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# EFFICACY AND SELECTIVITY OF IMAZAMOX-CONTAINING HERBICIDES AT CLEARFIELD® AND CLEARFIELD® PLUS SUNFLOWER HYBRIDS

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***Abstract***

*In 2018 a field experiment with the sunflower hybrids SY Bacardi CLP and SY Diamantis CL was conducted. The experiment included the following treatments: 1. Untreated control; 2. Pulsar 40 - 1.25 l ha$^{-1}$; 3. Pulsar 40 - 2.50 l ha$^{-1}$; 4. Pulsar Plus - 1.20 l ha$^{-1}$, 5. Pulsar Plus - 2.40 l ha$^{-1}$. The herbicides were applied in phenophase 4$^{th}$-6$^{th}$ true leaf of the crop. The efficacy and the selectivity of the studied herbicides were evaluated. The highest efficacy against S. halepense from rhizomes was recorded for treatment 5 (Pulsar Plus - 2.40 l ha$^{-1}$). S. halepense developed from seeds, S. viridis, A. retroflexus, Xa. strumarium, S. nigrum and S. arvensis were successfully controlled by application of Pulsar 40 or Pulsar Plus in the low examined rates. Ch. album and A. theophrasti can be controlled by Pulsar Plus at the lower rate - 1.20 l ha$^{-1}$. The absolute seed mass of 1000 seeds and the yield as well as the seed oil content from the plants treated with the registered and double herbicide rates, independently the herbicide product and studied hybrid, were higher than those of the untreated controls highly infested with weeds.*

***Key words****: efficacy, selectivity, Imazamox, sunflower, yields.*

## INTRODUCTION

Bulgaria and Romania are the largest sunflower seed producers in the EU, with sunflower yields increasing twice over the past ten years. The results in the sector are good starting point for a debate over its competitiveness and efficiency (Hristov et al., 2019).

In order to achieve high yields, along with the optimization of the main vegetation factors, it is necessary to effectively control the weeds (Tonev, 2000). Weed control at sunflower should be performed in the optimal phases of the crop before the critical period for decreasing the morphological parameters is reached (Simic et al., 2011).

In Bulgaria, the most common weeds in the sunflower fields are *Amaranthus* spp., *Sinapis arvensis* L., *Chenopodium album* L., *Cannabis ruderalis* Janisch, *Setaria* spp., *Echinochloa crus-galli* L., *Sorghum halepense* (L.) Pers., *Cirsium arvense* Scop., *Convolvulus arvensis* L., some new races of *Orobanche cumana* Wallr. etc. (Manilov and Zhalnov, 2015; Tonev et al., 2010).

In the region of the cities of Plovdiv and Stara Zagora, Bulgaria it is found that in the sunflower fields *Amaranthus blitoides* L. and *Amaranthus albus* L. occupy much of the total weed infestation with annual weeds. The authors report that the most common perennial weeds is *Convolvulus arvensis* L. (Moskova et al., 2016).

Breeding of hybrids resistant to imazamox and tribenuron-methyl enabled an efficient control of the main broadleaf and grassy weeds, including parasitic species from genus *Orobanche* (Fernandez-Martinez et al., 2009; Malidza et al., 2003).

At the Clearfield® tecnology, the grown hybrids are resistant to the imidazolinone herbicide imazamox. The active substance inhibits the acetolactate synthase - ALS, the enzyme common to the biosynthesis of the amino acids valine, leucine and isoleucine. By its mode of action, the active substance controls the broadleaf weeds, as well as the grass weeds. For optimization of the existing technology, control of the new broomrape races and increasing the tolerance of the sunflower hybrids to imazamox, from 2016 there was released more developed version of the technology in Bulgaria. The name of the new technology is Clearfield Plus®. This system provides sunflower growers a better tool to manage weeds (Pfenning et al., 2012).

The aim of the current study is to evaluate the efficacy and selectivity of imazamox-containing herbicides at two sunflower hybrids bred to be grown by the Clearfield® and Clearfield® Plus technologies.

## MATERIALS AND METHODS

The experiment was situated in the experimental field of the base for training and implementation of the Agricultural University of Plovdiv, Bulgaria. The trial was conducted by the randomized block design in 4 replications. The size of the experimental plot was 28 m². The sowing date is on the 18th of April 2018 with planting distance 25 x 70 cm. The grown sunflower hybrids were SY Bacardi CLP and SY Diamantis CL. The experiment included the following treatments: 1. Untreated control; 2. Pulsar 40 - 1.25 l/ha; 3. Pulsar 40 - 2.50 l/ha; 4. Pulsar Plus - 1.20 l/ha, 5. Pulsar Plus - 2.40 l/ha. Both sunflower hybrids were treated with the same rates and herbicides products. Pulsar® 40 is containing 40.0 g/l Imazamox and Pulsar® Plus is containing 25 g/l Imazamox. The herbicides were applied in phenophase 4th-6th true leaf of the sunflower (BBCH 14-16).

A predecessor of the sunflower was winter wheat. On the trial field deep ploughing, two times disc harrowing and two times cultivation before sowing were done. Basic combine fertilization with 250 kg ha$^{-1}$ NPK 15:15:15 and spring dressing with 200 kg/ha $NH_4NO_3$ was performed.

The efficacy of the studied herbicides and rates was evaluated by the 10 score scale of EWRS was evaluated on the 14th, 28th and 56th day after application as described by Zhelyazkov et al. (2017). The weed infestation was presented by Johnson grass (*Sorghum halepense* Pers.) developed from rhizomes, Johnson grass (*S. halepense*) developed from seeds, Green bristle grass (*Setaria viridis* L.), Fat-hen (*Chenopodium album* L.), Common amaranth (*Amaranthus retroflexus* L.), Rough cocklebur (*Xanthium strumarium* L.), Velvetleaf (*Abutilon theophrasti* L.), Black nightshade (*Solanum nigrum* L.) and Wild mustard (*Sinapis arvensis* L.). The selectivity by the 9 score scale of EWRS as described by Zhelyazkov et al. (2017) was evaluated on the 7th and on the 14th day after the herbicide application (at score 0 there are not damages on the crop, and at score 9 the crop is completely destroyed).

The hectoliter seed mass was measured by weighing two parallel samples of 100 dm$^3$ air dry seeds. The hectoliter mass is calculated, as the arithmetic means of the established mass of the two samples (in grams) multiply by 100 and the resulting is divided into 1000 to obtain the mass in kilograms (Tonev et al., 2018).

The absolute seed mass of 1000 clean, air-dry seeds, expressed in grams was also measured (Tonev et al., 2018).

The oil content in the sunflower seeds was determined by the Soxhlet method as described by Ivanov and Popov (1994).

Statistical analysis of collected data was performed by using Duncan's multiple range test by the software SPSS 19. Statistical differences were considered significant at $p<0.05$.

## RESULTS AND DISCUSSIONS

Because of the fact that the efficacy of both herbicide products is performed parallel for both sunflower hybrids the results are going to be presented together independently the hybrids.

Table 1. Efficacy against Johnson grass (*Sorghum halepense* Pers.) developed from rhizomes (%)

| Treatments | 14 day | 28 day | 56 day |
|---|---|---|---|
| 1. Untreated control | - | - | - |
| 2. Pulsar 40 - 1.25 l ha$^{-1}$ | 20 | 35 | 45 |
| 3. Pulsar 40 - 2.50 l ha$^{-1}$ | 20 | 40 | 50 |
| 4. Pulsar Plus - 1.20 l ha$^{-1}$ | 30 | 40 | 55 |
| 5. Pulsar Plus - 2.40 l ha$^{-1}$ | 40 | 55 | 65 |

On the 14th day after the treatments, the highest efficacy against Johnson grass (*S. halepense*) developed from rhizomes was recorded for variant 5 (Pulsar Plus - 2.40 l ha$^{-1}$) - 40%, followed by variant 4 (Pulsar Plus - 2.40 l ha$^{-1}$) - 30% (Table 1). The efficacy on this evaluation date against this difficult-to-control weed was unsatisfactory.

On the next evaluation dates the efficacy increased insignificantly. The efficacy data showed that Johnson grass developed from rhizomes cannot be controlled by application of Pulsar 40 or Pulsar Plus independently the

examined rate. In situation with infestation of Johnson grass developed from rhizomes a partner grass herbicide product should be applied. Such a herbicide product is Stratos Ultra/Focus Ultra (100 g/l Cycloxydim) at rate of 2.00 l/ha.

On the 14th day after the treatments, the highest efficacy against the Johnson grass (*S. halepense*) developed from seeds was recorded for variant 5 (Pulsar Plus - 2.40 l $ha^{-1}$) - 90% (Table 2).

Table 2. Efficacy against Johnson grass (*S. halepense*) developed from seeds (%)

| Treatments | 14 day | 28 day | 56 day |
|---|---|---|---|
| 1. Untreated control | - | - | - |
| 2. Pulsar 40 - 1.25 l $ha^{-1}$ | 85 | 100 | 100 |
| 3. Pulsar 40 - 2.50 l $ha^{-1}$ | 85 | 100 | 100 |
| 4. Pulsar Plus - 1.20 l $ha^{-1}$ | 80 | 100 | 100 |
| 5. Pulsar Plus - 2.40 l $ha^{-1}$ | 90 | 100 | 100 |

For the other treatments the efficacy was also satisfactory from 80 to 85%.

On the 28th and on the 56th day after application the efficacy increased and reached 100% for all treatments. The efficacy data showed that Johnson grass (*S. halepense*) developed from seeds can be successfully controlled by application of Pulsar 40 or Pulsar Plus.

On the 14th day after the treatments, the highest efficacy against the Green bristle grass (*S. viridis*) was recorded for variant 5 (Pulsar Plus - 2.40 l $ha^{-1}$) - 90% (Table 3). For the other treatments the efficacy was also satisfactory - 85%. On the 56th day after application the efficacy increased and reached 100% for all treatments. The efficacy data showed that Green bristle grass developed from seeds can be controlled by Pulsar 40 or Pulsar Plus.

Table 3. Efficacy against Green bristle grass (*Setaria viridis* L.) (%)

| Treatments | 14 day | 28 day | 56 day |
|---|---|---|---|
| 1. Untreated control | - | - | - |
| 2. Pulsar 40 - 1.25 l $ha^{-1}$ | 85 | 90 | 100 |
| 3. Pulsar 40 - 2.50 l $ha^{-1}$ | 85 | 90 | 100 |
| 4. Pulsar Plus - 1.20 l $ha^{-1}$ | 85 | 90 | 100 |
| 5. Pulsar Plus - 2.40 l $ha^{-1}$ | 90 | 100 | 100 |

On the 14th day after the treatments, the highest efficacy against the Fat-hen (*Ch. album*) was recorded for variants 5 (Pulsar Plus - 2.40 l $ha^{-1}$). For the other treatments, accept for variant 2 (Pulsar 40 - 1.25 l $ha^{-1}$) - 65%, the efficacy was also satisfactory - from 80 to 85% (Table 4).

Table 4. Efficacy against Fat-hen (*Chenopodium album* L.) (%)

| Treatments | 14 day | 28 day | 56 day |
|---|---|---|---|
| 1. Untreated control | - | - | - |
| 2. Pulsar 40 - 1.25 l $ha^{-1}$ | 65 | 75 | 80 |
| 3. Pulsar 40 - 2.50 l $ha^{-1}$ | 85 | 95 | 95 |
| 4. Pulsar Plus - 1.20 l $ha^{-1}$ | 80 | 100 | 100 |
| 5. Pulsar Plus - 2.40 l $ha^{-1}$ | 95 | 100 | 100 |

On the 56th day after application the efficacy increased and reached 95-100% for all treatments accept treatment 2 (Pulsar 40 - 1.25 l $ha^{-1}$) which stayed the lowest - 75% on the 28th day and 80% on the 56th day after the herbicide treatment.

The efficacy data showed that the Fat-hen can be successfully controlled by application of Pulsar Plus even from the lowest of 1.20 l/ha, and Pulsar 40 cannot assure efficient control of this weed species.

On the 14th day after the treatments, the highest efficacy against the Common amaranth (*A. retroflexus*) was recorded for treatments 5 (Pulsar Plus - 2.40 l/ha) and 3 (Pulsar 40 - 2.50 l $ha^{-1}$) - 95% (Table 5). For the other treatments, the efficacy was also satisfactory - from 80 to 85%.

Table 5. Efficacy against Common amaranth (*Amaranthus retroflexus* L.) (%)

| Treatments | 14 day | 28 day | 56 day |
|---|---|---|---|
| 1. Untreated control | - | - | - |
| 2. Pulsar 40 - 1.25 l $ha^{-1}$ | 85 | 95 | 100 |
| 3. Pulsar 40 - 2.50 l $ha^{-1}$ | 95 | 100 | 100 |
| 4. Pulsar Plus - 1.20 l $ha^{-1}$ | 80 | 95 | 100 |
| 5. Pulsar Plus - 2.40 l $ha^{-1}$ | 95 | 100 | 100 |

On the 56th day after application the efficacy increased and reached 100% for all treatments. The efficacy data showed that the Common amaranth can be successfully controlled by application of Pulsar 40 or Pulsar Plus applied even in the lowest examined rates.

Tan et al. (2005) stated that using IMI herbicide resistant hybrids gave farmers, the opportunity to control broadleaf weeds such wide spread *Xanthium* sp., *Cirsium* sp. and the root parasite broomrape. The statement is confirmed in our study. On the 14th day after the treatments, the

highest efficacy against the Rough cocklebur (*Xa. strumarium*) was recorded for variant 5 (Pulsar Plus - 2.40 l $ha^{-1}$) - 95% (Table 6).
On the 56th day after application the efficacy increased and reached 100% for all treatments.

Table 6. Efficacy against Rough cocklebur (*Xanthium strumarium* L.) (%)

| Treatments | 14 day | 28 day | 56 day |
|---|---|---|---|
| 1. Untreated control | - | - | - |
| 2. Pulsar 40 - 1.25 l $ha^{-1}$ | 85 | 95 | 100 |
| 3. Pulsar 40 - 2.50 l $ha^{-1}$ | 90 | 100 | 100 |
| 4. Pulsar Plus - 1.20 l $ha^{-1}$ | 85 | 100 | 100 |
| 5. Pulsar Plus - 2.40 l $ha^{-1}$ | 95 | 100 | 100 |

The efficacy data in our trial also showed that the Rough cocklebur can be successfully controlled by Pulsar 40 or Pulsar Plus used even in the lowest rates.
On the 14th day after the treatments, the highest efficacy against the Velvetleaf (*A. theophrasti*) was recorded for variant 5 (Pulsar Plus - 2.40 l $ha^{-1}$) - 95% (Table 7).

Table 7. Efficacy against Velvetleaf (*Abutilon theophrasti* L.) (%)

| Treatments | 14 day | 28 day | 56 day |
|---|---|---|---|
| 1. Untreated control | - | - | - |
| 2. Pulsar 40 - 1.25 l $ha^{-1}$ | 75 | 85 | 90 |
| 3. Pulsar 40 - 2.50 l $ha^{-1}$ | 85 | 95 | 100 |
| 4. Pulsar Plus - 1.20 l $ha^{-1}$ | 85 | 95 | 100 |
| 5. Pulsar Plus - 2.40 l $ha^{-1}$ | 95 | 100 | 100 |

For the other treatments, except for variant 2 (Pulsar 40 - 1.25 l $ha^{-1}$) - 75%, the efficacy was satisfactory - 85%. On the 28th and 56th day after application the efficacy reached 95 - 100% for all treatments except for treatment 2 which stayed the lowest - 85% on the 28th day and 90% on the 56th day.
The efficacy data showed that the Velvetleaf can be successfully controlled by application of Pulsar Plus even from the lowest rate of 1.20 $ha^{-1}$, and Pulsar 40 showed lower efficacy against this weed species.
On the 14th day after the treatments, the highest efficacy against the Black nightshade (*S. nigrum*) was recorded for variant 5 (Pulsar Plus - 2.40 l $ha^{-1}$) - 100% (Table 8). For the other treatments the efficacy was also satisfactory - from 85 to 95%.
On the 56th day after application the efficacy increased and reached 100% for all treatments. The efficacy data showed that the Black nightshade can be successfully controlled by application of Pulsar 40 or Pulsar Plus in the lowest examined rates.

Table 8. Efficacy against Black nightshade (*Solanum nigrum* L.) (%)

| Treatments | 14 day | 28 day | 56 day |
|---|---|---|---|
| 1. Untreated control | - | - | - |
| 2. Pulsar 40 - 1.25 l $ha^{-1}$ | 90 | 95 | 100 |
| 3. Pulsar 40 - 2.50 l $ha^{-1}$ | 95 | 100 | 100 |
| 4. Pulsar Plus - 1.20 l $ha^{-1}$ | 85 | 100 | 100 |
| 5. Pulsar Plus - 2.40 l $ha^{-1}$ | 100 | 100 | 100 |

On the 14th day after the treatments the efficacy against the Wild mustard was the highest for variant 5 (Pulsar Plus - 2.40 l $ha^{-1}$) - 100% (Table 9). For the other treatments the efficacy on this reporting date was also satisfactory - from 85 to 90%.
On the 56th day after application the efficacy increased and reached 100% for all treatments. The efficacy data showed that the Wild mustard can be also successfully controlled by the low rates of both studied herbicide products.

Table 9. Efficacy against Wild mustard (*Sinapis arvensis* L.) (%)

| Treatments | 14 day | 28 day | 56 day |
|---|---|---|---|
| 1. Untreated control | - | - | - |
| 2. Pulsar 40 - 1.25 l $ha^{-1}$ | 85 | 95 | 100 |
| 3. Pulsar 40 - 2.50 l $ha^{-1}$ | 90 | 100 | 100 |
| 4. Pulsar Plus - 1.20 l $ha^{-1}$ | 85 | 100 | 100 |
| 5. Pulsar Plus - 2.40 l $ha^{-1}$ | 100 | 100 | 100 |

The visual phytotoxicity 7 and 14 days after the treatments for hybrid SY Bacardi CLP is on Figure 1, and for hybrid SY Diamantis CL is on Figure 2.
Balabanova and Vassilev (2015) concluded that the treatment with the herbicide imazamox causes an inhibition of growth and photosynthetic performance in IMI-R Clearfield sunflower hybrids. The inhibition is less pronounced in the plants treated with the recommendable dose (120 ml/da Pulsar 40) and significantly higher in the plants treated with the exceeded imazamox dose.
The highest phytotoxicity for hybrid SY Bacardi CLP was observed for variant 3 (Pulsar 40 - 2.50) l $ha^{-1}$ - score 2. It was determined as low phytotoxicity. This was due to the treatment of the doubled rate of Pulsar 40. The

content of the active substance in the herbicide product is higher and it was more aggressive to the sunflower hybrid that is bred to be grown by the Clearfield Plus technology. After the treatments for variant 2 the phytotoxic symptoms were classified as very weak - score 1. Phytotoxic symptoms were not reported after the application of Pulsar Plus even in the double rate of 2.50 l $ha^{-1}$.

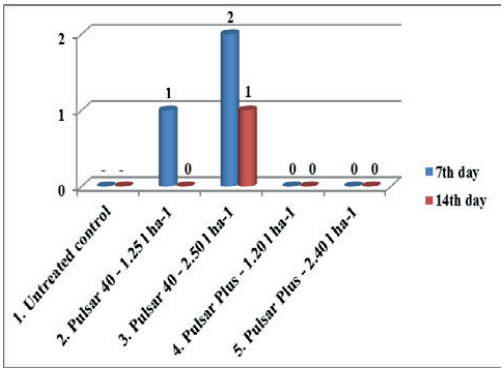


Figure 1. Visual phytotoxicity 7 and 14 days after the treatments for hybrid SY Bacardi CLP (Scores)

In our trial the phytotoxicity was higher for the hybrid SY Diamantis CL and it was determined as weak (score 2) after the application of the doubled Pulsar 40 rate (variant 3). After the treatments Pulsar Plus the phytotoxic symptoms for all variants were determined as weak (score 2) to very weak (score 1).
On the second evaluation date the phytotoxicity decreased independently the hybrid, herbicide and application rate.

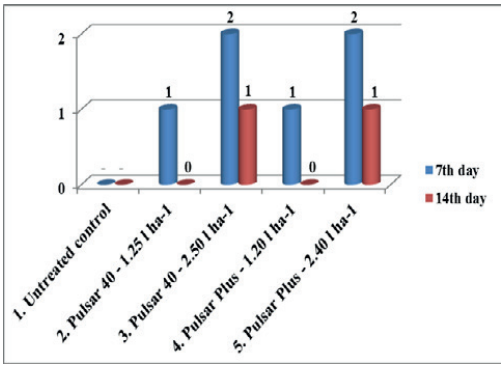


Figure 2. Visual phytotoxicity 7 and 14 days after the treatments for hybrid SY Diamantis CL (Scores)

The absolute seed mass of 1000 seeds is a very important quality indicator. The results from the current study are presented in Table 10. The seeds with higher values of the indicator have a higher price. According to a lot of authors this indicator is crucial for the formation of the yields (Georgiev et al., 2014).
The highest absolute seed mass of 1000 sunflower seeds for the hybrid SY Bacardi CLP was reported for treatments 2 and 4 (Table 10). The differences of the obtained results for these treatments are with proved differences according to Duncan's multiple range test ($p<0.05$) in comparison to the rest of the treatments.

Table 10. Absolute seed mass of 1000 seeds (g)

| Treatments | SY Bacardi CLP | SY Diamantis CL |
|---|---|---|
| 1. Untreated control | 55.47 c | 57.22 c |
| 2. Pulsar 40 - 1.25 l $ha^{-1}$ | 61.50 a | 61.02 a |
| 3. Pulsar 40 - 2.50 l $ha^{-1}$ | 59.30 b | 60.63 b |
| 4. Pulsar Plus - 1.20 l $ha^{-1}$ | 61.35 a | 61.71 a |
| 5. Pulsar Plus - 2.40 l $ha^{-1}$ | 58.89 b | 60.10 b |

All values with different letters are with proved difference according Duncan's test, $p < 0.05$

The lowest absolute seed mass of 1000 sunflower seeds for the untreated control was recorded - 55.47 g.
For the hybrid SY Diamantis CL similar results were obtained. The plants treated with doubled herbicide rates independently the studied herbicide product had lower absolute seed mass.
The lowest absolute seed mass of 1000 seeds for the untreated highly infested with weeds control was recorded - 57.22 g. The result concerning this indicator for the control plants was with a proved difference in comparison to all treated variants according to Duncan's multiple range test at $p<0.05$.
High hectoliter mass is thus preferred by the industry (Abraham Nel, 2001). The lowest hectoliter mass of the sunflower seeds was the lowest for the control for both sunflower hybrids - 41.17 and 40.83 kg for SY Bacardi CLP and SY Diamantis CL respectively (Table 11). The magnitude of the hectoliter seed mass is determined by the grain size, the presence of impurities, etc. (Tonev et al., 2018).

The highest hectoliter mass of the sunflower seeds for SY Bacardi CLP was recorded at variants 2, 4 and 5 (Table11).
The differences of the obtained results for these treatments were with proved differences with the treatment 3. This could be a result of the doubled Pulsar 40 rate and the fact that this is a hybrid bred to be grown by the Clearfield Plus technology.
The lowest results were recorded for the untreated control - 40.10 kg.

Table 11. Hectoliter mass of the sunflower seeds (kg)

| Treatments | SY Bacardi CLP | SY Diamantis CL |
|---|---|---|
| 1. Untreated control | 40.10 c | 40.80 c |
| 2. Pulsar 40 - 1.25 l ha$^{-1}$ | 43.60 a | 43.60 a |
| 3. Pulsar 40 - 2.50 l ha$^{-1}$ | 42.60 b | 42.30 b |
| 4. Pulsar Plus - 1.20 l ha$^{-1}$ | 43.35 a | 43.60 a |
| 5. Pulsar Plus - 2.40 l ha$^{-1}$ | 43.60 a | 43.30 a |

All values with different letters are with proved difference according Duncan's test, $p < 0.05$.

The highest hectoliter mass of the sunflower seeds for SY Diamantis CL was recorded for variants 2, 4 and 5 (Table11). The differences of the obtained results for these treatments were with proved differences regarding the data for treatment 3 according to Duncan's test. This could be also a result of an herbicide stress caused by the double Pulsar 40 rate.
As well as for the 1000 seeds mass the values and for the indicator hectoliter seed mass, a decrease in the values after the application of double herbicide rates for both studied sunflower hybrids was recorded. This could be a result of herbicide stress caused by the doubled herbicide doses.
In our previous study similar results were gained. The values of the hectoliter mass after the application of double herbicide rates independently the phenophase of the sunflower were lower (Mitkov et al., 2019).
Yield can generally decrease with increased duration of weed interference (Elezovic et al., 2012). In order to obtain maximum yields, along with the use of high-yield hybrids it is necessary to effectively control the weeds (Manilov and Zhalnov, 2015).
The results in our study correspond with these statements. The highest sunflower seed yield for the hybrid SY Bacardi CLP was obtained for variant 4 (Pulsar Plus - 1.20 l ha$^{-1}$) - 3.38 t ha$^{-1}$. The yield of the untreated control was the lowest -1.85 t/ha (Table 12). This in turn shows how harmful the weed infestation in the sunflower fields can be.
The variants treated with doubled imazamox rates had lower yields in comparison to those treated with lower doses.

Table 12. Seed yield of SY Bacardi CLP (t/ha)

| Treatments | t ha$^{-1}$ |
|---|---|
| 1. Untreated control | 1.85 d |
| 2. Pulsar 40 - 1.25 l ha$^{-1}$ | 2.96 b |
| 3. Pulsar 40 - 2.50 l ha$^{-1}$ | 2.21 c |
| 4. Pulsar Plus - 1.20 l ha$^{-1}$ | 3.38 a |
| 5. Pulsar Plus - 2.40 l ha$^{-1}$ | 2.42 c |

All values with different letters are with proved difference according Duncan's test, $p < 0.05$.

The highest sunflower seed yield for the hybrid SY Diamantis CL was recorded for variant 4 (Pulsar Plus - 1.20 l ha$^{-1}$) - 3.51 t ha$^{-1}$. The difference of the gained results for the sunflower seed yield at this variants was with proved differences according to Duncan's multiple range test ($p<0.05$) in comparison to the other treatments. The yield of the untreated control was the lowest for this hybrid also - 1.89 t ha$^{-1}$ (Table 13).

Table 13. Seed yield of SY Diamantis CL (t/ha)

| Treatments | t ha$^{-1}$ |
|---|---|
| 1. Untreated control | 1.89 d |
| 2. Pulsar 40 - 1.25 l ha$^{-1}$ | 2.96 b |
| 3. Pulsar 40 - 2.50 l ha$^{-1}$ | 2.32 c |
| 4. Pulsar Plus - 1.20 l ha$^{-1}$ | 3.51 a |
| 5. Pulsar Plus - 2.40 l ha$^{-1}$ | 2.35 c |

All values with different letters are with proved difference according Duncan's test, $p < 0.05$.

Oil quality is determined by the fatty acid composition and the levels of tocopherols, sterols, carotenoids and other compounds. Sunflower is regarded as one of the most promising crops when it comes to the genetic alteration of oil quality (Scharp, 1986). The high weed infestation can decrease the oil content in the sunflower seeds, so it is important to effectively control the weeds (Tonev et al., 2007).
In the resent research we also reported decrease of the oil content in the sunflower seeds from the untreated control for both studied hybrids (Table 14) 48.43% for SY Bacardi CLP and 44.98 % for hybrid SY Diamantis CL. The results were the lowest in the study.

Table 14. Sunflower seed oil content (%)

| Treatments | SY Bacardi CLP | SY Diamantis CL |
|---|---|---|
| 1. Untreated control | 48.43 e | 44.98 d |
| 2. Pulsar 40 - 1.25 l ha$^{-1}$ | 54.01 b | 49.36 a |
| 3. Pulsar 40 - 2.50 l ha$^{-1}$ | 51.43 d | 46.86 c |
| 4. Pulsar Plus - 1.20 l ha$^{-1}$ | 55.48 a | 49.91 a |
| 5. Pulsar Plus - 2.40 l ha$^{-1}$ | 53.47 c | 48.11 b |

All values with different letters are with proved difference according Duncan's test, $p < 0.05$.

There are differences in the sunflower seed oil content between the varieties (Clagett et al., 1951; Cummins et al., 1967; Pehlivanov et al., 1998; Khoufi et al., 2014). It is also found in our study. The oil content of the seeds for the hybrid SY Bacardi CLP was higher than the oil content of hybrid SY Diamantis CL (Table 14). The highest oil content of SY Bacardi CLP was recorded for treatment 4 (Pulsar Plus - 1.20 l ha$^{-1}$) – 55.48%. In comparison to the other treatments, the difference of the obtained results for the sunflower seed oil content at treatment 4 (Pulsar Plus - 1.20 l/ha) was with proved differences according to Duncan's multiple range test ($p<0.05$). It was also reported that the seed oil content for the treatments with doubled herbicide rates was decreased (Table 14).

The highest oil content of SY Diamantis CL was recorded for treatments 2 (Pulsar 40 - 1.25 l ha$^{-1}$) and 4 (Pulsar Plus - 1.20 l ha$^{-1}$) - 49.36-49.91%. In comparison to the other treatments, the difference of the obtained results for the sunflower seed oil content at treatments 2 and 4 were with proved differences according to Duncan's multiple range test.

It was also reported that the seed oil content for the treatments with doubled herbicide rates was also decreased (Table 14).

## CONCLUSIONS

The highest efficacy against the Johnson grass (*S. halepense*) developed from rhizomes was recorded for variant 5 (Pulsar Plus - 2.40 l ha$^{-1}$). If there is infestation with this difficult-to-control weed a partner grass herbicide should be applied.

The Johnson grass (*S. halepense*) developed from seeds, the Green bristle grass (*S. viridis*), the Common amaranth (*A. retroflexus*), the Rough cocklebur (*Xa. strumarium*), the Black nightshade (*S. nigrum*) and the Wild mustard (*S. arvensis*) can be successfully controlled by application of Pulsar 40 or Pulsar Plus even in the low examined rates.

The Fat-hen (*Ch. album*) and the Velvetleaf (*A. theophrasti*) can be successfully controlled by application of Pulsar Plus even from the lowest of 1.20 l ha$^{-1}$.

Pulsar 40 is more selective for the Clearfield Plus hybrid SY Bacardi CLP than Pulsar Plus for the Clearfield hybrid SY Diamantis CL.

The absolute seed mass of 1000 seeds, the hectoliter seed mass and the yield as well as the seed oil of the plants from the doubled herbicide rates, independently the herbicide product and studied hybrid, were higher than those of the untreated controls highly infested with weeds.

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