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EFFECTS OF CHEMICAL WEED CONTROL ON PLANT GROWTH AND YIELD FORMATION IN SUNFLOWER CROPS GROWN UNDER CONVENTIONAL TECHNOLOGY

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Abstract

In the period 2014-2016 a filed experiment with sunflower was conducted. The trial included 9 variants, of which two controls (zero and economic) and 7 variants with herbicide application (soil and foliar). The experimental field was stated in the region of the city of Pazardzhik. A number of principal and concomitant indicators relevant to the formation of the quantity and quality of the yield were studied.

The results presented in the current paper indicate that the herbicide combinations as required by the Conventional Sunflower Technology had a beneficial effect on plant height, which at the end of the vegetation period was 3 to 11 cm greater, and the mass of the sunflower seed from one sunflower head was 1 to 11 g larger for the variants after herbicide application in comparison with the control group earthed up once. In the latter, the yield increased by 26%, and for the variants treated with herbicides an increase in yield from 122.3 to 144.5% was achieved as compared to the zero control group.

The results obtained from our experiment confirm that the highest yield increase is observed in the following treatment combinations: Wing-P + Stratos Ultra, Stomp Aqua + Stratos Ultra and Gardoprim Plus Gold 500 SC + Fusilade Forte.

Keywords: sunflower, height, a mass of the grain, herbicides, yield.

INTRODUCTION

The weed control in sunflower is particularly important in the earliest phenophases of the crop. Sunflower deals successfully with weed competition when intensive growth of stems begins (Tonev, 2000). The most common weeds in the sunflower fields are Amaranthus spp., Orobanche spp., Sinapis arvensis L, Datura stramonium L., Solanum nigrum L., Xanthium strumarium L. Chenopodium album L, Setaria glauca L., Setaria viridis L., Fallopia convolvulus L., Cannabis sativa L., Echinochloa crus-galli (L.) Beauv., Sorghum halepense (L.) Pers, Cirsium arvense (L) Scop, Convolvulus arvensis L. (Tiourebaev, K. S et al., 2001, Malidza, G.; Jocic, S.; Skoric, D., 2003, Osman, A. S.; El-Habieb, R. Y.; Elkhawad, M., 2014. Poienaru, S.; Sarpe, N.; Sarpe, I., 2005, Semerci, A. et al., 2010, Konstantinovic´ et al., 2010, Mirshekari, B., 2010, Pinke and Karacsony, 2010, Tonev, 2000, Elezovic, I et al., 2012, Tyr and Vavrik, 2015, Moskova, et al., 2016). The inclusion of sunflower in proper crop rotations facilitates the control of perennial and late spring weeds (Malidza et al., 2011; Reddy et al., 2012). In the conventional sunflower cultivation, the deep plowing and the additional summer-autumn treatments are crucial for successful weed control by which we can achieve a seeding bed clean from weeds (Tonev et al., 2010; Wanikorn, 1991; Tracchi et al., 1998). From spring pre-sowing, the most important is early spring cultivation, which destroys all winter weeds and provokes germination of new weed seeds. (Tonev, 2000). During the vegetation, two or three inter-row tillage operations are performed at depth of 6–8 cm and it is desirable with the last one to achieve a slight earthing-up of the sunflower plants. Thus, a large percentage of the germinated weeds are buried with soil and die (Tonev et al., 2010). The control of *X. strumarim* and *C. arvense* at the conventional sunflower hybrids is very difficult, and therefore the alternative technologies - ExpressSun and Clearfield have been developed in recent years (Suresh and Reddy, 1994; Santos, G. et al., 2012; Delchev, G., 2013, Delchev, G. 2014, Dochev et al., 2016, Mitkov et al., 2016, Neshev et al., 2017).

MATERIALS AND METHODS

In the period 2014-2016 year in the land of the village of Chernogorovo, municipality of Pazardjik, on carbonate-alluvial soils with pH-7.8 and content of humus – 1.72%, a field experiment with the application of Conventional weed control system at sunflower was conducted. The sunflower hybrid was grown after predecessor winter wheat.

The sowing rate was 6000/da. The inter-row distance was 0.7 m which provides crop density around 5500 plants/da. The trial 9 variants of which 2 controls – the 1st with one hand earthing-up and the 2nd without any entrenchment (control). The other variants were combinations of two herbicide – soil and foliar.

The experiment was conducted by the randomized block design in 4 replications. The harvesting plot was with the size of 21 m^2 (*Dimova and Marinkov,* 1999). The weed evaluation was carried out in standardized meters according to the following scheme: On the 21st, 35th and 56th day after application of soil herbicides and on 0, 14th and 35th day after application of the foliar herbicides. Herbicide application was performed with a spraying machine with 400 l/ha solution for herbicides with soil action and 200 l/ha for herbicides with a foliar mode of action. The height of the sunflower plants in the physiological maturity phase was determined by averaging the results of 10 sunflower plants (40 per variant).

The seed mass in 1 sunflower head was determined by crushing and weighing the seeds of 5 heads the repeat (20 for variant). The yield of sunflower seeds was reported on the basis of a harvest plot (5 m^2), averaging the 4 replicates and was recalculated for 1 da.

Experimental variants

Herbicide	Dose rate cm^3/da	Application
1. UTC		
2. UTC with cultivation		
3. **Wing-P** + Stratos Ultra	400 cm^3 + 200 cm^3	A1 + A2
4. **Pledge 50WP** + Fusilade Forte	8 g + 130 cm^3	A1 + A2
5. **Gardoprim Plus Gold 500 SC** + Fusilade Forte	350 cm^3 + 130 cm^3	A1 + A2
6. **Stomp Aqua** + Stratos Ultra	350 cm^3 + 200 cm^3	A1 + A2
7. **Linuron 45SC**+ Ajil 100 EC	300 cm^3 + 80 cm^3	A1 + A2
8**. Goal 2E** + Ajil 100 EC	100 cm^3 + 80 cm^3	A1 + A2
9**. Pledge 50WP** + Ajil 100 EC	8 g + 80 cm^3	A1 + A2

****Bold are marked with the following soil herbicides***
A1 – After treatment before sowing, germination of sunflower seeds.
A2 – Treatment in a culture of phenophase vegetation 2–4 – sheet.

RESULTS AND DISCUSSION

The height is an indicator that shows the rate and conditions of plant growth.

In Tab. 1 is shown the results of the height of sunflower plants in the stage 10th leaf in conventional cultivation technology over the three experimental years and an average for the period. The measured height in this stage of the control without chopping (Var. 1) is 1 to 5 cm taller than this, without the weed control. A similar trend is also observed with respect to the herbicide application variants. In one of the soil herbicides, such as Pledge 50 WP, Linuron 45 SC and Goal 2E, weak signs of phytotoxicity are observed in the early stages of sunflower development, which are subsequently overcome.

The large competition between sunflower plants and weeds in the zero control are the main reason for the differences in height between the unheated version and the other variants. The height of the sunflower plants in the grazing control is similar to that of the Wing-P, Gardoprim Plus Gold 500 SC and Stomp Aqua soil herbicide variants. For the period 2014–2016, the height of sunflower plants in the 10th leaf stage ranges from 62 to 75 cm, depending on climatic, agro-technical and chemical factors.

By the second measurement of the height of sunflower plants in this technology shows significant differences compared to the first reading. In all variants, the plants have increased their height by more than 100 cm over the three years.

Both the results per year and the summary results shown that the height indicator of sunflower plants is stable and under similar conditions of plant breeding its variation is in close range.

From the data in Tab. 2, it can be seen that in the var. 1 where the sunflower growth conditions are worst they remain lower at the end of the vegetation by 10 to 20 cm. There are also some differences between herbicide applications, but they are within a narrow range. As in the three years and the average for the period, the highest height of the sunflower plants at the end of the vegetation was measured in the following variants: Stomp Aqua + Stratos Ultra (186.7cm), Gardoprim Plus Gold 500 SC + Fusilade Forte (185.1cm) and Wing-P + Stratos Ultra (184.1 cm).

Table 1. A height of sunflower plants in the 10th Sheet phase, cm

Variants	2014	2015	2016	2014-2016	%
1. UTC	75	73	73.9	74.0	100.0
2. UTC with cultivation	70	72	71.4	71.1	96.2
3. Wing-P + Stratos Ultra	73	73	73.1	73.0	98.7
4. Pledge 50WP + Fusilade Forte	68	68	68.5	68.2	92.2
5. **Gardoprim Plus Gold 500 SC** + Fusilade Forte	70	69	70.1	69.7	94.2
6. Stomp Aqua + Stratos Ultra	72	70	70.6	70.9	95.8
7. Linuron 45SC+ Ajil 100 EC	68	65	66.4	66.5	89.9
8. Goal 2E + Ajil 100 EC	62	66	65.8	64.6	87.3
9. Pledge 50WP + Ajil 100 EC	64	67	66.3	65.8	88.9

Table 2. A height of sunflower plants in physiological maturity phase, cm

Variants	2014	2015	2016	2014-2016	%
1. UTC	168	165	171.0	168.0	100.0
2. UTC with cultivation	170	180	179.0	176.3	105.0
3. Wing-P + Stratos Ultra	184	182	186.4	184.1	109.6
4. Pledge 50WP + Fusilade Forte	179	179	180.1	179.4	106.8
5. **Gardoprim Plus Gold 500 SC** + Fusilade Forte	186	184	185.2	185.1	110.2
6. Stomp Aqua + Stratos Ultra	188	186	186.2	186.7	111.2
7. Linuron 45SC+ Ajil 100 EC	182	180	179.5	180.5	107.4
8. Goal 2E + Ajil 100 EC	180	180	180.2	180.1	107.2
9. Pledge 50WP + Ajil 100 EC	183	182	179.8	181.6	108.1

The data about the seed number in 1 sunflower head (**Table 3**) shows that this indicator had the highest values in 2014, while over the next two years the results are almost equal. As in the three years of the study, aggregated data show that in the herbicide application scenarios two groups are differentiated according to the values of this indicator. To the first group can be added the variants whose summing parameters were highest - Stomp Aqua + Stratos Ultra (88.3 g), Gardoprim Plus Gold 500 SC + Fusilade Forte (87.6 g) and Wing-P + Stratos Ultra (86.8 g), and to the second group - the with the lowest values - Linuron 45 SC + Agil 100 EC (80.1g) and Pledge 50 WP + Fusilade forte (80.6g). The results of this indicator confirm the tendency of better results in certain variants.

Table 4 gives an average of the three-year survey period of the sunflower grain yield. The results show that the variants with herbicide application can be graded according to grain yield in the following way: Highest results - Wing-P at a dose of 4000 cm^3/ha + Stratis Ultra at a dose of 2000 cm^3/ha - 2017 kg/ha; Stomps Aqua at a dose of 3500 cm^3/ha + Stratis Ultra at a dose of 2000 cm^3/ha - 1995 kg/ha and Gardoprim Plus Gold 500 SC at a dose of 3500 cm^3/ha + Fusilade Forte at a dose of 1300 cm^3/ha - 1964 kg/ha. The difference in yield between the best and the worst variant was 183 kg (variants 3 and 4) and in percent, this value was less than 10%. Despite the relatively low increase in sunflower yields for treatments 3 and 4, the data were statistically proven.

CONCLUSIONS

1. The herbicide combinations at the Conventional sunflower crop production have a beneficial effect on plant height, which was from 3 to 11 cm longer at the end of the vegetation, and the mass of sunflower seeds per sunflower head was from 1 to 11 g more for the variants with herbicide application in comparison with the one time earthed-up control.

2. Herbicide applications have provided higher yields of sunflower grain. If the yield gain increased by only 26% compared for the control without earhing-up, the variants where the herbicides have applied the yield was increased from 122.3 to 144.5%. The highest yield was recorded for the following variants: Wing-P + Stratos Ultra, Stomp Aqua + Stratos Ultra and Gardoprim Plus Gold 500 SC + Fusilade Forte.

Table 3. Seed mass in 1 sunflower cake, g

Variants	2014	2015	2016	2014-2016	%
1. UTC	77.6	65.3	68.4	70.4	100.0
2. UTC with cultivation	73.6	68.8	75.8	78.8	111.8
3. Wing-P + Stratos Ultra	93.5	92.6	94.0	86.8	123.2
4. Pledge 50WP + Fusilade Forte	84.1	75.1	74.3	80.6	114.5
5. **Gardoprim Plus Gold 500 SC** + Fusilade Forte	91.7	83.4	82.7	87.6	124.4
6. Stomp Aqua + Stratos Ultra	99.1	88.8	87.8	88.3	125.4
7. Linuron 45SC+ Ajil 100 EC	83.3	76.8	77.0	80.1	113.7
8. Goal 2E + Ajil 100 EC	95.2	81.0	80.2	85.4	121.3
9. Pledge 50WP + Ajil 100 EC	85.2	77.4	75.6	79.4	112.8

Table 4. An average yield of sunflower seed, кg/da

Variants	2014	2015	2016	2014-2016	%
1. UTC	76.2a	83.1a	88.2a	82.5	100.0
2. UTC with cultivation	103.8b	104.7d	105.7b	104.7	126.9
3. Wing-P + Stratos Ultra	193.9e	206.4f	204.8e	201.7	244.5
4. Pledge 50WP + Fusilade Forte	180.5cd	181.5c	188.2c	183.4	222.3
5. **Gardoprim Plus Gold 500 SC** + Fusilade Forte	188.3de	201.4ef	199.6de	196.4	238.1
6. Stomp Aqua + Stratos Ultra	194.8e	197.8def	206.0e	199.5	241.8
7. Linuron 45SC+ Ajil 100 EC	186.9cde	188.4cd	190.5cd	188.6	228.6
8. Goal 2E + Ajil 100 EC	176.2c	191.0cde	186.2c	184.5	223.6
9. Pledge 50WP + Ajil 100 EC	178.3cd	194.2def	184.4c	185.6	225.0

*LSD statistically has proven differences **a, b, c, d, e, f** at P = 0.05*

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