bacardy (by ClearField plus technology) and Estiva (by ClearField technology), and then destroyed by herbicides. By one side Pulsar plus and Listego have completed control against this parasitic weed and by other side the herbicides decrease its seed reserve in the soil.

By conventional and ExpressSun technologies fight against *Orobanche cumana* Wall. is conducted by using resistant hybrids. Hybrids Sumico (by ExpressSun technology) and Arizona (by conventional technology) which are included in the experience are resistant to all its races.

Herbicide Express controls of 100% all perennial and annual broadleaved weeds - *Cirsium arvense* Scop., *Convolvulus arvensis* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Solanum nigrum* L., *Datura stramonium* L., *Abutilon theophrasti* Medic., *Portulaca oleracea* L., *Sinapis arvensis* L., *Polygonum aviculare* L., *Hibiscum trionum* L., *Papaver rhoes* L., *Capsella bursa-pastoris* L., *Tribulus terrestris* L. et al. To the herbicide Express is absolutely necessary adding adjuvant Trend for better control of weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L.

Table 2. Efficacy of some vegetation-applied herbicides and tank mixtures against annual broadleaved weeds at sunflower according to the 100% visual scale of EWRS (mean 2012-2014)

Variants	Weeds								
	<i>Xanthium strumarium</i>	<i>Amaranthus retroflexus</i>	<i>Chenopodium album</i>	<i>Solanum nigrum</i>	<i>Datura stramonium</i>	<i>Abutilon theophrasti</i>	<i>Polygonum aviculare</i>	<i>Sinapis arvensis</i>	
ClearField plus technology - hybrid Bacardy									
Check	0	0	0	0	0	0	0	0	
Pulsar plus - 1.2 l/ha	100	100	100	100	100	100	100	100	
Pulsar plus - 1.2 l/ha + Stomp aqua - 2.3 l/ha	100	100	100	100	100	100	100	100	
ClearField technology - hybrid Estiva									
Check	0	0	0	0	0	0	0	0	
Listego 40 - 1.2 l/ha	100	100	85	100	100	100	87	100	
Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha	100	100	100	100	100	100	100	100	
Listego 40 - 1.2 l/ha + Sharpen 33 EC - 2.3 l/ha	100	100	88	100	100	100	92	100	
Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha + Sharpen 33 EC - 2.3 l/ha	100	100	100	100	100	100	100	100	
ExpressSun technology - hybrid Sumico									
Check	0	0	0	0	0	0	0	0	
Express 50 SX - 40 g/ha + Trend 90 - 0.1 %	100	100	100	100	100	100	100	100	
Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha	96	100	90	100	100	100	93	100	
Express 50 SX - 40 g/ha + Trend 90 - 0.1 % + Select super 120 EC - 1.6 l/ha	100	100	100	100	100	100	100	100	
Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha + Select super 120 EC - 1.6 l/ha	96	100	90	100	100	100	93	100	
Conventional technology - hybrid Arizona									
Check	0	0	0	0	0	0	0	0	
Smerch 24 EC - 800 ml/ha + Amalgerol premium - 5 l/ha	96	100	100	100	100	100	100	100	
Pendigan 330 EC - 4 l/ha + Amalgerol premium - 5 l/ha	0	100	100	100	95	96	100	98	
Raft 400 SC - 800 ml/ha + Amalgerol premium - 5 l/ha	90	100	100	100	98	100	100	100	
Wing P - 4 l/ha + Amalgerol premium - 5 l/ha	0	100	93	100	80	90	95	92	
Pledge 50 WP - 80 g/ha + Amalgerol premium - 5 l/ha	90	100	100	100	100	95	100	100	
Modown 4 F - 1.5 l/ha + Amalgerol premium - 5 l/ha	0	100	100	100	100	100	100	100	

Gardoprim plus gold - 3.5 l/ha

Herbicide Express controls of 100 % all perennial and annual broadleaved weeds - *Cirsium arvense* Scop., *Convolvulus arvensis* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Solanum nigrum* L., *Datura*

stramonium L., *Abutilon theophrasti* Medic., *Portulaca oleracea* L., *Sinapis arvensis* L., *Polygonum aviculare* L., *Hibiscum trionum* L., *Papaver rhoes* L., *Capsella bursa-pastoris* L., *Tribulus terrestris* L. et al.

Table 3. Efficacy of some vegetation-applied herbicides and tank mixtures against perennial broadleaved, annual and perennial graminaceous weeds at sunflower according to the 100% visual scale of EWRS and selectivity according to the 9-rate scale of EWRS (mean 2012-2014)

Variants	Weeds							Selectivity
	<i>Cirsium arvense</i>	<i>Convolvulus arvensis</i>	<i>Echinochloa crus-gali</i>	<i>Setaria viridis</i>	<i>Setaria glauca</i>	<i>Digitaria sanguinalis</i>	<i>Sorghum helipense</i>	
ClearField plus technology - hybrid Bacardy								
Check	0	0	0	0	0	0	0	1
Pulsar plus - 1.2 l/ha	100	100	100	100	100	100	100	1
Pulsar plus - 1.2 l/ha + Stomp aqua - 2.3 l/ha	100	100	100	100	100	100	100	1
ClearField technology - hybrid Estiva								
Check	0	0	0	0	0	0	0	1
Listego 40 - 1.2 l/ha	100	100	100	100	100	100	90	2
Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha	100	100	100	100	100	100	100	2.5
Listego 40 - 1.2 l/ha + Sharpen 33 EC - 2.3 l/ha	100	100	100	100	100	100	90	2
Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha + Sharpen 33 EC - 2.3 l/ha	100	100	100	100	100	100	100	2.5
ExpressSun technology - hybrid Sumico								
Check	0	0	0	0	0	0	0	1
Express 50 SX - 40 g/ha + Trend 90 - 0.1 %	100	100	0	0	0	0	0	1
Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha	94	95	0	0	0	0	0	1
Express 50 SX - 40 g/ha + Trend 90 - 0.1 % + Select super 120 EC - 1.6 l/ha	100	100	100	100	100	100	100	1.5
Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha + Select super 120 EC - 1.6 l/ha	94	95	100	100	100	100	100	1
Conventional technology - hybrid Arizona								
Check	0	0	0	0	0	0	0	1
Smerch 24 EC - 800 ml/ha + Amalgerol premium - 5 l/ha	95	100	85	80	0	0	0	4
Pendigan 330 EC- 4 l/ha + Amalgerol premium - 5 l/ha	0	0	97	98	98	95	50*	3
Raft 400 SC - 800 ml/ha + Amalgerol premium - 5 l/ha	90	98	100	100	100	100	50*	3
Wing P - 4 l/ha + Amalgerol premium - 5 l/ha	0	0	100	100	100	100	50*	3
Pledge 50 WP - 80 g/ha + Amalgerol premium - 5 l/ha	90	95	90	90	90	90	0	3.5
Modown 4 F - 1.5 l/ha + Amalgerol premium - 5 l/ha	0	0	0	0	0	0	0	3

*- only against *Sorghum helipense* Pers. by seeds

To the herbicide Express is absolutely necessary to add adjuvant Trend for better control of weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L.

Express is a typical antibroadleaved herbicide. It does not have antigraminaceous effect. At presence of graminaceous weeds it is necessary to combine with antigraminaceous herbicide. Tank mixture Express + Select super controls successfully also and all annual and perennial

graminaceous weeds, including *Cynodon dactylon* Pers., *Agropyrum repens* L. and *Sorghum halepense* Pers. from rhizomes. The replacement of adjuvant Trend with complex foliar fertilizer Lactofol B in mixture Express + Select super increase selectivity of this tank herbicide mixture, but decrease its efficacy against some annual broadleaved weeds as *Xanthium strumarium* L., *Chenopodium album* L. and *Polygonum aviculare* L.

Herbicides Smerch, Raft and Pledge applied as tank mixtures with growth regulator Amalgerol premium have efficacy from 90 to 100% against annual broadleaved weeds *Xanthium strumarium* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Solanum nigrum* L., *Datura stramonium* L., *Abutilon theophrasti* Medic., *Portulaca oleracea* L., *Sinapis arvensis* L. Partial recovery is observed only single (often passed optimal stage of treatment) weeds of *Xanthium strumarium* L. Herbicide Smerch has stronger effect on *Cirsium arvense* Scop. from perennial weeds and depress more their development compared with *Convolvulus arvensis* L. Raft and Pledge are efficacy against *Convolvulus arvensis* L. compared with *Cirsium arvense* Scop. The effect of these three herbicides on *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L. is totally in the early stages of their development - from cotyledons stage to the emergence of the first true leaf at *Xanthium strumarium* L. and to 2-3 leaves stage at *Cirsium arvense* Scop. and *Convolvulus arvensis* L. At later treatment is achieved only a retardation of development of these three weeds, but sunflower developing faster, overcomes competition and overshadows weeds. At the other cases foliar treatment with Smerch, Raft or Pledge, combined with soil-applied of Gardoprim plus gold has good control of broadleaved weeds at conventional herbicide Arizona.

Herbicides Smerch, Raft and Pledge have also antigraminaceous affect. Raft in combination with Gardoprim plus gold has very good efficacy against annual graminaceous weeds *Echinochloa crus-galli* L., *Setaria viridis* Beauv., *Setaria glauca* Beauv., *Panicum sanguinale* L., *Avena fatua* L. Combination Pledge + Gardoprim plus gold is inefficacy against *Avena fatua* L., but is efficacy at 90%

against *Echinochloa crus-galli* L., *Setaria viridis* Beauv., *Setaria glauca* Beauv. and *Panicum sanguinale* L. Smerch is efficacy at 80-90% against *Setaria viridis* Beauv., and *Echinochloa crus-galli* L., but is inefficacy against *Setaria glauca* Beauv., *Panicum sanguinale* L. and *Avena fatua* L.

Combinations of herbicides Pendigan and Wing applied as tank mixtures with growth regulator Amalgerol premium, after soil-applied of Gardoprim plus gold are inefficacy against *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L. Pendigan and Wing have very good antigraminaceous effect, including *Sorghum halepense* Pers. from rhizomes. They should be used at mixed weed infestation with annual graminaceous weeds and some broadleaved weeds, but in the absence of *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L.

Combination of herbicide Modown applied as tank mixture with growth regulator Amalgerol premium, after soil-applied of Gardoprim plus gold is inefficacy against *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L. This combination has inefficacy against annual graminaceous weeds *Echinochloa crus-galli* L., *Setaria viridis* Beauv., *Setaria glauca* Beauv., *Panicum sanguinale* L., *Avena fatua* L. This combination should be used at weed infestation mainly with annual broadleaved weeds, on which it exhibits efficacy from 95 to 100%.

After treatment with herbicides Pulsar plus, Listego and Express are visible weak phytotoxic effect in sunflower 2-3 days after treatment. At Listego they initially are stronger (rate 2-2.5 according to the scale of EWRS) than Pulsar plus and Express (rate 1 according to the scale of EWRS), and overcome more slowly. This is due to the addition of adjuvant Dash to Listego so as to increase the efficiency of the herbicide against weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L. The signs of phytotoxicity disappeared 8-10 days after treatment. Thereafter do not have any signs of phytotoxicity during vegetation influenced by herbicide Listego. Weak phytotoxic events in sunflower plants by technology ClearField plus

and ExpressSun overcomes faster than those ones by the technology ClearField.

Foliar use of herbicides Smerch, Pendigan Raft, Wing, Pledge and Modown during 3-4 leaf pair stage causes high phytotoxicity by sunflower hybrid Arena - yellow and white spots on the leaves that the herbicides fell. Phytotoxicity is the highest by Smerch, followed by Pledge. After vegetative treatment for 10 days the damage rating reaches to 4 by Goal, and to 3.5 by Pledge, 9-rate according to the scale of EWRS. At herbicides Pendigan, Raft, Wing and Modown phytotoxicity is weaker - rate 3 according to the scale of EWRS. Signs of phytotoxicity appear early by Smerch and Pledge - at the second day after treatment, followed by Pendigan - at the third day. At Raft, Wing and Modown phytotoxicity appears later. Use of growth stimulator Amalgerol premium with herbicides Smerch, Pendigan, Raft, Wing, Pledge and Modown as tank mixtures increases the selectivity of herbicides. Amalgerol premium assists also for faster overcoming the phytotoxic events of these six herbicides. At Smerch and Pledge although phytotoxicity is strongest, under influence of Amalgerol premium it overcomes equally with that one of Pendigan, Raft, Wing and Modown. These six herbicides did not show systemic action and damage to sunflower consists of contact necrosis on the leaves where vegetation tip is remained. Duration of full recovery of damaged plants ranged from 15 to 20 or 30 days and it is directly dependent by agrometeorological conditions. The damages are stronger and lengthy in conditions of extreme drought during the period after herbicide treatment - in 2013, and weaker - in cool and wet weather during this period - in 2014.

Data about the influence of the investigated herbicides, adjuvants, foliar fertilizers, stimulators and their tank mixtures on sunflower seed yields (Table 4) show that the lowest yields were obtained by the checks by fourth technologies for sunflower growing, treated with soil-applied herbicide Gardoprim plus gold.

The biggest increase in seed yields in ClearField plus technology is obtained by herbicide tank mixture Pulsar plus + Stomp aqua - 129.4% over untreated check. The alone use of herbicide Pulsar plus leads to lower yields as a result of secondary weed infestation,

especially in the more humid years. Differences between the two variants are small and have not been mathematically proven.

The highest yield at ClearField technology is obtained by tank mixture Listego + Dash + Sharpen - 129.3% over the check. The use of the herbicide Listego with adjuvant Dash, but without herbicide Sharpen, leads to lower yields due to the lack of control of the secondary emerged weeds, especially during more humid years. Herbicide tank mixture Listego + Sharpen, but without adjuvant Dash, leads even lower yields. The main reason for this is insufficient control during the all vegetation period of weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L. The lowest yield at ClearField technology is obtained by alone use of herbicide Listego without adjuvant and without partner soil-applied herbicide.

The highest yield at ExpressSun technology is obtained by tank mixture Express + Trend + Select super - 128.9% over the check. Substituting of adjuvant Trend with complex foliar fertilizer Lactofol B in herbicide mixture Express + Select super leads to poor and mathematically unproven yield decrease. Bigger yield decrease is obtained by combinations Express + Trend and Express + Lactofol B. Herbicide Express is a typical antibroadleaved herbicide and cannot control annual and perennial graminaceous weeds in the absence of antigraminaceous herbicide.

It was studied six herbicides with foliar and soil action at conventional technology for sunflower growing. They are applied as tank mixtures with growth stimulator Amalgerol premium to decrease their phytotoxicity.

The highest yields are obtained by combinations Smerch + Amalgerol premium, Wing + Amalgerol premium and Raft + Amalgerol premium, followed by combinations Pledge + Amalgerol premium and Modown + Amalgerol premium. The worst result is obtained by combining of herbicide Pendigan with Amalgerol premium. Growth stimulator in this tank mixture does not decrease the herbicide phytotoxicity. At all variants by conventional technology seed yields are lower than those of technologies ClearField plus, ClearField and ExpressSun. The main reason

for this is the impossibility in conventional technology to control weeds as *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L.

Table 4. Influence of some vegetation-applied herbicide and tank mixtures on sunflower seed yield (2012-2014)

Variants	2012		2013		2014		Mean	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
ClearField plus technology - hybrid Bacardy								
Check	1976	100	1845	100	2142	100	1991	100
Pulsar plus - 1.2 l/ha	2450	124.0	2334	126.5	2872	134.1	2552	128.2
Pulsar plus - 1.2 l/ha + Stomp aqua - 2.3 l/ha	2474	125.2	2354	127.6	2898	135.3	2576	129.4
ClearField technology - hybrid Estiva								
Check	1965	100	1825	100	2120	100	1970	100
Listego 40 - 1.2 l/ha	2384	121.3	2241	122.8	2820	133.0	2476	125.7
Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha	2417	123.0	2283	125.1	2864	135.1	2516	127.7
Listego 40 - 1.2 l/ha + Sharpen 33 EC - 2.3 l/ha	2401	122.2	2268	124.3	2845	134.2	2500	126.9
Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha + Sharpen 33 EC - 2.3 l/ha	2439	124.1	2312	126.7	2894	136.5	2548	129.3
ExpressSun technology - hybrid Sumico								
Check	1952	100	1856	100	2180	100	1996	100
Express 50 SX - 40 g/ha + Trend 90 - 0.1 %	2376	121.7	2285	123.1	2921	134.0	2521	126.3
Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha	2346	120.2	2264	122.0	2886	132.8	2495	125.0
Express 50 SX - 40 g/ha + Trend 90 - 0.1 % + Select super 120 EC - 1.6 l/ha	2409	123.4	2355	126.9	2956	135.6	2573	128.9
Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha + Select super 120 EC - 1.6 l/ha	2385	122.2	2327	125.4	2906	133.3	2535	127.0
Conventional technology - hybrid Arizona								
Check	1979	100	1889	100	2222	100	2030	100
Smerch 24 EC - 800 ml/ha + Amalgerol premium - 5 l/ha	2333	117.9	2286	121.0	2620	117.9	2442	120.3
Pendigan 330 EC - 4 l/ha + Amalgerol premium - 5 l/ha	2308	116.6	2221	117.6	2591	116.6	2355	116.0
Raft 400 SC - 800 ml/ha + Amalgerol premium - 5 l/ha	2351	118.8	2257	119.5	2640	118.8	2436	120.0
Wing P - 4 l/ha + Amalgerol premium - 5 l/ha	2343	118.4	2272	120.3	2631	118.4	2438	120.1
Pledge 50 WP - 80 g/ha + Amalgerol premium - 5 l/ha	2327	117.6	2263	119.8	2613	117.6	2420	119.2
Modown 4 F - 1.5 l/ha + Amalgerol premium - 5 l/ha	2311	116.8	2221	117.6	2595	116.8	2395	118.0
	LSD 5 %	121	110	123				
	LSD 1 %	136	125	140				
	LSD 0.1 %	148	139	157				

CONCLUSIONS

Herbicide Pulsar plus by Clearfield plus technology and herbicide Listego by Clearfield technology, destroy completely all annual and perennial graminaceous and broadleaved weeds

in sunflower crops, including *Orobancha cumana* Wall.

Herbicide Express by ExpressSun technology, controls all perennial and annual broadleaved weeds. Tank mixture of Express with antigraminaceous herbicide Select super

controlled successfully and all annual and perennial weeds.

The highest seed yield is obtained at herbicide tank mixture Pulsar plus + Stomp aqua by Clearfield plus technology.

Tank mixture Listego + Dash + Sharpen by Clearfield technology and Express + Trend + Select super by ExpressSun technology also lead to obtaining of high seed yields.

Tank mixtures of herbicides Smerch, Pendigan, Wing, Raft, Pledge and Modown with Amalgerol premium by conventional technology have lower yields due to insufficient control of weeds as *Xanthium strumarium* L., *Cirsium arvense* Scop., *Convolvulus arvensis* L. in sunflower crops.

REFERENCES

- Brighenti, A.M., Rocha, W.S., Souza-Sobrinho, F., Castro, C.C., Martins, C.E., Muller, M.D. (2012). Application of reduced rates of ACCase-inhibiting herbicides to sunflower intercropped with *Brachiaria ruziziensis*. *Helia*, 34(54), 39–48.
- Delchev, Gr. (2018). *Chemical control of weeds and self-sown plants in eight field crops* (p. 397). Monograph, ISBN: 978-613-7-43367-6. LAP LAMBERT Academic Publishing, Saarbrücken, Germany.
- Simić, M., Dragičević, V., Knežević, S., Radosavljević, M., Dolijanović, Ž., Filipović, M. (2012). Effects of applied herbicides on crop productivity and on weed infestation in different growth stages of sunflower (*Helianthus annuus* L.). *Helia*, 34(54), 27–38.
- Zand, E., Khaymi, M., Diaji, R., Yavari, H., Yazdi, M. (2009). Response of rotational crops of wheat to soil residues of sulfonylurea herbicides. *Iranian Research of Plant Protection*, vol. C, 20–22.
- Jocić, S., Malidža, G., Cvejić, C., Hladni, N., Miklič, V., Škorić, D. (2011). Development of sunflower hybrids tolerant to tribenuron methyl. *Genetika*, 43(1), 175–182.
- Knežević, S., Malidža, G., Elezović, I., Simić, M., Glamočlija, Đ. (2011). Critical periods for weed control and obtaining yield increase in sunflower (*Helianthus annuus* L.) tolerant to imidazolinones. *11th Conference about Plant Protection*, Zlatibor (Serbia), 111–112.
- Mitric, S., Vuckovic, B., (2008). Preliminary bioassay for determination of threshold doses of herbicides. *Acta Herbologica*, 17 (2), 161–166.
- Saskevich, P.A., Tibets, J.L., Gurikova, E.I. (2009). Agro-ecological assessment of plant protection products in the cultivation of spring rape. *Bulletin of the Belarusian State Agricultural Academy: Scientific Methods Journal*, 2, 83–87.
- Suresh, G., Reddy, B. (2010). Effect of weed control practices on weed dry matter, production potential and nutrient uptake of sunflower (*Helianthus annuus*) in Vertisols. *Indian Journal of Agricultural Sciences*, 80(1), 33–37.