WEED CONTROL IN SUNFLOWER FIELDS BY CLEARFIELD TECHNOLOGY

Anyo Mitkov[1], Mariyan Yanev[1], Tonyo Tonev[1]*, Miroslav Tityanov[2]

[1]Agricultural University – Plovdiv
[2]University of Forestry – Sofia

***E-mail: tonytonev@abv.bg**

Abstract

Three block design field experiments were carried out in the period 2012 – 2015, following the same methods, on three different sites in the country, which differ significantly in the spectrum of the available weeds. The subject of the experiments was the improved version of the Clearfield Plus technology. In all the three years the sunflower hybrid ES Candimis CL Plus was planted on the three sites. The major aim of the experiments on the three sites was to establish the selectivity for sunflower and the efficacy of Pulsar 40 (40 g/l imazamox) against almost all the economically important weeds in that crop. The reported phytotoxicity caused to sunflower on the three sites in the three years was expressed in a slight discoloration of the treated sunflower plants, which was totally overcome between the 14th and 20th day.

The results of the experiments show that the greatest differences in the efficacy of Pulsar 40 were reported about its activity against perennial weed species. When Pulsar 40 was applied separately without DASH, its efficacy against Johnson grass, corn thistle, field bindweed, hemp agrimony, rough cocklebur, white goosefoot, purslane and broomrape was significantly reduced. Referring to its efficacy against the annual broad-leaved weed species redroot pigweed, charlock mustard, wild radish, clea-vers, black nightshade, etc., it was 100% and no differences were observed between the rates of 80, 100 and 125 ml/da. The separate use of the herbicide at a rate of 125 ml/da shows the same efficacy against more stubborn weeds, as that of Pulsar applied at the rate of 80 ml/da together with 80 ml/da of the adjuvant DASH.

Key words: selectivity, efficacy, herbicides, sunflower.

INTRODUCTION

Weed control in sunflower is especially important at the earliest phenological stages of crop development. When sunflower stems start growing intensively, the crop successfully overcomes weed competition (Tonev, 2000). The most widely spread weed species in sunflower fields are: redroot pigweed, charlock mustard, white goosefoot, rough cocklebur, *Setaria* spp., barnyardgrass, Johnson grass, corn thistle, field bindweed, some new races of broomrape, etc. In conventional cultivation of sunflower, the early deep plowing immediately after harvesting the predecessor and additional summer-autumn soil tillage have crucial importance for the successful weed control. That helps achieving a bed free of weed seeds for sowing the sunflower crop (Wanikorn, 1991). The most important of the spring pre-sowing treatments is the first early harrowing, which destroys all the overwintering weeds but provokes the emergence of new weed seeds. Sunflower is a crop resistant to both pre-emergence and post-emergence harrowing with a light tooth or rotary harrow for weed control. A high level of weed control is achieved by timely harrowing at the stage of mass weed emergence (not later than the stage of the first leaf of the grassy weed species and not later than the first to second leaf of the broad-leaved weed species), (Mitkov & Stoychev, 2014). When sunflower fields are infested by weeds, two or three inter-row cultivations should be carried out at the depth of 6-8 cm. They should be performed by adjusting the working organs in a way to achieve slight earthing up of the sunflower plants. Thus a large percentage of the later emerging weed plantlets are buried in the soil and die (Tonev et al., 2010). Depending on the success of the herbicide treatments for weed control after deep soil ploughing and additional autumn and pre-sowing soil tillage in spring, soil cultivation during sunflower vegetation is less necessary (Tonev & Mitkov, 2015). Taking into account that none of the selective herbicides is efficient against the widely spreading in the last years weed species rough cocklebur and corn thistle in the conventional sunflower hybrids, the so-called 'Sun' and Clearfield technologies in sunflower offer an alternative (Tonev et al., 2009). Clearfield technology is used for the control of all the races of broomrape in sunflower (Tóth et al., 2004; Suresh and Reddy, 2010). Inclusion of sunflower in proper, scientifically-based crop rotations, in which it is sown mainly after merged surface crops, makes weed control of perennial and late spring weeds much easier (Malidža et al., 2011; Reis et al., 2014).

The aims of the present study were: firstly, to conduct a comparative testing for establishing the selectivity of Pulsar 40 to the new generation of Clearfield sunflower hybrids and secondly, to establish the

efficacy of the different rates of Pulsar 40 (40 g/l imazamox), applied with and without the adjuvant DASH, against the economically most important weeds in that crop in the conditions of Bulgaria, grown under the improved version of Clearfield Plus technology.

MATERIALS AND METHODS

Several block design field experiments were carried out in the period 2012 – 2015, following the same methods, on three different sites in the country (the Experimental Fields of the Agricultural University – Plovdiv, the village of Krumovo, Plovdiv region and Radetski, Sliven Region), which differ significantly in the spectrum of the available weeds. The subject of our experiments was Clearfield Plus technology. In all the three years the sunflower hybrid ES Candimis CL Plus was planted on the three sites. The studied soil herbicide Stomp Aqua was applied immediately after sowing the sunflower seeds and all the other herbicides were applied at the stage 4^{th} – 6^{th} leaf of the crop, mainly at the rosette growth stage of the broad-leaved weeds and tillering stage of the grassy weeds.

The experiment was carried out following the non-standard design method with systematic arrangement of the variants, in four replications, the area of the plot being 25 m². Two adjacent untreated controls of 12,5 m² for each variant were included in the trial. The close positioning of the adjacent untreated controls helps to overcome the different weed infestation rates in the field, which contributes to a more objective evaluation of the efficacy of each of the studied products.

In all the trials, the selectivity for the sunflower crop was reported on 14^{th}, 28^{th} and 56^{th} day (in percentage, following EWRS scale) and the efficacy against the weeds (in percentage, following EWRS scale) on 14^{th}, 28^{th} and 56^{th} day after the application of the vegetative herbicides. The trials were carried out based on EPPO Standards of the EU.

RESULTS AND DISCUSSION

The phytotoxicity caused to sunflower on the three sites in the three years, reported on the 14^{th} day, was expressed in a slight discoloration of the treated sunflower plants. The symptoms were totally overcome between the 14^{th} and 20^{th} day after treatment with the vegetative herbicides.

The results of the experiments show that the greatest differences in the efficacy of Pulsar 40 were reported about its activity against perennial weed species. Separate application of Pulsar 40 without DASH showed significantly reduced efficacy against Johnson grass, corn thistle, field bindweed, hemp agrimony, rough cocklebur, white goosefoot, purslane and broomrape. Referring to its efficacy against the annual broad-leaved weed species redroot pigweed, charlock mustard, wild radish, cleavers, black nightshade, etc., it was 100% and no differences were observed between the three rates applied – 80, 100 and 125 ml/da. The separate use of the herbicide Pulsar at the rate of 125 ml/da without adding the adjuvant DASH showed the same efficacy against the most stubborn weeds, as that of the same herbicide applied at the rate of 80 ml/da together with 80 ml/da of the adjuvant DASH.

Variants of the Trial

No	HERBICIDE	RATE ml/da	Time of Application	Phenological stage of the crop BBCH
1	Untreated Control			
2	Pulsar 40	80	4^{th} - 6^{th} leaf	BBCH 14-16
3	Pulsar 40	100	4^{th} - 6^{th} leaf	BBCH 14 -16
4	Pulsar 40	125	4^{th} - 6^{th} leaf	BBCH 14-16
5	Pulsar 40+DASH	80+80	4^{th} - 6^{th} leaf	BBCH 14-16
6	Pulsar 40+DASH	100+100	4^{th} - 6^{th} leaf	BBCH 14-16
7	Pulsar 40+DASH	125+125	4^{th} - 6^{th} leaf	BBCH 14-16
8	Stomp Aqua Pulsar 40	300 125	PSPE 4^{th} – 6^{th} leaf	BBCH 00 BBCH 14-16
9	Stomp Aqua Pulsar 40+DASH	300 125 +100	PSPE 4^{th} – 6^{th} leaf	BBCH 00 BBCH 14-16
10	Stratus Ultra Pulsar 40+DASH	100 125 +100	4^{th} – 6^{th} leaf 4^{th} – 6^{th} leaf	BBCH 14-16 BBCH 14-16

PSPE - post sowing pre-emergence

The results of the trial conducted on the first site – the Training-and-Experimental Fields of the Agricultural University – Plovdiv helped to establish the efficacy of the products against a very high infestation level with Johnson grass from rhizomes. The field was highly infested with the weed (over 50-60 pcs/ m²). The prevailing annual grassy weed species were *Setaria* spp. and barnyardgrass and the annual broad-leaved ones – redroot pigweed, purslane, wild radish and white goosefoot. The obvious symptoms of phytotoxicity in sunflower on the three sites were expressed in a slight discoloration of the treated sunflower plants. Despite the accompanying stress caused to sunflower plants by waterlogging due to heavy rainfalls, crop disturbances were overcome between the 15th and 30th day in 2014.

The results of this experiment in the first and the second reporting periods showed satisfactory effect of the herbicide Pulsar against Johnson grass from rhizomes. In the third reporting period – two months after treatment, there was significant secondary weed infestation with Johnson grass from rhizomes. In the third reporting period, due to heavy infestation with the weed, the benefits of combining Pulsar with Stratus Ultra were clearly evident. Separate application of Pulsar 40 at the rate of 125 ml/da without DASH, showed significantly reduced efficacy against Johnson grass. Referring to the efficacy against the annual broad-leaved weed species redroot pigweed and wild radish, it was 100% and no differences were observed between the applied rates of Pulsar – 80, 100 and 125 ml/da. The single plants of Clearfield self-seeded oilseed rape, found in the fields, were not affected in any of the variants. Comparatively lower herbicide efficacy was observed in the single hemp agrimony plants.

The second trial was carried out in the village of Krumovo, Plovdiv Region under the conditions of strong infestation with charlock mustard, rough cocklebur, hemp agrimony and lower infestation with white goosefoot and Johnson grass from rhizomes.

The results of that trial showed that the greatest differences between the three studied rates (80, 100 и 125 ml/da) were established for the efficacy of Pulsar against the weeds hemp agrimony and rough cocklebur. A clearly expressed contrast tendency to an increase of the herbicide efficacy against rough cocklebur and hemp agrimony was observed with the increase of the applied rates (low, medium and high). The highest efficacy of Pulsar against rough cocklebur and hemp agrimony was reported when the herbicide was combined with the adhesive DASH, also used at the rate of 125 ml/da. The separate application of Pulsar at a rate of 125 ml/da, without DASH, showed the same efficacy against rough cocklebur and hemp agrimony as that of Pulsar applied at the rate of 80 ml/da plus 80 ml/da of DASH.

Regarding the efficacy against the annual broad-leaved weed species charlock mustard and wild radish, there were no differences between the rates of 80 and 125 ml/da + DASH. Even at the lowest rate of Pulsar applied against those weeds, the herbicide efficacy was 100%. Referring white goosefoot, the results were in favour of the higher rates of Pulsar.

In 2013 and 2014, in the village of Radetski, Sliven Region, the trial was carried out in the conditions of heavy weed infestation with corn thistle, field bindweed and the parasitic weed broomrape and of a lower level of infestation with the broad-leaved weeds cleavers, black nightshade and charlock mustard. Clear differences in the efficacy against broomrape were found between the three applied rates of Pulsar, the best results being obtained after treatment with the highest rate of 125 ml/da. The most distinct differences in the efficacy against broomrape were established on 56th day and at the end of the vegetation, before sunflower harvest.

The results of the trial showed that the greatest differences were established for the efficacy of the herbicide against corn thistle and field bindweed. In the first and the second reporting periods clearly expressed contrast tendencies to an increase of the herbicide efficacy against corn thistle and field bindweed were observed with the increase of the rates of Pulsar – low, medium and high. In the third reporting period, because of the heavy weed infestation with field bindweed and the lower level of infestation with corn thistle, the benefits of the highest rate of Pulsar and the benefits of supplementing the adhesive DASH, were clearly evident. Despite that, significantly high level of secondary weed infestation was established at the end of vegetation, the prevailing species being field bindweed. A total control of Johnson grass emerging from rhizomes was achieved only after treatment with Pulsar 40 – 125 ml/da + DASH and Stratus Ultra, both used at the rates of 100 ml/da.

Separate application of Pulsar 40 (without DASH) used at the rate of 125 ml/da, showed the same efficacy against Johnson grass from rhizomes, corn thistle and field bindweed as that of Pulsar 40 applied at the rate of 80 ml/da in combination with adjuvant DASH also used at the rate of 80 ml/da.

Referring to the efficacy against the annual broad-leaved species charlock mustard, cleavers and black nightshade, no differences between the separate rates were observed. 100% herbicide efficacy was established for Pulsar 40 against those weeds, even when applied at the lowest rate of 80 ml/da, without the adjuvant DASH. On the third site (the village of Radetski), accompanying weed infestation with species uncommon in sunflower fields, such as field larkspur, field poppy, dog mustard, tricolor pansy, etc. was reported. A complete control was achieved against all those weeds after applying Pulsar 40 even at the lowest tested rate of 80 ml/da.

Table 1. Average values of selectivity for sunflower (in %, EWRS scale) and average values of efficacy (in %, EWRS scale) against major weeds on the 14th day after vegetation treatment with herbicides

No	HERBICIDE	RATE ml/da	Selecti-vity (%, EWRS scale)	Johnson grass from rhizomes	Johnson grass seedlings	Field bindweed	Corn thistle	Redroot pigweed	Black nightshade	Abutilon	Hemp agrimony	Charlock mustard	Rough cocklebur	White goosefoot	Purslane	Wild radish	Broomrape
1	Untreated Control		100	0	0	0	0	0	0	0	0	0	0	0	0	0	-
2	Pulsar 40	80	85	66	90	60	70	100	100	100	30	100	70	80	80	100	-
3	Pulsar 40	100	80	72	90	66	77	100	100	100	40	100	70	84	85	100	-
4	Pulsar 40	125	80	82	100	70	84	100	100	100	60	100	74	87	88	100	-
5	Pulsar 40 +DASH	80+80	90	80	100	70	80	100	100	100	60	100	80	88	86	100	-
6	Pulsar 40+DASH	100+100	85	86	100	80	88	100	100	100	78	100	90	90	90	100	-
7	Pulsar 40+DASH	125+125	80	95	100	88	94	100	100	100	80	100	95	95	93	100	-
8	Stomp Aqua Pulsar 40	300 125	80	80	100	70	85	100	100	100	60	100	75	85	80	100	-
9	Stomp Aqua Pulsar 40+DASH	300 125 +100	80	95	100	90	95	100	100	100	78	100	92	92	91	100	-
10	Stratus Ultra Pulsar 40+DASH	100 125 +100	80	100	100	86	90	100	100	100	80	100	94	94	93	100	-
1	Average number of weeds/m² in untreated control	Total num-ber of weeds/m²	56,7	3,6	11,1	1,9	1,3	3,8	5,6	1,9	4,4	3,1	2,2	4,7	9,6	3,5	0

Table 2. Average values of selectivity for sunflower (in %, EWRS scale) and average values of efficacy (in %, EWRS scale) against major weeds on the 28th day after vegetation treatment with herbicides

No	HERBICIDE	RATE ml/da	Selectivity (%, EWRS scale)	Johnson grass from rhizomes	Johnson grass seedlings	Field bindweed	Corn thistle	Redroot pigweed	Black nightshade	Abutilon	Hemp agrimony	Charlock mustard	Rough cocklebur	White goosefoot	Purslane	Wild radish	Broomrape
1	Untreated control		100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Pulsar 40	80	100	30	80	52	50	100	100	100	30	100	40	70	64	100	100
3	Pulsar 40	100	100	40	85	55	60	100	100	100	36	100	50	75	70	100	100
4	Pulsar 40	125	100	54	90	60	66	100	100	100	52	100	58	80	75	100	100
5	Pulsar 40 +DASH	80+80	100	50	100	55	60	100	100	100	50	100	60	85	72	100	100
6	Pulsar 40+DASH	100+100	100	70	100	60	70	100	100	100	68	100	74	80	80	100	100
7	Pulsar 40+DASH	125+125	100	80	100	66	84	100	100	100	75	100	78	88	86	100	100
8	Stomp Aqua Pulsar 40	300 125	100	60	100	60	68	100	100	100	60	100	60	70	70	100	100
9	Stomp Aqua Pulsar 40+DASH	300 125 +100	100	83	100	70	85	100	100	100	70	100	80	75	84	100	100
10	Stratus Ultra Pulsar 40+DASH	100 125 +100	100	100	100	68	80	100	100	100	70	100	78	78	88	100	100
1	Average number of weeds/m² in untreated control	Total number of weeds/m²	82,2	4.9	12,2	3,1	2.2	3,8	7,7	2,6	6.8	3,7	3.0	5,5	12,2	3,5	11,0

Table 3. Average values of selectivity for sunflower (in %, EWRS scale) and average values of efficacy (in %, EWRS scale) against major weeds on the 56th day after vegetation treatment with herbicides

No	HERBICIDE	Rate ml/da	Selectivity (%, EWRS scale)	Johnson grass from rhizomes	Johnson grass seedlings	Field bindweed	Corn thistle	Redroot pigweed	Black nightshade	Abutilon	Hemp agrimony	Charlock mustard	Rough cocklebur	White goosefoot	Purslane	Wild radish	Broomrape
1	Untreated control		100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Pulsar 40	80	100	26	70	34	40	100	100	100	25	100	30	50	50	100	80
3	Pulsar 40	100	100	30	75	40	50	100	100	100	30	100	38	56	64	100	90
4	Pulsar 40	125	100	44	82	50	60	100	100	100	40	100	44	60	68	100	92
5	Pulsar 40 +DASH	80+80	100	40	100	48	60	100	100	100	40	100	50	60	65	100	90
6	Pulsar 40+DASH	100+100	100	66	100	54	66	100	100	100	55	100	66	72	70	100	96
7	Pulsar 40+DASH	125+125	100	72	100	58	75	100	100	100	68	100	75	78	75	100	100
8	Stomp Aqua Pulsar 40	300 125	100	54	100	50	62	100	100	100	40	100	48	60	62	100	91
9	Stomp Aqua Pulsar 40+DASH	300 125 +100	100	75	100	58	74	100	100	100	60	100	72	72	75	100	96
10	Stratus Ultra Pulsar 40+DASH	100 125 +100	100	100	100	60	75	100	100	100	64	100	76	72	74	100	98
1	Average number of weeds/m² in untreated control	Total number of weeds/m²	107,4	5,6	12,5	3,8	3,6	5,2	9,9	2,6	10,5	3,7	3,0	6,6	17,2	3,6	19,6

CONCLUSIONS

1. For achieving successful weed control of the more stubborn weeds, such as Johnson grass from rhizomes, corn thistle, field bindweed, hemp agrimony, rough cocklebur, white goosefoot, purslane and broomrape, Pulsar 40 must be applied at the highest tested rate of 125 ml/da in a combination with the adjuvant DASH.

2. For control of the most susceptible weeds, such as charlock mustard, cleavers, nightshade, field larkspur, field poppy, dog mustard, pansy, etc., Pulsar 40 could be applied at the lowest studied rate of 80 ml/da without combining it with the adjuvant DASH.

3. At a very high level of infestation with Johnson grass from rhizomes, it is recommended to use Pulsar 40 at the maximum rate of 125 ml/da, combined with Stratus Ultra 100 ml/da and the adjuvant DASH 100 ml/da in the tank mixture.

4. The combined use of Stomp Aqua at the rate of 300 ml/da with Pulsar 40 at the rate of 125 ml/da, is agrotechnically justified only when there is a high level of infestation with the annual grassy weeds and Johnson grass seedlings, on the one hand, and delayed application of Pulsar 40, on the other.

REFERENCES

Malidža, G., Elezović I., Simić M and Glamo člija Đ, 2011. Critical periods for weed control and obtaining yield increase in Vegetation-applied herbicides Goal, Raft and Pledge combined sunflower (*Helianthus annuus* L.) torerant to imidazolinones. 11th with the soil applied herbicide Pelican provide good control of Conference about Plant Protection, Zlatibor, Serbia, 111–112.

Mitkov, A., D. Stoychev, 2014. Integrated weed control in sunflower. Plant Protection, 2, 30–34.

Reis, R. M.; Souza, M. F.; Queiroz, G. P.; Siebert, I. G.; Silva, D. V.; Fereira, E. A.; Silva, A. A. Tolerance of sunflower to herbicide application in post-emergence. Universidade Estadual de Maringa, Umuarama, Brazil. Revista Brasileira de Herbicides, 2014, 13, 1, pp. 15–22.

Suresh, G and Reddy BN, 2010. Effect of weed control practices on Herbicide tank mixtures Pulsar + Stomp by Clearfield weed dry matter, production potential and nutrient uptake of technology and Express + Stratos ultra by Express Suntechnology sunflower (*Helianthus annuus L.*) in Vertisols. Indian Journal of completely destroyed all annual and perennial grassy and Agricultural Sciences, 80, 1, 33–37.

Tonev, T., 2000. Manual of integrated weed control and farming culture. colour atlas of 100 economically most important weeds in Bulgaria. Library of Agricultural Education, Book 2, Higher Institute of Agriculture – Plovdiv.

Tonev, T., A Mitkov, 2015. Chemical weed control in the major field crops. Farming Plus, 2, 33–44.

Tonev, T., A. Mitkov, Ch. Dochev, M. Tityanov, 2009. Possibilities of the SU technology for an efficient weed control in sunflower. Plant Science, 2, 161–166.

Tonev, T., M. Tityanov, A. Mitkov, 2010. Integrated weed control in sunflower. Scientific Works of the Agricultural University, LV, 2, 127–132.

Tóth, E.; Molnár, I.; Somlyay, I.; Popovics, I.; Gulyás, A.; Kara, B., 2004. A new possibility for post-emergence weed control of sunflower: Application of Granstar 75 DF in Granstar tolerant sunflower. Debreceni Egyetem, Agrártudományi Centrum, Mezögazdaságtudományi Kar, Debrecen, Hungary, 9. Tiszántúli Növényvédelmi Fórum, 20–21 October 2004, Debrecen, Hungary, pp 351–355.

Wanikorn, N, 1991. Weed competition and chemical weed control in Joci Ć S, Malidža G, Cveji Ć Hladni N, Mikli Č V and Škori Ć D, 2011. sunflower (Helianthus annuus (L.). Thesis for PhD, Kasetsart Development of sunflower hybrids tolerant to tribenuron methyl. University, Bangkok.