

**4<sup>th</sup> International Symposium on Broomrape in Sunflower**



# **EFFICACY AGAINST BROOMRAPE AND SELECTIVITY OF IMAZAMOX-CONTAINING HERBICIDES AT SUNFLOWER**

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# Statistical data about the sunflower production

Year	Yields t/ha	Total production/000 tons	Export/ 000 tons
2006	1,60	1201	628
2007	0,90	542	344
2008	1,80	1299	657
2009	1,90	1299	821
2010	2,10	1533	926
2011	1,93	1442	850
2012	1,78	1390	841
2013	2,04	1804	1211
2014	2,05	1638	1088
2015	2,10	1619	1058
2016	2,15	1622	1060
2017	2,21	1654	1087

In 2013 Bulgaria had the highest worldwide export of sunflower seeds – 17.8%

In order to achieve high yields, along with the optimization of the main vegetation factors, it is necessary to effectively control the weeds as well as the root parasite *Orobanche cumana* Wallr.!!!



# 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 with size of the experimental plot 28 m<sup>2</sup>.
- The grown sunflower hybrid was „Lucia CLP” – susceptible to parasitisation of *O. cumana*.
- The number of the parasites per one sunflower plant was counted at the end of the vegetation. Per every repetition of each variant 2 sunflower rows were taken out from each plot and the number of parasites was recorded.

# MATERIALS AND METHODS

- For clearing out the field from annual grass and broadleaf weeds soil application of Stomp<sup>®</sup> Aqua (455 g/l *pendimethalin*) at rate of 3500 ml ha<sup>-1</sup> was performed to all experimental plots.
- The hectoliter seed mass was measured by weighing two parallel samples of 100 dm<sup>3</sup> air dry seeds.
- The absolute seed mass of 1000 clean, air-dry seeds, expressed in grams was also measured.
- The selectivity by the 9 score scale of EWRS was evaluated on the 7<sup>th</sup> and the 14<sup>th</sup> day after the herbicide application (at score 0 there are not damages on the crop, and at score 9 the crop is completely destroyed).
- Statistical analysis of collected data was performed by using Duncan's multiple range test by the software SPSS 19.

# MATERIALS AND METHODS

Variants of the trial:

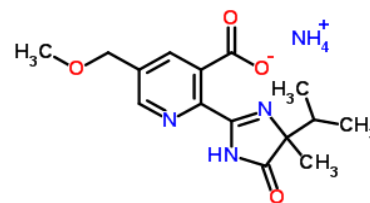
1. **Untreated control;**
2. Pulsar<sup>®</sup> 40 - 1200 ml ha<sup>-1</sup>
3. Pulsar<sup>®</sup> 40 - 2400 ml ha<sup>-1</sup>
4. Pulsar<sup>®</sup> 40 - 1200 ml ha<sup>-1</sup>
5. Pulsar<sup>®</sup> 40 - 2400 ml ha<sup>-1</sup>
6. Pulsar<sup>®</sup> Plus - 2000 ml ha<sup>-1</sup>
7. Pulsar<sup>®</sup> Plus - 4000 ml ha<sup>-1</sup>
8. Pulsar<sup>®</sup> Plus - 2000 ml ha<sup>-1</sup>
9. Pulsar<sup>®</sup> Plus - 4000 ml ha<sup>-1</sup>

✓ Pulsar<sup>®</sup> 40 is containing 40.0 g/l *Imazamox*

✓ Pulsar<sup>®</sup> Plus is containing 25.0 g/l *Imazamox*.

✓ At variants 2, 3, 6 and 7 the herbicides were applied in phenophase 4<sup>th</sup> – 6<sup>th</sup> true leaf of the sunflower (BBCH 14-16)

✓ At variants 4, 5, 8 and 9 – in phenophase 8<sup>th</sup> – 10<sup>th</sup> true leaf  
• (BBCH 18-19).



# RESULTS AND DISCUSSIONS

Table 1. Number of *O. cumana* per sunflower plant

Treatments	2016	2017	Average
1. Untreated control	9,29 a	18,00 a	13,64 a
2. Pulsar® 40 - 1200 ml ha <sup>-1</sup>	2,94 b	5,68 b	4,31 b
3. Pulsar® 40 - 2400 ml ha <sup>-1</sup>	1,69 c	3,13 c	2,41 c
4. Pulsar® 40 - 1200 ml ha <sup>-1</sup>	0,21 e	0,60 e	0,41 e
5. Pulsar® 40 - 2400 ml ha <sup>-1</sup>	0,05 f	0,08 f	0,07 f
6. Pulsar® Plus - 2000 ml ha <sup>-1</sup>	0,80 d	1,14 d	0,97 d
7. Pulsar® Plus - 4000 ml ha <sup>-1</sup>	0,66 d	0,83 d	0,75 d
8. Pulsar® Plus - 2000 ml ha <sup>-1</sup>	0,26 e	0,48 e	0,37 e
9. Pulsar® Plus - 4000 ml ha <sup>-1</sup>	0,04 f	0,07 f	0,06 f

Figures with different letters are with proved difference according to Duncan's multiple range test ( $p < 0.05$ )

At variants 2, 3, 6 and 7 the herbicides are applied in 4th – 6th true leaf of the sunflower (BBCH 14-16)

At variants 4, 5, 8 and 9 – in phenophase 8th – 10th true leaf (BBCH 18-19).



**Untreated control**





**Untreated control in 2017**





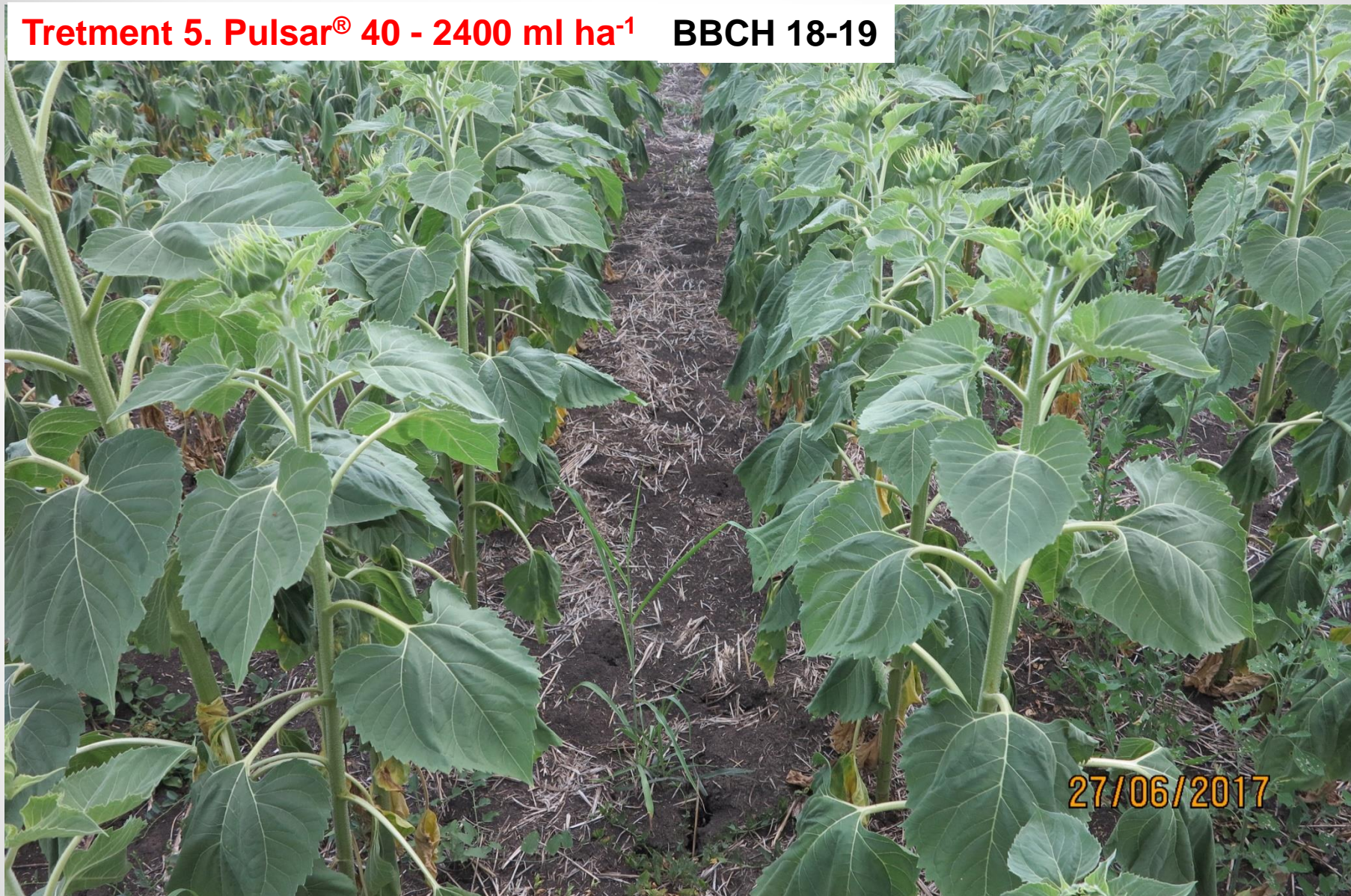


**2. Pulsar® 40 - 1200 ml ha<sup>-1</sup> BBCH 14-16**





**Treatment 5. Pulsar<sup>®</sup> 40 - 2400 ml ha<sup>-1</sup> BBCH 18-19**



27/06/2017



**Treatment 9.**

**BBCH 18-19**

**Pulsar<sup>®</sup> Plus - 4000 ml ha<sup>-1</sup>**



**27/06/2017**

# RESULTS AND DISCUSSIONS

**Table 2. Visual phytotoxicity at the sunflower on the 7<sup>th</sup> day after herbicide application (by the visual score scale of EWRS)**

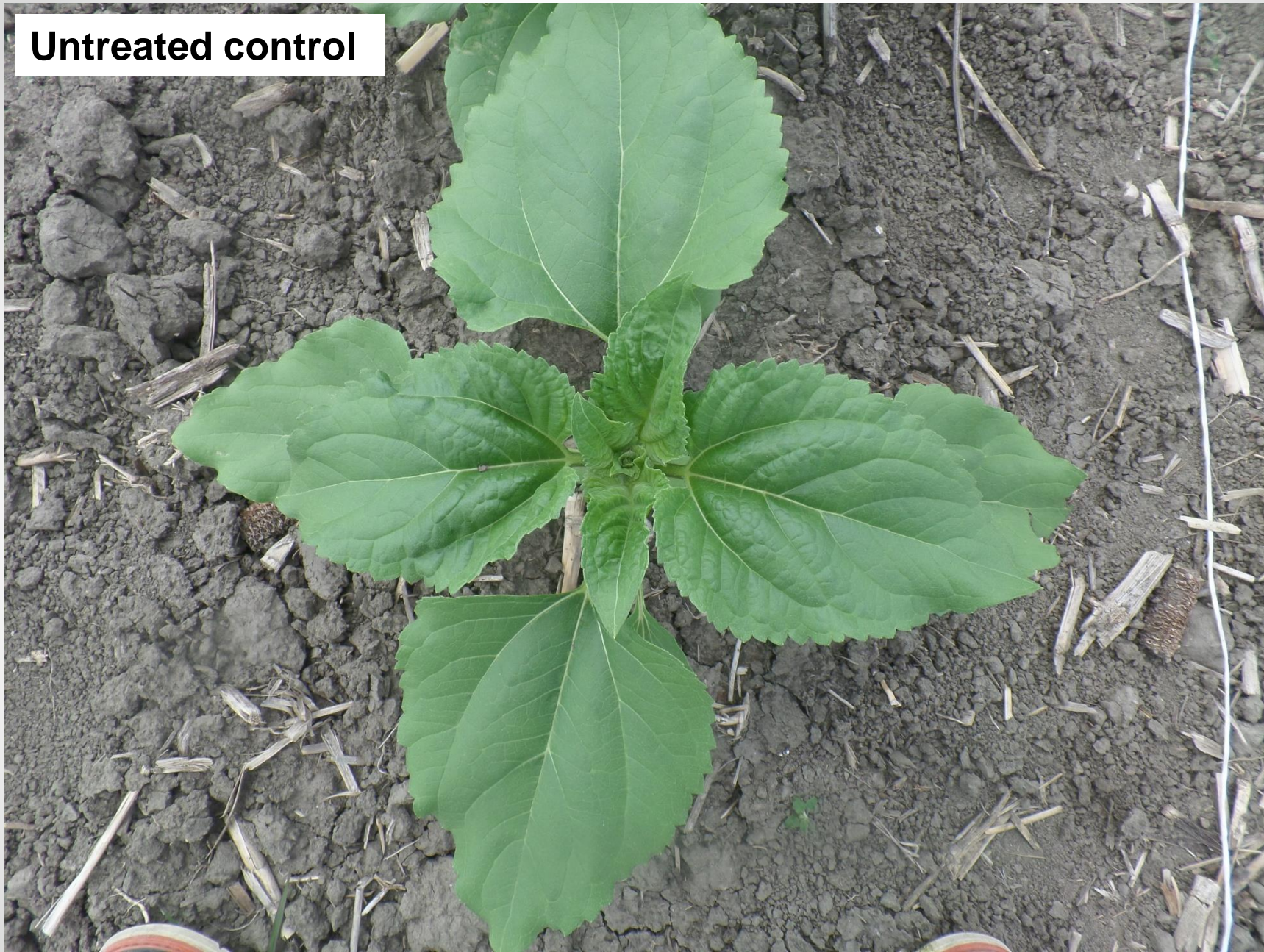
Treatments	2016	2017	Average
1. Untreated control	-	-	-
2. Pulsar <sup>®</sup> 40 - 1200 ml ha <sup>-1</sup>	2	2	2
3. Pulsar <sup>®</sup> 40 - 2400 ml ha <sup>-1</sup>	<u>3</u>	<u>3</u>	<u>3</u>
4. Pulsar <sup>®</sup> 40 - 1200 ml ha <sup>-1</sup>	2	2	2
5. Pulsar <sup>®</sup> 40 - 2400 ml ha <sup>-1</sup>	<u>3</u>	<u>3</u>	<u>3</u>
6. Pulsar <sup>®</sup> Plus - 2000 ml ha <sup>-1</sup>	1	1	1
7. Pulsar <sup>®</sup> Plus - 4000 ml ha <sup>-1</sup>	2	2	2
8. Pulsar <sup>®</sup> Plus - 2000 ml ha <sup>-1</sup>	1	1	1
9. Pulsar <sup>®</sup> Plus - 4000 ml ha <sup>-1</sup>	2	2	2

At variants 2, 3, 6 and 7 the herbicides are applied in 4th – 6th true leaf of the sunflower (BBCH 14-16)

At variants 4, 5, 8 and 9 – in phenophase 8th – 10th true leaf (BBCH 18-19).



**Untreated control**







**3. Pulsar® 40 - 2400 ml ha<sup>-1</sup>**



**6. Pulsar® Plus - 2000 ml ha<sup>-1</sup>**



# RESULTS AND DISCUSSIONS

**Table 3. Visual phytotoxicity at the sunflower on the 14<sup>th</sup> day after herbicide application (by the visual score scale of EWRS)**

Treatments	2016	2017	Average
1. Untreated control	-	-	-
2. Pulsar <sup>®</sup> 40 - 1200 ml ha <sup>-1</sup>	0	0	0
3. Pulsar <sup>®</sup> 40 - 2400 ml ha <sup>-1</sup>	<u>1</u>	<u>1</u>	<u>1</u>
4. Pulsar <sup>®</sup> 40 - 1200 ml ha <sup>-1</sup>	0	0	0
5. Pulsar <sup>®</sup> 40 - 2400 ml ha <sup>-1</sup>	<u>1</u>	<u>1</u>	<u>1</u>
6. Pulsar <sup>®</sup> Plus - 2000 ml ha <sup>-1</sup>	0	0	0
7. Pulsar <sup>®</sup> Plus - 4000 ml ha <sup>-1</sup>	0	0	0
8. Pulsar <sup>®</sup> Plus - 2000 ml ha <sup>-1</sup>	0	0	0
9. Pulsar <sup>®</sup> Plus - 4000 ml ha <sup>-1</sup>	0	0	0

At variants 2, 3, 6 and 7 the herbicides are applied in 4th – 6th true leaf of the sunflower (BBCH 14-16)

At variants 4, 5, 8 and 9 – in phenophase 8th – 10th true leaf (BBCH 18-19).

# RESULTS AND DISCUSSIONS

Table 4. Absolute seed mass of 1000 seeds, g

Treatments	2016	2017	Average
1. Untreated control	62,09 e	60,38 d	61,23 d
2. Pulsar® 40 - 1200 ml ha <sup>-1</sup>	64,19 c	63,48 b	63,84 b
3. Pulsar® 40 - 2400 ml ha <sup>-1</sup>	62,65 de	61,26 cd	61,96 d
4. Pulsar® 40 - 1200 ml ha <sup>-1</sup>	67,35 a	64,98 a	66,17 a
5. Pulsar® 40 - 2400 ml ha <sup>-1</sup>	62,46 de	61,33 cd	61,89 d
6. Pulsar® Plus - 2000 ml ha <sup>-1</sup>	67,43 a	64,98 a	66,21 a
7. Pulsar® Plus - 4000 ml ha <sup>-1</sup>	62,79 d	60,69 cd	61,74 d
8. Pulsar® Plus - 2000 ml ha <sup>-1</sup>	66,46 b	65,14 a	65,80 a
9. Pulsar® Plus - 4000 ml ha <sup>-1</sup>	63,83 c	61,80 c	62,82 c

Figures with different letters are with proved difference according to Duncan's multiple range test ( $p < 0.05$ )

At variants 2, 3, 6 and 7 the herbicides are applied in 4th – 6th true leaf of the sunflower (BBCH 14-16)

At variants 4, 5, 8 and 9 – in phenophase 8th – 10th true leaf (BBCH 18-19).



# RESULTS AND DISCUSSIONS

Table 5. Hectoliter seed mass, kg

Treatments	2016	2017	Average
1. Untreated control	26,33 d	26,04 e	26,19 e
2. Pulsar <sup>®</sup> 40 - 1200 ml ha <sup>-1</sup>	32,63 b	32,13 b	32,38 b
3. Pulsar <sup>®</sup> 40 - 2400 ml ha <sup>-1</sup>	30,45 c	29,72 cd	30,08 c
4. Pulsar <sup>®</sup> 40 - 1200 ml ha <sup>-1</sup>	33,15 ab	31,95 bc	32,55 b
5. Pulsar <sup>®</sup> 40 - 2400 ml ha <sup>-1</sup>	29,38 cd	27,08 de	28,23 d
6. Pulsar <sup>®</sup> Plus - 2000 ml ha <sup>-1</sup>	32,24 b	31,76 bc	32,00 b
7. Pulsar <sup>®</sup> Plus - 4000 ml ha <sup>-1</sup>	31,22 bc	30,06 c	30,64 c
8. Pulsar <sup>®</sup> Plus - 2000 ml ha <sup>-1</sup>	34,24 a	33,20 a	33,72 a
9. Pulsar <sup>®</sup> Plus - 4000 ml ha <sup>-1</sup>	30,41 c	29,43 d	29,92 cd

Figures with different letters are with proved difference according to Duncan's multiple range test ( $p < 0.05$ )

At variants 2, 3, 6 and 7 the herbicides are applied in 4th – 6th true leaf of the sunflower (BBCH 14-16)

At variants 4, 5, 8 and 9 – in phenophase 8th – 10th true leaf (BBCH 18-19).

# RESULTS AND DISCUSSIONS

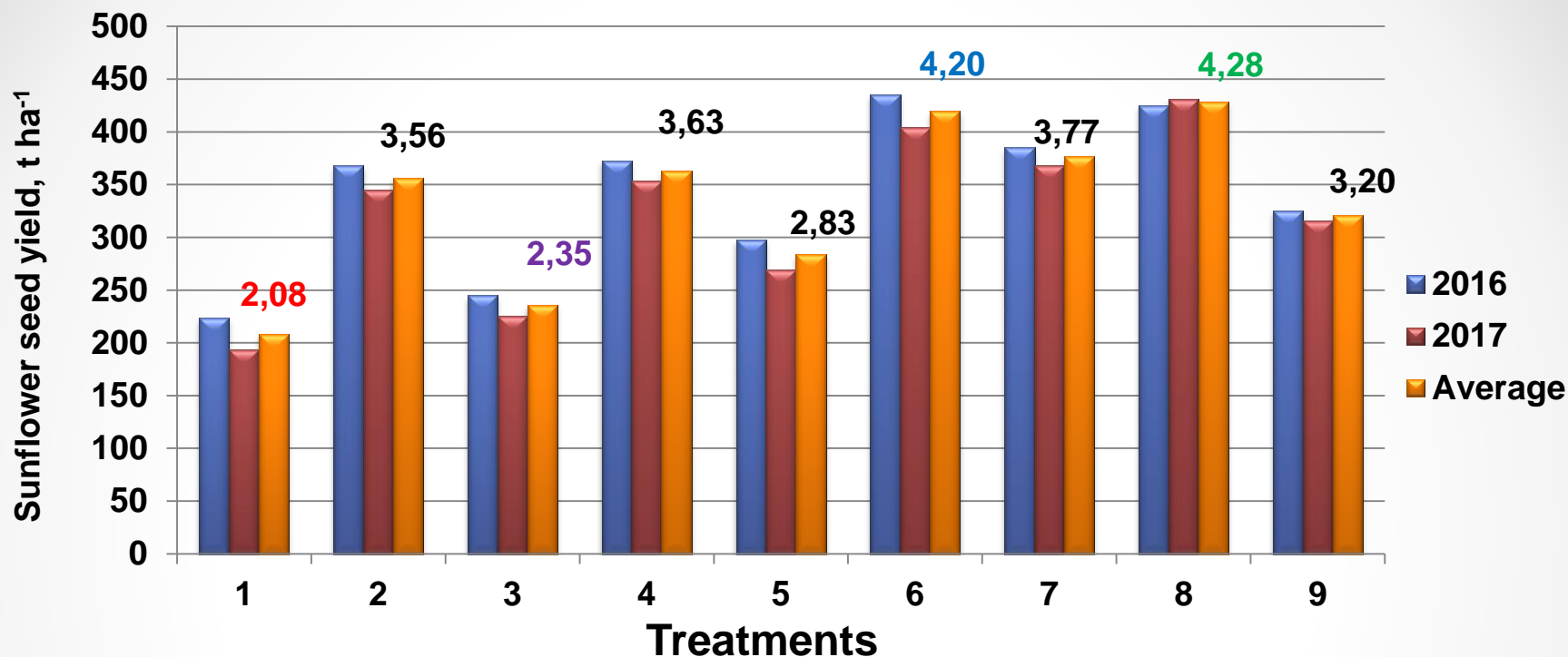


Figure 1. Sunflower seed yield, t ha<sup>-1</sup>

1. Untreated control

2. Pulsar<sup>®</sup> 40 - 1200 ml ha<sup>-1</sup> BBCH 14-16

3. Pulsar<sup>®</sup> 40 - 2400 ml ha<sup>-1</sup> BBCH 14-16

4. Pulsar<sup>®</sup> 40 - 1200 ml ha<sup>-1</sup> BBCH 18-19

5. Pulsar<sup>®</sup> 40 - 2400 ml ha<sup>-1</sup> BBCH 18-19

6. Pulsar<sup>®</sup> Plus - 2000 ml ha<sup>-1</sup> BBCH 14-16

7. Pulsar<sup>®</sup> Plus - 4000 ml ha<sup>-1</sup> BBCH 14-16

8. Pulsar<sup>®</sup> Plus - 2000 ml ha<sup>-1</sup> BBCH 18-19

9. Pulsar<sup>®</sup> Plus - 4000 ml ha<sup>-1</sup> BBCH 18-19

# CONCLUSIONS

- ✓ Average for the trial period the highest biological efficacy against *O. cumana* was recorded after the treatment with Pulsar<sup>®</sup> Plus - 4000 ml ha<sup>-1</sup> at BBCH 18-19, where the infestation varies from 0,04 to 0,07 parasites per sunflower.
- ✓ During the two years of the study the highest broomrape infestation was observed in the untreated control, where the density of the parasites were from 9,29 (in 2016) to 18,00 (in 2017) specimens per sunflower.
- ✓ The highest herbicide toxicity was found for the treatments with Pulsar<sup>®</sup> 40 at rate of 2400 ml ha<sup>-1</sup> at BBCH 14-16 as well as at BBCH 18-19.

# CONCLUSIONS

- ✓ The highest sunflower seed yield was recorded after the treatment with Pulsar<sup>®</sup> Plus - 2000 ml ha<sup>-1</sup> at BBCH 18-19 – 4,28 t ha<sup>-1</sup> followed by Pulsar<sup>®</sup> Plus - 2000 ml ha<sup>-1</sup> at BBCH 14-16 – 4,20 t ha<sup>-1</sup>.
- ✓ The lowest average yield for the experimental years was recorded for the untreated control – 2,08 t ha<sup>-1</sup>.
- ✓ It was statistically proved that the yield of the stressed from the doubled rates of Imazamox plants is higher than the yield of the untreated control.

# RECOMMENDATIONS FOR THE PRACTICE

- *On fields with high infestation of the root parasite **Orobanche cumana Wallr.** it is recommended to grow **Clearfiled<sup>®</sup> Plus** sunflower hybrids.*
- *For higher biological efficacy the imazamox treatment should be performed with the highest registered rates (**Pulsar<sup>®</sup> Plus** – 2000 ml/ha) and if possible in higher phenological stages (BBCH 18-19) of the sunflower.*



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**THANK YOU FOR YOUR ATTENTION!!!**

