

EVALUATION OF IMAZAMOX-CONTAINING HERBICIDES FOR WEED CONTROL IN COMMON BEANS (*Phaseolus vulgaris* L.)

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Abstract

In 2024 and 2025, a field experiment was conducted with common beans, variety 'Elexir'. The study was conducted on the agricultural land in the village of Madrets, Stara Zagora region, Bulgaria. The variants of the experiment were: 1. Untreated control - without the use of herbicides and without hoeing; 2. Economic control - removal of weeds by hoeing, without the application of herbicides; 3. Pulsar 40 (0.70 l ha⁻¹); 4. Pulsar 40 (1.00 l ha⁻¹); 5. Pulsar 40 (1.30 l ha⁻¹); 6. Pulsar Plus (1.12 l ha⁻¹); 7. Pulsar Plus (1.60 l ha⁻¹); 8. Pulsar Plus (2.08 l ha⁻¹). The herbicides were applied during the second lateral branching phenophase of the crop (BBCH 22). The highest herbicidal control against *Setaria viridis* L., *Xanthium strumarium* L., *Chenopodium album* L. and *Abutilon theophrasti* Medik. was found after the application of Pulsar Plus (2.08 l/ha) and Pulsar 40 (1.30 l/ha). *Convolvulus arvensis* L. is the most difficult to control of the herbicides studied. The highest bean yield was obtained with Economic control, Pulsar Plus (2.08 l ha⁻¹) and Pulsar 40 (1.30 l ha⁻¹).

Key words: common bean, weeds, herbicides, efficacy, yield.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) in Bulgaria was grown on an area of 1944 ha in 2024 with an average yield of 614 kg/ha (Ministry of Agriculture and Food, 2025). It is a major source of cheap protein food (Duranti and Gius, 1997), and is therefore an important crop in many parts of the world, including the USA (Urwin et al., 1996), Canada (Blackshaw et al., 2000), the Mediterranean (Önder and Babaoglu, 2001) and Africa (Maingi et al., 2001). According to Pavlovic et al. (2024) in the USA *Ph. vulgaris* L. is an important crop for both fresh consumption and processing. In Europe, beans are traditionally grown in countries such as Bulgaria, Greece, Italy and Spain. (Pavlovic et al., 2024).

Successful weed control is an important component of sustainable bean production. Since beans are characterized by limited above-ground development, they are considered to be weak competitors to weeds. High levels of weed density can lead to stunted crop growth and reduced leaf area, as well as fewer pods per plant (Ghamari & Ahmadvand, 2012). Studies conducted in the USA and Canada have reported yield losses of around 80% at high weed densities. Stagnari & Pisante (2011) found that the presence of weeds throughout the growing

season of *Ph. vulgaris* L. resulted in a 59 to 65% yield reduction, and Goudarzi et al. (2023) reported that uncontrolled annual weeds caused a 70% yield reduction in common bean. Other authors have shown that weed associations, in addition to reducing crop yield by 53.3%, have a negative effect on phenological development and delay flowering by 6 days (Kebede et al., 2016). For this reason, successful weed control is important for profitable bean production, with herbicide application currently being the most common practice (Malik et al., 1993; Soltani et al., 2018; Taziar et al., 2017).

Weed control depends on correctly determining the critical period of weed competition. According to Bolaños Espinoza et al. (2009) this is the phenophase after the formation of the first triple leaf, before the flowering of the crop. Stagnari & Pisante (2011) found that weeds are most dangerous for beans from the 11th to the 28th day after crop emergence. Mehrpoyan (2010) reported that the critical period is from the 21st to the 43rd day after emergence of *Ph. vulgaris* L. Bean yield decreases with increasing duration of weed coexistence with the crop (Mehrpoyan, 2010).

The most common weeds in common bean fields are representatives of the dicot species such as *Amaranthus retroflexus* L., *Chenopodium album* L., *Portulaca oleracea* L.,

Datura stramonium L., *Convolvulus arvensis* L., the reed weed species *Cyperus esculentus* L., *Cyperus rotundus* L. and the monocot species *Cynodon dactylon* L., *Sorghum halepense* L., *Echinochloa crus-galli* L., *Eleusine indica* L., *Setaria viridis* L., *Digitaria sanguinalis* L. (Sadeghi et al., 2013; da Costa et al., 2013; Feizollah et al., 2016; Singh et al., 2018).

Chemical control is the most popular method for weed management in common bean, with trifluralin, bentazone, pendimethalin, fomesafen, fluazifop-p-butyl and quizalofop-p-ethyl being among the most commonly used herbicides (da Costa et al., 2013; Głowacka, A. 2013; Singh et al., 2018; Ayonoadu et al., 1974). According to Singh et al. (2018), pendimethalin and quizalofop-p-ethyl significantly reduced weed biomass and density, while pendimethalin provided high efficacy against *Chenopodium album* L., leading to a 72% increase in seed yield compared to the untreated control (Srivastava et al., 2013).

Vegetative treatments are most effective against weeds less than 5 to 7 cm tall, and crop development stage should be considered to avoid plant injury and yield reduction (Bailey et al. 2003). Imazamox, fomesafen, and bentazone – used in beans during the vegetative stage – should be applied only after the first trifoliate leaf is fully developed (Wyenandt et al. 2024). It has been found that the combination of bentazone with fomesafen damages plants up to 34%, while the individual application of these herbicides leads to moderate damage – 12-20%. Treatments in the cotyledon and simple leaf phase are the riskiest, and application in the first three-leaf stage is the safest for the plant. Yields are reduced the most with bentazone + fomesafen and imazamox – 76-77% compared to the control, which confirms that vegetative herbicides should be applied after the full development of the first three-leaf stage in order to minimize phytotoxicity and not compromise yield (Sosnoskie et al., 2025).

Imazamox is an imidazolinone herbicide that inhibits the enzyme acetolactate synthase (ALS). It is absorbed by the leaves and roots and readily translocates into the plant to the point of growth, inhibiting the activity of ALS. This results in the blocking of branched-chain amino acid production and a reduction in protein synthesis and cell division in plants, causing

weed death. Imazamox has been reported to provide effective control against broadleaf weeds (ADAMA, 2021). The first symptoms may appear 2 days after herbicide application, but plant death may take 2-3 weeks (ADAMA, 2021). Soltani et al. (2010) reported that recommended doses of imazethapyr in dry beans can be reduced by combining with trifluralin. The objective of this study was to evaluate imazamox-containing herbicides for weed control in common bean.

MATERIALS AND METHODS

In 2024 and 2025, a field experiment was conducted with beans, variety 'Elexir' grown in the land of the village of Madrets, Stara Zagora region, Republic of Bulgaria. The experiment was set up using a block method in 4 replications with an experimental area of 20 m². Against a natural background of weeding, the efficacy and selectivity of two imazamox containing herbicides - Pulsar 40 (containing 40 g/l imazamox) and Pulsar Plus (containing 25 g/l imazamox and adjuvants) was studied. The experiment variants are: 1. Untreated control – without herbicides and without hoeing; 2. Economic control – hoeing without herbicides; 3. Pulsar 40 – 0.70 l/ha; 4. Pulsar 40 – 1.00 l/ha; 5. Pulsar 40 – 1.30 l/ha; 6. Pulsar Plus – 1.12 l/ha; 7. Pulsar Plus – 1.60 l/ha; 8. Pulsar Plus – 2.08 l/ha. The herbicide was applied in the phenophase second lateral branch BBCH – 22 with a backpack sprayer and a working solution of 300 l/ha, the dates of herbicide application are indicated in Table 1.

Table 1. Term of taking into account the biological efficacy and selectivity of imazamox-containing herbicides

Date of treatment	Bio efficiency reporting		Selectivity reporting			
	20 th	40 th	3 rd	7 th	14 th	28 th
28.05.2024	17.06	07.07	31.05	04.06	11.06	25.06
04.06.2025	24.06	14.07	07.06	11.06	18.06	02.07

In both experimental years, the predecessor of the beans was winter soft wheat. For field preparation in both experimental years, the following treatments were carried out: vertical tillage to a depth of 30 cm after the field was cleared of the predecessor (July) and cultivation to a depth of 15 cm in March and 10 cm in April.

The beans were sown on April 18, 2024 and April 22, 2025 with a sowing rate of 13.5 germinating seeds per linear meter and a row spacing of 75 cm. Immediately afterwards, rolling was carried out with a grapple roller.

To overcome the adverse weather conditions in 2025, the beans were irrigated by sprinkling. In 2024, the beans were not irrigated despite the need, which had an adverse effect on the yield. The biological efficacy of the tested herbicides was recorded on the 20th and 40th day after treatment using the quantitative method pcs/m² (Table 1.). The natural weed vegetation was represented by: common cocklebur (*Xanthium strumarium* L.), lambsquarters (*Chenopodium album* L.), common purslane (*Portulaca oleracea* L.), venice mallow (*Hibiscus trionum* L.), velvetleaf (*Abutilon theophrasti* Medik), green foxtail (*Setaria viridis* L.) and field bindweed (*Convolvulus arvensis* L.). During the two experimental years, single plants of redroot pigweed (*Amaranthus retroflexus* L.) and prickly lettuce (*Lactuca serriola* L.) were also found.

The selectivity of the studied herbicides was determined on the 3rd, 7th, 14th and 28th day after their application (Table 1.) according to the 9-point EWRS scale, where at a score of 1 no damage is observed, and at a score of 9 – the crop is completely destroyed.

In addition to the biological efficacy and selectivity of the studied herbicides, grain yield (t/ha) was also determined. Duncan's method was used for statistical data processing with the

SPSS 19 program (Duncan, 1955). Differences were considered significant at $p < 0.05$.

RESULTS AND DISCUSSIONS

On the 20th day after treatment, the highest average efficacy against common cocklebur (*Xanthium strumarium* L.) was reported in Pulsar Plus – 2.08 l/ha – 84% and Pulsar 40 – 1.30 l/ha – 81%. These two options also show high efficiency when considering the results on the 40th day, when they reach almost excellent values – 91% for Pulsar Plus – 2.08 l/ha and 90% for Pulsar 40 – 1.30 l/ha. On this reporting date, good efficacy was also reported in variants Pulsar Plus – 1.60 l/ha – 80% and Pulsar 40 – 1.00 l/ha – 75%. Satisfactory control (55-58%) against the available weeds was reported in the variants with the lowest imazamox content (Table 2). The good efficacy against *Xa. strumarium* L. after the use of imazamox has been confirmed by other studies. In a vessel trial to determine the minimum doses of imazamox for common cocklebur control in green beans, Gurbuz & Yentur, (2022) found that 46.18 g ai/da of imazamox provided 90% weed control when applied at the 2-4 true leaf stage. The same efficacy was achieved when imazamox was applied at a dose of 36.11 g ai/da at the 6-8 true leaf stage. The authors suggest that the efficacy of the herbicide depends not only on the dose, but also on the weed stage. With increasing leaf area, respectively, and with the higher degree of herbicide retention in the 6-8 leaf stage of *Xa. strumarium* L., very good control was reported.

Table 2. Biological efficacy against common cocklebur (*Xanthium strumarium* L.) in pcs/m² and % efficacy

Variants	20 th day after treatment						40 th day after treatment					
	2024		2025		Average		2024		2025		Average	
	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%
1. Untreated control	9.50	-	11.00	-	10.25	-	13.00	-	11.75	-	12.38	-
2. Economic control	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100
3. Pulsar 40 - 0.70 l/ha	5.25	45	5.50	50	5.38	47	6.25	52	5.00	57	5.63	55
4. Pulsar 40 - 1.00 l/ha	3.50	63	5.00	55	4.25	59	3.50	73	2.75	77	3.13	75
5. Pulsar 40 - 1.30 l/ha	1.25	87	2.75	75	2.00	81	1.00	92	1.50	87	1.25	90
6. Pulsar Plus - 1.12 l/ha	5.00	47	4.50	59	4.75	53	6.25	52	4.25	64	5.25	58
7. Pulsar Plus - 1.60 l/ha	2.75	71	3.50	68	3.13	70	3.00	77	2.00	83	2.50	80
8. Pulsar Plus - 2.08 l/ha	1.25	87	2.00	82	1.63	84	1.00	92	1.25	89	1.13	91

Under the conditions of the experiment on the 20th day after treatment, the best control against lambsquarters (*Chenopodium album* L.) was recorded with Pulsar Plus – 2.08 l/ha – 72%. Satisfactory efficacy was registered in variants

4, 5 and 7 – ranging from 53 to 69%. On the 40th day after treatment, the control against *Chenopodium album* L. increased and reached 80% in variant 8. It is worth noting that the efficacy after the application of Pulsar 40 – 1.30

l/ha – 78% is close to this. In variants 4 and 7, the efficacy is 58% and 65%, respectively. Variants 3 and 6, which have the lowest dose of the herbicide, show limited control against lambsquarters (Table 3). Studies by other authors related to the efficacy of imazamox against *Chenopodium album* L. show the following. Kousta et al. (2024) found that treatment of

lambsquarters with Pulsar 4 SL – 375 g ai ha⁻¹ + Dash 225 g ai ha⁻¹ was effective between 70% and 73.3%. In a study by Neshev et al. (2020) it was found that Pulsar 40 at a dose of 1.25 l/ha on the 56th day after treatment destroyed 80% of lambsquarters, and in the variant with Pulsar Plus – 1.20 l/ha on the 28th day 100% weed control was reported.

Table 3. Biological efficacy against lambsquarters (*Chenopodium album* L.) in pcs/m² and % efficacy

Variants	20 th day after treatment						40 th day after treatment					
	2024		2025		Average		2024		2025		Average	
	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%
1. Untreated control	6.00	-	10.50	-	8.25	-	10.00	-	12.00	-	11.00	-
2. Economic control	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100
3. Pulsar 40 - 0.70 l/ha	3.50	42	7.25	31	5.38	36	5.50	45	7.00	42	6.25	43
4. Pulsar 40 - 1.00 l/ha	2.50	58	5.25	50	3.88	54	4.00	60	5.25	56	4.63	58
5. Pulsar 40 - 1.30 l/ha	1.75	71	3.50	67	2.63	69	2.00	80	3.00	75	2.50	78
6. Pulsar Plus - 1.12 l/ha	3.75	38	7.00	33	5.38	35	5.50	45	6.00	50	5.75	48
7. Pulsar Plus - 1.60 l/ha	2.75	54	5.00	52	3.88	53	3.50	65	4.25	65	3.88	65
8. Pulsar Plus - 2.08 l/ha	1.50	75	3.25	69	2.38	72	1.50	85	3.00	75	2.25	80

Under the experimental conditions, the herbicides studied in both years showed unsatisfactory efficacy against common purslane (*Portulaca oleracea* L.). On the 40th day after treatment, an average efficacy of only 32% was recorded for the period (Table 4). However, some authors reported a higher

efficacy of Pulsar 40 against common purslane (Kristó et al., 2019). These differences in the data on the efficacy of imazamox against common purslane may be due to differences in agrometeorological conditions, in the different phenophases of the weed at the time of treatment, and others.

Table 4. Biological efficacy against common purslane (*Portulaca oleracea* L.) in pcs/m² and % efficacy

Variants	20 th day after treatment						40 th day after treatment					
	2024		2025		Average		2024		2025		Average	
	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%
1. Untreated control	5.00	-	12.50	-	8.75	-	8.00	-	13.00	-	10.50	-
2. Economic control	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100
3. Pulsar 40 - 0.70 l/ha	4.50	10	12.25	2	8.38	6	7.00	13	12.25	6	9.63	9
4. Pulsar 40 - 1.00 l/ha	4.00	20	10.50	16	7.25	18	6.00	25	10.25	21	8.13	23
5. Pulsar 40 - 1.30 l/ha	3.25	35	10.00	20	6.63	28	5.00	38	9.50	27	7.25	32
6. Pulsar Plus - 1.12 l/ha	4.25	15	12.00	4	8.13	10	6.75	16	11.75	10	9.25	13
7. Pulsar Plus - 1.60 l/ha	4.00	20	10.25	18	7.13	19	6.00	25	10.00	23	8.00	24
8. Pulsar Plus - 2.08 l/ha	3.50	30	10.00	20	6.75	25	5.00	38	9.75	25	7.38	31

Under the experimental conditions, the studied herbicides exhibited very good control against green foxtail (*Setaria viridis* L.). High average efficacy (>70%) was reported on the 40th day after the application of the herbicides. Excellent efficacy was recorded with Pulsar Plus – 2.08 l/ha – 97% and Pulsar 40 – 1.30 l/ha – 96%. Very good efficacy was recorded with the other two variants – Pulsar 40 - 1.00 l/ha and Pulsar Plus – 1.60 l/ha, respectively 88% and 89%. Despite having the lowest active ingredient content, variants 3 and 6 also provided good control

against green foxtail (Table 5). High efficacy from the application of imazamox against *Setaria viridis* L. was also established by Neshev et al. (2020). The authors found that on the 28th day after treatment with Pulsar 40 – 1.25 l/ha and Pulsar Plus – 1.20 l/ha, green foxtail control was 90%.

In addition to common purslane, limited control of venice mallow (*Hibiscus trionum* L.) was also observed after application of the tested herbicide. On the 40th day after treatment, the average efficacy reported in variant 5 (Pulsar 40

– 1.30 l/ha) was only 39%, and in variant 8 (Pulsar Plus – 2.08 l/ha) – 38% (Table 6). In the other variants under the conditions of the experiment, the efficacy of imazamox against venice mallow was even lower.

Regarding the control of velvetleaf (*Abutilon theophrasti* Medik) on the 20th day after treatment, the highest efficacy was recorded for variant 5 (Pulsar 40 – 1.30 l/ha) – 68% and variant 8 (Pulsar Plus – 2.08 l/ha) – 65%. In the remaining variants, the efficacy was lower (<54%). On average for the period of the 40th day after treatment, the efficacy against *A. theophrasti* Medik increased, reaching 78% for variant 8 (Pulsar Plus – 2.08 l/ha) and 74% for variant 5 (Pulsar 40 – 1.30 l/ha). Satisfactory

control was recorded for variants 4 (Pulsar 40 – 1.00 l/ha) and variant 7 (Pulsar Plus – 1.60 l/ha), respectively 57% and 66% (Table 7).

In both years of study, the control of field bindweed (*Convolvulus arvensis* L.) proved to be the most difficult. On the 40th day after the application of Pulsar 40 at a dose of 1.30 l/ha and Pulsar Plus at a dose of 2.08 l/ha, 3% and 6% of field bindweed were destroyed, respectively. Zero efficacy was recorded for the other variants (Table 8). Limited herbicidal control against *Convolvulus arvensis* L., after the use of imazamox, but in chickpeas was also reported by Kristó et al. (2019). The authors found only 10% control of field bindweed after the use of Pulsar 40 SL – 1.00 l/ha.

Table 5. Biological efficacy against green foxtail (*Setaria viridis* L.) in pcs/m² and % efficiency

Variants	20 th day after treatment						40 th day after treatment					
	2024		2025		Average		2024		2025		Average	
	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%
1. Untreated control	7.00	-	12.50	-	9.75	-	12.00	-	16.00	-	14.00	-
2. Economic control	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100
3. Pulsar 40 - 0.70 l/ha	3.00	57	4.00	68	3.50	63	3.75	69	3.25	80	3.50	74
4. Pulsar 40 - 1.00 l/ha	2.00	71	3.75	70	2.88	71	2.25	81	1.00	94	1.63	88
5. Pulsar 40 - 1.30 l/ha	1.00	86	2.50	80	1.75	83	0.50	96	0.75	95	0.63	96
6. Pulsar Plus - 1.12 l/ha	3.00	57	3.75	70	3.38	64	3.75	69	3.00	81	3.38	75
7. Pulsar Plus - 1.60 l/ha	1.75	75	2.25	82	2.00	79	2.00	83	0.75	95	1.38	89
8. Pulsar Plus - 2.08 l/ha	0.75	89	1.75	86	1.25	88	0.25	98	0.50	97	0.38	97

Table 6. Biological efficacy against venice mallow (*Hibiscus trionum* L.) in pcs/m² and % efficacy

Variants	20 th day after treatment						40 th day after treatment					
	2024		2025		Average		2024		2025		Average	
	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%
1. Untreated control	8.00	-	4.75	-	6.38	-	11.00	-	5.50	-	8.25	-
2. Economic control	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100
3. Pulsar 40 - 0.70 l/ha	7.50	6	4.25	11	5.88	8	10.00	9	4.00	27	7.00	18
4. Pulsar 40 - 1.00 l/ha	6.75	16	3.50	26	5.13	21	8.75	20	3.25	41	6.00	31
5. Pulsar 40 - 1.30 l/ha	5.50	31	3.25	32	4.38	31	7.00	36	3.25	41	5.13	39
6. Pulsar Plus - 1.12 l/ha	7.25	9	4.50	5	5.88	7	10.00	9	4.25	23	7.13	16
7. Pulsar Plus - 1.60 l/ha	6.50	19	3.75	21	5.13	20	8.25	25	3.50	36	5.88	31
8. Pulsar Plus - 2.08 l/ha	5.75	28	3.00	37	4.38	32	7.25	34	3.25	41	5.25	38

Table 7. Biological efficacy against velvetleaf (*Abutilon theophrasti* Medik) in pcs/m² and % efficacy

Variants	20 th day after treatment						40 th day after treatment					
	2024		2025		Average		2024		2025		Средно	
	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%
1. Untreated control	7.00	-	5.25	-	6.13	-	9.00	-	6.00	-	7.50	-
2. Economic control	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100
3. Pulsar 40 - 0.70 l/ha	4.00	43	3.50	33	3.75	38	5.25	42	3.00	50	4.13	46
4. Pulsar 40 - 1.00 l/ha	3.50	50	3.00	43	3.25	46	4.00	56	2.50	58	3.25	57
5. Pulsar 40 - 1.30 l/ha	2.50	64	1.50	71	2.00	68	2.75	69	1.25	79	2.00	74
6. Pulsar Plus - 1.12 l/ha	4.00	43	3.25	38	3.63	40	5.00	44	2.75	54	3.88	49
7. Pulsar Plus - 1.60 l/ha	3.25	54	2.50	52	2.88	53	3.50	61	1.75	71	2.63	66
8. Pulsar Plus - 2.08 l/ha	2.25	68	2.00	62	2.13	65	2.50	72	1.00	83	1.75	78

Table 8. Biological efficacy against field bindweed (*Convolvulus arvensis* L.) in pcs/m² and % efficacy

Variants	20 th day after treatment						40 th day after treatment					
	2024		2025		Average		2024		2025		Average	
	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%	pcs/m ²	%
1. Untreated control	5.00	-	8.25	-	6.63	-	7.00	-	9.00	-	8.00	-
2. Economic control	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100
3. Pulsar 40 - 0.70 l/ha	5.00	0	8.25	0	6.63	0	7.00	0	9.00	0	8.00	0
4. Pulsar 40 - 1.00 l/ha	5.00	0	8.25	0	6.63	0	7.00	0	9.00	0	8.00	0
5. Pulsar 40 - 1.30 l/ha	4.50	10	8.25	0	6.38	5	6.75	4	8.75	3	7.75	3
6. Pulsar Plus - 1.12 l/ha	5.00	0	8.25	0	6.63	0	7.00	0	9.00	0	8.00	0
7. Pulsar Plus - 1.60 l/ha	4.75	5	8.25	0	6.50	3	7.00	0	9.00	0	8.00	0
8. Pulsar Plus - 2.08 l/ha	4.50	10	8.00	3	6.25	7	6.50	7	8.50	6	7.50	6

Regarding the selectivity of imazamox towards beans under the conditions of the experiment, the following results were obtained. In 2024, on the 3rd day after the application of Pulsar 40 – 1.00 l/ha, Pulsar 40 – 1.30 l/ha, Pulsar Plus – 1.60 l/ha and Pulsar Plus – 2.08 l/ha, phytotoxic manifestations with a score of 2 were detected. The observed damage to the treated plants is expressed in yellowing of the leaf petiole. On the 7th day, phytotoxicity with a score of 2 was also recorded in the variants Pulsar 40 – 0.70 l/ha and Pulsar Plus – 1.12 l/ha. The symptoms are identical to those in the other variants. On the third reporting date, all herbicide-treated variants retained phytotoxicity and were given a score of 2. On the 28th day, the bean variety 'Elixir' overcame herbicide stress and regained normal leaf colour, and was given a score of 1 (Table 9).

Table 9. Selectivity of the studied imazamox-containing herbicides against beans on the EWRS scale

Variants	3 rd day		7 th day		14 th day		28 th day	
	2024	2025	2024	2025	2024	2025	2024	2025
1. Untreated control	1	1	1	1	1	1	1	1
2. Economic control	1	1	1	1	1	1	1	1
3. Pulsar 40 - 0.70 l/ha	1	1	2	2	2	1	1	1
4. Pulsar 40 - 1.00 l/ha	2	1	2	2	2	2	1	1
5. Pulsar 40 - 1.30 l/ha	2	2	2	2	2	2	1	1
6. Pulsar Plus - 1.12 l/ha	1	1	2	2	2	1	1	1
7. Pulsar Plus - 1.60 l/ha	2	1	2	2	2	2	1	1
8. Pulsar Plus - 2.08 l/ha	2	2	2	2	2	2	1	1

Unlike the first year in 2025, on the 3rd day after treatment, only Pulsar 40 at a dose of 1.30 l/ha and Pulsar Plus at a dose of 2.08 l/ha showed phytotoxicity with a score of 2, with the damage being identical to that in 2024. On the 7th day, the same phytotoxic manifestations were observed in all herbicide variants. On the 14th day after treatment, phytotoxicity was overcome

only with the low doses of Pulsar 40 and Pulsar Plus. Twenty-eight days after treatment, all variants had overcome the herbicide stress and regained normal leaf colour.

The phytotoxicity observed in 2024, already on the 3rd day after application of Pulsar 40 – 1.00 and Pulsar Plus – 1.60 l/ha, was most likely due to the extremely high temperatures during the growing season of the crop, combined with the lack of precipitation.

The results of the yield of common beans are presented in Table 10. It is correct to note that as a result of the additional irrigation in the critical periods of crop development in 2025, in all variants the yield obtained was higher compared to 2024. The highest yield of beans, variety 'Elixir' was obtained in economic control (variant 2), as in 2024 it was 0.723 t/ha, and in 2025 it was 1.030 t/ha. This is most likely due to the created optimal conditions for growing the crop, without competition from weeds. High crop yield was also recorded after the application of Pulsar Plus (2.08 l/ha) – an average of 0.844 t/ha and Pulsar 40 (1.30 l/ha) – an average of 0.843 t/ha. The results obtained correspond to the demonstrated biological efficacy of the herbicides against the weeds present in the experiment (Tables 2-8). Close to the yield of variants 8 and 5 was obtained in variants 7 and 4. It is worth noting that according to Duncan's multiple range test ($p < 0.05$) between the variants Pulsar Plus – 2.08 l/ha, Pulsar 40 – 1.30 l/ha, Pulsar Plus – 1.60 l/ha and Pulsar 40 – 1.00 l/ha there is no statistically proven difference (Table 10). Proven lower than the above four variants is the yield of Pulsar Plus – 1.12 l/ha and Pulsar 40 – 0.70 l/ha. However, the yield of variants 3 and 6 is significantly higher than the untreated control. Under the conditions of the experiment, the lowest yield was recorded in the untreated control, where

competition from weeds is the greatest. In 2024, a yield of 0.158 t/ha was obtained, and in 2025 – 0.192 t/ha.

Table 10. Seed yield of beans (t/ha) in 2024 and 2025

Variants	2024	2025	Average
1. Untreated control	0.158 d	0.192 d	0.175
2. Economic control	0.723 a	1.030 a	0.877
3. Pulsar 40 - 0.70 l/ha	0.683 c	0.855 c	0.769
4. Pulsar 40 - 1.00 l/ha	0.702 b	0.969 b	0.836
5. Pulsar 40 - 1.30 l/ha	0.709 b	0.976 b	0.843
6. Pulsar Plus - 1.12 l/ha	0.680 c	0.849 c	0.765
7. Pulsar Plus - 1.60 l/ha	0.698 b	0.976 b	0.837
8. Pulsar Plus - 2.08 l/ha	0.707 b	0.981 b	0.844

Variants with different letters are with proved difference according to Duncan’s multiple range test ($p < 0.05$).

CONCLUSIONS

During the study period, Pulsar Plus at a dose of 2.08 l/ha and Pulsar 40 at a dose of 1.30 l/ha exhibited the highest efficacy against *Setaria viridis* L., *Xanthium stumarium* L., *Chenopodium album* L. and *Abutilon theophrasti* Medik on the 40th day after their application. Their biological efficacy varied from 74% to 97% for different weed species. The control against *Portulaca oleracea* L. and *Hibiscus trionum* L. was significantly more limited, with the highest efficacy being shown by Pulsar Plus at a dose of 2.08 l/ha and Pulsar 40 at a dose of 1.30 l/ha. *Convolvulus arvensis* L. is the most difficult to control of the herbicides studied. Under the conditions of the experiment, Pulsar Plus – 2.08 l/ha destroyed only 6% of the weeds, and with Pulsar 40 – 1.30 l/ha only 3%. Under the conditions of the experiment, on the 7th day after the application of the herbicides, phytotoxicity with a score of 2 was recorded in beans, variety ‘Eleksir’. By the 28th day, the crop was fully recovered – score 1. The highest bean yield was obtained with economic control – 0.877 t/ha. Similar yields were also reported after the application of Pulsar Plus at a dose of 2.08 l/ha – 0.844 t/ha and Pulsar 40 at a dose of 1.30 l/ha – 0.843 t/ha.

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