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Efficacy of weed control for opium poppy (*Papaver somniferum* L.) with a mixture of tembotrione and fluroxypyr

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Abstract: The study was carried out in the years 2013 and 2014 at the Łagiewniki farm to determine the effect of some herbicides on the yield and development of two opium poppy cultivars: 'Lazur' – with high morphine content, and 'Borowski Biały' – with low morphine content. The development and yield of the poppy was a derivative of environmental and agronomic conditions. The mixture of tembotrione and fluroxypyr applied post-emergence at a rate of 88 and 75 g a.i. · ha^{-1}, respectively, effectively controlled most weeds which are harmful for the poppy and did not phytotoxically affect opium poppy plants. The level of yield also depended on the cultivar's ability to grow under unfavourable weather conditions. A lower yield was noted for the cultivar with a lower content of morphine – 'Borowski Biały'.

Key words: mixture of herbicides, opium poppy cultivars, seed yield, weed control

Introduction

In the Czech Republic, Slovakia and Hungary an attempt has been made to reduce labour consumption and improve the profitability of opium poppy cultivation by replacing hand weeding with chemical weed control. The long-term, wide-spread use of cultivation technology for opium poppy using herbicides in these countries enables the cultivation of this plant on large-scale plantations. Presently in Poland there is no registered herbicide for opium poppy weed control, and the herbicide mixtures recommended in the late 1980s (Horodyski *et al*. 1989) – Lentagran 45 WP + Fusilade Super EC or Lentagran 45 WP + Illoxan 36 EC, are not widely used due to their insufficient efficacy and phytotoxicity to the crop. A consequence of the absence on the domestic market of an herbicide which effectively protects opium poppy plants against weeds is the widespread use of hand weeding. Unfortunately, hand weeding is very labour-intensive. Fulara and Dobrzański (1973) report that the work outlay during hand weeding represents approximately 50% of the time designated to opium poppy cultivation. Given the potential reduction of time outlay for Polish farmers, research has been undertaken at the Poznan branch of Plant Breeding and Acclimatization Institute – National Research Institute. The goal was to find an herbicide useful for weed control in opium poppy. Investigations carried out thus far have showed the possibility of weed control in opium poppy with Callisto™ 100 SC herbicide – mesotrione (Wójtowicz and Wójtowicz 2009; Wójtowicz 2011). Positive results in terms of poppy protection against weeds with the use of this herbicide have also been shown by Pinke *et al*. (2011). This herbicide was found to be very effective in weed control of many species of weeds commonly present on poppy plantations, including one of the most harmful – lambsquarter – *Chenopodium album* L. A negative feature of this herbicide is its insufficient efficacy towards another harmful weed for the poppy – black bindweed – *Polygonum convolvulus* L., and its phytotoxic action in relation to the crop, manifested as chlorosis of leaves and reduced growth of the crop immediately after application of the herbicide (Wójtowicz 2011). Therefore, it is necessary to continue searching for herbicides which ensure efficient weed control and which do not show phytotoxic effects in relation to the crop.

This study was undertaken to estimate the efficacy of herbicides applied to protect poppies against weeds. Another goal was to determine the response of poppy cultivars to herbicides. The importance of the research with cultivars showed their diverse response to herbicides (Cihlář *et al*. 2003; Wójtowicz and Wójtowicz 2006, 2009), as well as their varied sensitivity to abiotic stresses (Wójtowicz 2007).

Materials and Methods

The experiment was carried out in 2013 and 2014 at the Łagiewniki farm located in the south-western part of Wysoczyzna Kaliska (N51°46'E17°14') on suitable brown soil belonging to a good wheat complex of the IIIa class. In

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both years the preceding crop was field pea. Before winter ploughing, the field was given 15 kg · ha^{-1} N, 50 kg · ha^{-1} P_2O_5, and 90 kg · ha^{-1} K_2O. In the spring 40 kg N after sowing was applied and 30 kg N at the 6–8 leaf stage of opium poppy in the form of ammonium nitrate. The experiment was conducted in randomised block design with three replications. The main plots were assigned to weed control treatments. The treatments were:

1) without pre-emergence herbicide application. Tembotrione applied post-emergence at a rate of 88 g a.i. · ha^{-1} (Laudis™ 44 OD at the dose of 2.0 l · ha^{-1});
2) mesotrione applied pre-emergence at a rate of 50 g a.i. · ha^{-1} (Callisto™ 100 SC at the dose 0.5 l · ha^{-1}) and a mixture of tembotrione and fluroxypyr applied post-emergence respectively at rates of 88 and 75 g a.i. · ha^{-1} (Laudis™ 44 OD + Starane 250 EC respectively at doses of 2.0 and 0.3 l · ha^{-1});
3) hand cultivation carried out at the stage of four leaves.

Pre-emergence application of herbicides was performed after sowing i.e. 19 April in 2013 and 2 April in 2014 and post-emergence application, at the poppy 4-leaf stage i.e. 30 May in 2013 and 21 May in 2014. Post-emergence application was performed three days after rain in 2013 and five days after rain in 2014 (17 and 13, mm, respectively). Herbicide treatments were applied using a hand plot sprayer at a volume of 270 l · ha^{-1} with a flat-fan nozzle. The sub-plot treatments were two poppy cultivars – 'Lazur' with high morphine concentration (1.2%) and 'Borowski Biały', primarily a food poppy with white seeds and low morphine content (0.09%). Poppy seeds were sown on 7.2 m^2 plots at the rate of 1 kg · ha^{-1} with 15 cm spacing. Sowing was performed on 18 April 2013 and on 1 April 2014. The efficacy of pre-emergence herbicides was assessed five weeks after treatment i.e. 24 May in 2013 and 6 May in 2014, and post-emergence herbicides two weeks after their application i.e. 13 June in 2013 and 4 June in 2014 by counting weeds over an area of 4 × 0.25 m^2 in each plot and determining the percentage of destruction of the various weed species in comparison with the control object. The selectivity of the herbicide to the crop was rated two (13 June 2013 and 4 June 2014) and five (4 July in 2013 and 19 July in 2014) weeks after the application of post-emergence herbicides using a valuation method recommended by EWRC (European Weed Research Council), where 1 represents no damage, 2 – slight symptoms, 3 – weak but clearly visible signs, 4 – strong symptoms that do not necessarily affect the yield, 5 – thinning, strong chlorosis or strong suppression, expected strong reduction in yields, 6, 7, 8, 9 – great damage, dying plants. Moreover, the number of poppy plants per plot was counted before (24 May 2013 and 6 May 2014) and after (4 July 2013 and 19 July 2014) herbicide application. Before harvest, plants per 1 m^2 and capsules per plant were counted (7 August 2013 and 1 August 2014). Harvest was performed 14 August 2013 and 6 August 2014. Seed yield was defined as kg · ha^{-1}, g · plant^{-1}and g · capsule^{-1}.

Results

The early spring weather conditions during the years in which the experiment was carried out differed significantly. In 2013, the start of plant vegetation was observed late, i.e. around 10 April. However, in 2014, plant vegetation had already started by 15 March. As a consequence of the varied earliness of spring the sowing dates and the emergence of the poppy differed. In 2013, emergence was reported on 5 May, and in 2014 on 18 April. Plant growth in both years was hampered by heavy rainfall in the early stages of poppy development. Excess rainfall during this period was conducive to decay and thinning of plants. Particularly unfavourable weather conditions were observed in 2014, when, during a critical period of budding and flowering, the plants were not sufficiently supplied with water as a result of insufficient rainfall (Table 1).

Significant differences in the conditions of spring vegetation in the years of investigations were important not just for plant growth, but also for weed species composition. In 2013, the late spring induced the dominance of thermophilic species such as cockspur grass – *Echinochloa crus-galli* (L.) P. Beauv (Table 2). The high density of this weed could also have been the consequence of inappropriate weed management in the preceding crop in 2012. Over a surface area of 1 m^2 more than 100 weeds of this species were observed, which accounted for almost 80% of the monitored weed community. In second place in terms of numbers was lambsquarters – *Ch. album*, and third was black bindweed – *P. convolvulus*. The proportion of these three weeds in the weed community was over 98%. The following plants were sparsely represented: pale persicaria – *Polygonum lapathifolium* L. ssp. *lapathifolium*, field pansy – *Viola arvensis* Murr., and field penny-cress – *Thlaspi arvense* L. In 2014 the dominant weed was black bindweed with an average of more than 130 weeds per m^2, which accounted for over 98% of the monitored weed community. In that year, the presence of lambsquarters and penny-cress was also noted on experimental plots.

Table 1. Weather conditions of opium poppy growing period

Month	Temperature [°C]			Precipitation [mm]		
	2013	2014	long-term	2013	2014	long-term
IV	8.3	10.2	8.3	27.3	29.0	31.6
V	14.6	13.2	13.6	95.0	114.0	57.1
VI	17.5	16.4	16.8	76.9	16.4	66.4
VII	20.2	21.5	18.5	38.3	88.9	81.8
VIII	19.2	17.8	17.9	56.2	47.3	67.9

Table 2. Number of weeds and weed species composition

Measure of weed infestation	Year	ECHCG	CHEAL	POLCO	POLLA	VIOAR	THLAR	Total
No. of weeds per 1 m^2	2013	107.3	18.9	6.8	1.3	0.4	0.3	135.0
	2014	0.0	1.6	133.3	0.0	0.0	0.3	135.2
Weed species composition [%]	2013	79.5	13.9	5.1	1.0	0.3	0.2	100.0
	2014	0.0	1.2	98.6	0.0	0.0	0.2	100.0

ECHCG – cockspur grass, [*Echinochloa crus-galli* (L.) P. Beauv.]; CHEAL – lambsquarter, (*Chenopodium album* L.); POLCO – black bindweed, (*Polygonum convolvulus* L.); POLLA – pale persicaria, (*Polygonum lapathifolium* L. ssp. *lapathifolium)*; VIOAR – field pansy, (*Viola arvensis* Murr.); THLAR – field penny-cress, (*Thlaspi arvense* L.)

In both years of the experiment the efficacy of mesotrione applied pre-emergence at a rate of 50 g a.i. · ha^{-1} was not sufficient. Reduction of the dominant species, which were cockspur grass in 2013 and black bindweed in 2014, did not exceed 30% (Table 3). The efficacy of this herbicide applied pre-emergence in relation to the emergence of fewer weeds was also not satisfactory.

The efficacy of herbicides applied post-emergence at the 4-leaf poppy stage was determined (Table 4). A mixture of tembotrione and fluroxypyr applied post-emergence at a rate of 88 and 75 g a.i. · ha^{-1}, respectively, on those plots where mesotrione was applied pre-emergence at a rate of 50 g a.i. · ha^{-1} efficiently controlled all species of weeds which were present. In 2013, this mixture efficiently controlled cockspur grass, lambsquarter, black bindweed, pale persicaria, field penny-cress and field pansy and in 2014 lambsquarter, black bindweed, and field penny-cress. On the other hand, tembotrione applied post-emergence at a rate of 88 g a.i. · ha^{-1} on those plots where poppy was not protected pre-emergence effectively controlled cockspur grass and field penny-cress in 2013. However, this herbicide was not efficient enough to protect the crop against lambsquarter, black bindweed, pale persicaria or field pansy. In 2014, this herbicide did not effectively control the dominant weed, which was black bindweed.

Both opium poppy cultivars responded well to chemical protection. No plant losses, chlorosis of leaves or inhibition of plant height under the influence of the applied herbicides were observed. The similar cultivar response to herbicides in the two years of investigations allows the presentation of the results without separating cultivars and years (Table 5).

The abundance of individual weed species resulting from environmental conditions and methods of weed control proposed in the experiment exerted a significant im-

Table 3. Efficacy of mesotrione applied pre-emergence in poppy protection against monocotyledonous and dicotyledonous weed species (%)

Herbicide	Year	Dose [g a.i. · ha^{-1}]	ECHCG	CHEAL	POLCO	POLLA	VIOAR	THLAR
Mesotrione	2013	50	29	81	42	66	78	40
	2014	50	–	78	26	–	–	33

Explanations – see table 2

Table 4. Efficacy of herbicides applied post-emergence in poppy protection against monocotyledonous and dicotyledonous weed species (%)

Herbicides	Year	Dose [g a.i. · ha^{-1}]	ECHCG	CHEAL	POLCO	POLLA	VIOAR	THLAR
Tembotrione	2013	88	100	52	0	0	67	90
	2014	88	–	100	0	–	–	100
Tembotrione + Fluroxypyr	2013	88 + 75	100	100	96	100	100	100
	2014	88 + 75	–	100	100	–	–	100

Explanations – see table 2

Table 5. Sensitivity of opium poppy to the applied herbicides

Herbicides	Dose [g a.i. · ha^{-1}]	Plant losses		Chlorosis		Supression of plant growtch	
		estimation time after herbicide application (number of weeks)					
		2	5	2	5	2	5
Tembotrione	88	1	1	1	1	1	1
Tembotrione + Fluroxypyr	88 + 75	1	1	1	1	1	1

European Weed Research Council (EWRS) scale where 1 means no symptoms – healthy plants pact on plant density (Table 6). In 2013 herbicides effectively controlled weeds. Thus, plant density on plots protected chemically did not differ significantly from those plots protected by hand weeding. In 2014, there was no effective protection against black bindweed, which is characterised by a strong ability to compete, on plots where only tembotrione was used, resulting in a smaller density of the crop. On these plots there was less than half as many plants in comparison with the plots on which the poppy was protected by hand weeding or with a mixture containing fluroxypyr. The number of plants per area was also significantly influenced by poppy cultivar. 'Lazur' cultivar was characterised by significantly higher plant density. Cultivar and environmental conditions also significantly affected the number of capsules per plant. In 2013, the 'Borowski Biały' cultivar showed a high level of ability to create capsules. However in 2014, which was characterised by a shortage of precipitation during budding and flowering, both cultivars produced similar numbers of capsules. Significant interaction between environmental conditions, weed control and poppy cultivar was found for the number of capsules per area unit. In the 'Lazur' cultivar significantly fewer capsules per area unit were found on plots where only tembotrine was applied than on hand weeded plots.

Interaction between experimental factors was also significant with regard to the yield of seeds (Table 7). In 2014 essential differences were observed resulting from weed control of the 'Lazur' cultivar. This cultivar's seed yield was significantly lower on those plots on which only tembotrione was applied. In contrast, the method of weed control had no significant effect on the seed yield of the 'Borowski Biały' cultivar. A difference between the average yields of the cultivars was also found.

The 'Lazur' cultivar produced a significantly higher yield. This yield was also influenced by environmental conditions. A considerably lower yield of seeds was harvested in 2014, when precipitation deficiency during critical stages of budding and flowering was noticed.

Environmental conditions also affected seed yield per plant. Significantly higher values for that feature were observed in 2013. Seed yield per plant was also influenced by the method of weed control and cultivar. Seed yield per plant was significantly lower, when only tembotrione was used for weed control. The 'Borowski Biały' cultivar produced a lower yield.

Environmental conditions, the method of weed control and cultivar interaction were also significant with regard to the yield per capsule. Significant differences in terms of this feature were seen for the 'Lazur' cultivar in 2014. Also, the poppy cultivar had a vital effect on this feature. 'Lazur' produced a higher average yield per capsule. Environmental conditions also significantly affected the yield per capsule. Higher values for this feature were observed in 2013.

Discussion

The results of the experiment indicated the ability of the application of a tembotrione and fluroxypyr mixture to effectively control weeds in poppy crops. A mixture of these herbicides applied at 4-leaf stage of the crop in the plots treated before emergence of poppy with mesotrione controlled all weed species registered in this experiment; cockspur grass, lambsquarter, black bindweed, pale persicaria, field penny-cress and field pansy. One should not forget that pre-emergence application of mesotrione modified weed control efficacy of the mixture of tembotrione and fluroxypyr. It needs to be emphasized that application of mesotrione followed by the mixture of tembotrione and fluroxypyr enable effective control of the most dangerous weed species in poppy fields such as: cockspur grass, lambsquarter and black bindweed and make it possible to obtain a yield not significantly different from that achieved in plots where hand weeding was used. Tembotrione applied alone at a rate of 88 g a.i. · ha^{-1} was not very effective even when black bindweed did not appear in the field, as seen in the results of 2013. These results are confirmed by Pinke *et al*. (2014). Nevertheless, the yield of poppy registered in 2013 in the plots treated only with tembotrione and plots where hand weeding was used did not differ significantly. The efficacy of weed control and absence of phytotoxic action on the crop as a result of the doses of herbicides proposed in the experiment indicated progress in the technology of the production of herbicides used in protecting poppies against weeds. Experiments conducted so far in Poland have shown the ability of lambsquarter by mesotrione in effective weed control (Wójtowicz and Wójtowicz 2009; Wójtowicz 2011). This is in accordance with the results of Pannacci and Covarelli (2009) and Pinke *et al*. (2011, 2014). Unfortunately, the impact of this herbicide was noticeable, because immediately after application chlorosis of leaves and reduction of growth of the crop were observed (Wójtowicz 2011). Also, previous reports have stressed the phytotoxic impact of herbicides on poppies (Adamczewski and Kawczyński 1980; Horodyski *et al*. 1990; Bartoška 2002, Kubni and Tiwari 2004; Jakubiak 2005; Wójtowicz and Wójtowicz 2006). Transient phytotoxic yellowish discoloration of the poppy after tembotrione treatment was found by Godáné-Biczó (2008) and Pinke *et al*. (2014). The results of our experiment confirmed the good response of both cultivars to the chosen chemical weed control. Herbicides did not affect plant losses, chlorosis of leaves or inhibition of crop plant height. The high level of efficacy of the herbicides relative to the most harmful species of weeds and the absence of any phytotoxic action on the crop indicate their usefulness in the protection of the poppy against weeds. Currently, no herbicide to protect the poppy has been registered in Poland. This forces farmers to employ labour-intensive hand weeding, which is not conducive to enlarging the area of the crop. According to the authors of this research, the introduction of herbicides to poppy production technology is one of the essential conditions necessary to increase the area of cultivation of this plant in Poland. Acreage is also linked to the ability of cultivars to produce high and consistent yields. Under non-conducive growing conditions, cultivars with low morphine content cultivated in Poland produce lower yields in comparison with cultivars of high morphine content (Wójtowicz 2007). Also, the results of this experiment confirm a greater sensitivity of the cultivar with low morphine content – 'Borowski Biały' to unfavourable weather conditions e.g. excess rainfall in the early stages of development and its deficiency during

Table 6. Effect of weed control on the number of plants per area unit, number of capsules per plant and area unit of 'Lazur' and 'Borowski Biały' cultivars

Pre-emergence herbicide	Dose [g a.i. · ha⁻¹]	Post-emergence herbicide	Dose [g a.i. · ha⁻¹]	2013		2014		2013	2014	Lazur	Borowski Biały	Mean
				Lazur	Borowski Biały	Lazur	Borowski Biały					
Number of plants per m^2												
Untreated	–	tembotrione	88	29.7 a	24.3 a	19.6 a	10.2 a	27.0 a	14.9 b	24.6 a	17.3 a	20.9 b
Mesotrione	50	tembotrione + fluroxypyr	88 + 75	50.7 a	13.7 a	42.2 a	36.9 a	32.2 a	39.6 a	46.4 a	25.3 a	35.9 a
Control – hand weeding				32.7 a	23.0 a	44.9 a	29.3 a	27.8 a	37.1 a	38.8 a	26.2 a	32.5 a
$LSD_{0.05}$		–			ns			14.96		ns		8.26
Mean		–		37.7 a	20.3 a	35.6 a	25 a	29.0 a	30.5 a	36.6 a	22.9 b	–
$LSD_{0.05}$		–			ns			ns		8.48		–
Number of capsules per plant												
Untreated	–	tembotrione	88	1.1 a	1.5 a	1.0 a	1.0 a	1.3 a	1.0 a	1.1 a	1.3 a	1.2 a
Mesotrione	50	tembotrione + fluroxypyr	88 + 75	1.3 a	2.5 a	1.0 a	1.0 a	1.9 a	1.0 a	1.1 a	1.7 a	1.4 a
Control – hand weeding				1.1 a	1.9 a	1.4 a	1.2 a	1.5 a	1.3 a	1.3 a	1.6 a	1.4 a
$LSD_{0.05}$		–			ns			ns		ns		ns
Mean		–		1.2 ab	2.0 a	1.2 ab	1.1 b	1.6 a	1.1 a	1.2 b	1.5 a	–
$LSD_{0.05}$		–			0.88			ns		0.23		–
Number of capsules per m^2												
Untreated	–	tembotrione	88	33.0 a	35.7 a	19.6 a	10.2 a	34.3 a	14.9 a	26.3 a	22.9 a	24.6 b
Mesotrione	50	tembotrione + fluroxypyr	88 + 75	62.7 a	32.3 a	42.2 ab	36.9 a	47.5 a	39.6 a	52.4 a	34.6 a	43.5 a
Control – hand weeding				38.3 a	43.7 a	63.6 a	34.0 a	41.0 a	48.8 a	50.9 a	38.8 a	44.9 a
$LSD_{0.05}$		–			41.9			ns		ns		14.7
Mean		–		44.7	37.2	41.8	27.0	40.9 a	34.4 a	43.2a	32.1 b	–
$LSD_{0.05}$		–			ns			ns		9.4		–

ns – not significante; means followed by the same letter are not significantly different according to Tukey's test (p = 0.05)

Table 7. Effect of weed control on yield of seeds of 'Lazur' and 'Borowski Biały' cultivars

Pre-emergence herbicide	Dose [g a.i. · ha⁻¹]	Post-emergence herbicide	Dose [g a.i. · ha⁻¹]	2013		2014		2013	2014	Lazur	Borowski Biały	Mean
				Lazur	Borowski Biały	Lazur	Borowski Biały					
Seed yield [kg · ha⁻¹]												
Untreated	–	tembotrione	88	809 a	439 a	36 b	16 a	624 a	26 b	422 b	228 a	325 b
Mesotrione	50	tembotrione + fluroxypyr	88 + 75	968 a	526 a	797 a	272 a	747 a	534 a	883 a	399 a	641 a
Control – hand weeding				1068 a	523 a	1047 a	289 a	795 a	668 a	1057 a	406 a	732 a
$LSD_{0.05}$		–			317			227		190		126
Mean		–		948 a	496 a	626 a	192 a	722 a	409 b	787 a	344 b	–
$LSD_{0.05}$		–			ns			149		71		–
Seed yield per plant [g · plant⁻¹]												
Untreated	–	tembotrione	88	2.92 a	1.91 a	0.20 a	0.21 a	2.42 a	0.21 a	1.56 a	1.06 a	1.31 b
Mesotrione	50	tembotrione + fluroxypyr	88 + 75	2.07 a	4.51 a	1.90 a	0.76 a	3.29 a	1.33 a	1.98 a	2.63 a	2.31 a
Control – hand weeding				3.64 a	2.28 a	2.33 a	1.08 a	2.96 a	1.71 a	2.99 a	1.68 a	2.33 a
$LSD_{0.05}$		–			ns			ns		ns		0.99
Mean		–		2.88 a	2.90 a	1.48 a	0.6 8a	2.89 a	1.08 b	2.18 a	1.79 b	
$LSD_{0.05}$					ns			0.88		0.37		–
Seed yield per capsule [g · poppy capsule⁻¹]												
Untreated		tembotrione	88	2.58 a	1.35 a	0.20 b	0.21 a	1.97 a	0.21 a	1.39 a	0.78 a	1.09
Mesotrione	50	tembotrione + fluroxypyr	88 + 75	1.62 a	1.79 a	1.89 a	0.75 a	1.71 a	1.33 a	1.76 a	1.27 a	1.52
Control – hand weeding				3.28 a	1.36 a	1.71 ab	0.90 a	2.32 a	1.31 a	2.50 a	1.13 a	1.81
$LSD_{0.05}$		–			1.68			ns		ns		ns
Mean		–		2.49 a	1.50 a	1.27 a	0.62 a	1.99 a	0.94 b	1.88 a	1.06 b	–
$LSD_{0.05}$		–			ns			0.90		0.38		–

ns – not significante; means followed by the same letter are not significantly different according to Tukey's test ($p = 0.05$)

budding and flowering. This is reflected by lower plant density and lower yields per plant of the high morphine cultivar – 'Lazur'. A comparison of cultivar yields with control objects in 2014 and 2013 indicates that, under unfavourable conditions, the differences between cultivars are larger. The ability of a low-morphine cultivar to compensate for small density with a greater production of capsules per single plant (Zając 2011) does not protect efficiently against a decline in seed yield. According to Zając *et al*. (2010), the impact of the lower productivity of low-morphine forms is of less interest to farmers involved in poppy cultivation in Poland. The author of this article believes that an increase in the yield of low-morphine cultivars is essential to the growth of its crop area. He is also sceptical about the possibility of the cultivars adapting to demands posed to the poppy ideotype (Zając *et al*. 2010). In this paper, the author cites the belief that, in order to ensure a yield of 2 t · ha^{-1}, plant density should be between 65–70 plants per m^2. In turn, Novak *et al*. (2010) expect that at this density poppy capsules should contain 2.2–2.5 g of seeds. Comparing the values of components evaluated in an experiment with a poppy ideotype, it cannot be forgetten that poor plant growth and low yields from plants and capsules are the results of very adverse weather conditions. However, the far lower values of yield components of low-morphine cultivars confirm the concerns of Zając (2010), in terms of the possibility of these forms producing yield components with values similar to those projected for the ideotype. This confirms the important role of the cultivar in obtaining high yields and the need to intensify research and breeding work on developing cultivars with the desired characteristics. The results of previous research by the author (Wójtowicz 2007) indicate the consistency of yield of high-morphine cultivars, and the hypothesis about the relationship between the yield of low-morphine cultivars and the acreage of that crop (Zając 2010). In Poland this should encourage debate on the possibility of restoring to common cultivation a high-morphine form of poppy. Our results showed that farmers can expect higher yields by cultivating the high morphine cultivar – 'Lazur'. This cultivar is characterized also by more consistent yield than the cultivar with low morphine content – 'Borowski Biały'. The experiment also indicates that the best herbicide combination is mesotrione applied pre-emergence at a rate of 50 g a.i. · ha^{-1} followed by the mixture of tembotrione and fluroxypyr applied post-emergence at a rate of 88 and 75 g a.i. · ha^{-1}, respectively.

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