

Comparative evaluation of the herbicide effectiveness in spring barley crops

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The purpose. Comparative assessment of efficiency of herbicides in sowings of spring barley in conditions of North-East Ukraine. **Methods.** Field probes with several experiments, analysis of results of biological, economical efficiency of herbicides. For comparison they used benchmark herbicide 2,4-D. **Results.** Long-term probes with 10 herbicides were carried out. On the average in control the quantity of grasses from millet family, as well as annual and biennial dicotyledons (including weeds) made accordingly 224, 197 and 25 plants/m². Average crude mass of weeds before harvesting was 428 g/m². The indicated groups took conforming places in the structure of general biomass of weed component of agrophytocenosis — 18, 26 and 56%. Efficiency of preparations in monitoring separate groups of weeds and their aggregate was shown. In rank order of lowering mass of weeds the first 5 places took the following herbicides Lontrel 300, Granstar Pro 75, Kalibr 75, Prima and Laren Pro 60. It was fixed that increase of yield of spring barley depended not only on biological efficiency of herbicides, but also tolerance of crop to separate preparations. **Conclusions.** From the point of view of economical efficiency the best herbicides in sowings of spring barley are Prima and Kalibr 75. In sowings with the reduced weediness advantage has herbicide Logran 75 WG. On the fields with quarantine species of *Ambrosia artemisifolia* L. it is necessary to use highly effective preparation Dialen Super 464 SL, in spite of the fact that it insufficiently tolerant to spring barley.

Key words: spring barley, herbicides, weeds, tolerance.

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According to the size of sown area, spring barley occupies the third place among the grain crops in Ukraine. This culture is relatively resistant to weeds, but despite this, it is often necessary to control this group of harmful organisms in its crops [1-3]. Unlike common crops, real fighting measures to control weeds in spring barley crops have to be carried out only by using chemical means. As of now, over 150 herbicide drugs, which are based on 30 active substances have been registered in Ukraine.

For such a variety of herbicides, the farmer could choose the most appropriate drugs for his crops. But unfortunately there is very little relevant information. Herbicide sellers advertise their products quite intensively, but sometimes they prove the benefits of their drugs relative to some anonymous standard. Independent public services could provide with objective information on plant protection products, but there are none of them. Only scientific institutions and higher educational institutions somehow study the effectiveness of chemical means of combating weeds in spring barley crops [4-10]. In experiments they study mostly one herbicide, in some rare cases not more than four. In addition, normally experiments are carried out strictly in a separate region. In order to objectively evaluate the effectiveness of a particular compound, an expanded experimental base is required. That is, it is desirable to study the drug in different natural zones and under different types of weediness and individual types of weeds in combination with various meteorological conditions. But, unfortunately, it is impossible now. Therefore, in this article we have set a limited research goal - to conduct a comparative assessment of the effectiveness of a part of herbicides in spring barley crops under the conditions of north-eastern Ukraine.

Materials and methods of research. The article is based on the summary of four experiments carried out in 2013-2017, as well as the results of the study on individual herbicides since 1989. Experiments were conducted under the conditions of the State Enterprise "Elite" of the Institute of Plant

Cultivation. V.Ya. Yuryeva NAAS, and starting from 2013 - in the experimental field of the Department of Agriculture named after O.M. Mozheyka at Kharkiv National Agrarian University named after V.V. Dokuchaev. The location of experimental sites - Kharkiv district of Kharkiv region. The soil of experimental fields is a typical low-humic heavy-bodied black earth. The technology of growing spring barley cultivation has been commonplace for the region. Fertilizers were not introduced.

The field research technique was generally accepted. Most of the experiments included a herbicide based on 2,4-dichlorophenoxyacetic acid in the form of dimethylamine salt, 600 g/l (standard). The presence of the 2,4-D standard in the experimental schemes allowed to objectively compare all proposed herbicides (Table 1).

Research results. Year-long records have shown that the weed species composition in spring barley crops represents the herbological conditions for the north-eastern region of Ukraine. The total number of weeds in the crops reached 60 species. Segetal vegetation was grouped into annual cereal, dicotyledonous minor and root-tiller. On average, the number of weeds in spring barley crops reached 449 pcs./m. Out of these, the annual cereal crops, dicotyledonous minor and root-tiller weeds accounted respectively 224, 197 and 25 pcs./m. The most numerous were *Setaria glauca* (L.) Beauv. and *Echinochloa crus-gali* (L.) Beauv. Among the dicotyledonous minor species, the weeds were arranged according to abundance in the following order: Common *Amaranthus retroflexus* L., *Chenopodium album* L., A. Love, *Polygonum lapathifolium* L., *Ambrosia artemisifolia* L., White Gold (*Melandrium album* (Mill.) Garcke), *Thlaspi arvense* L. The main representatives of the root-tilled weeds were the thistle (*Cirsium arvense* (L.) Scop.), Thistle yellow field (*Sonchus arvensis* L.), field birch (*Convolvulus arvensis* L.). The average weight of weeds before barley yields was 428 g/m. Cereal annual, dicotyledonal, dicotyledonous minor including culture weeds (sunflower, buckwheat), and root-tiller species took respectively 18, 26 and 56% of the aggregated specific weight.

1. List of herbicides tested

Herbicides and their norm of induction	Numer of research years	
	common	with 2,4-D
1. 2,4-Д (dimethyl amine salt 2,4-D, 600 g/l, WS), 1,3 l/ha – standard	18	
2. Dialen Super 464 SL (dimethyl amine salt 2,4-D and dicamba, 344 g/l + 120 g/l, WS), 0,7 l/ha	14	9
3. Lontrel 300 (clopypirid, 300 g/l, WS), 0,4 l/ha	10	9
4. Laren Pro 60 (metsulfuron-methyl, 600 g/kg, WG), 10 g/ha	8	8
5. Granstar Pro 75 (tribenuron-methyl, 750 g/kg, WG), 15 g/ha	7	6
6. Logran 75 WG (triasulfuron, 750 g/kg, WG), 10 g/ha	6	6
7. Peak 75 WG (prosulfuron, 725 – 775 g/kg, WG), 20 g/ha	8	6
8. Grodyl Maxi OD (amidosulfuron + iodinesulfuron-methyl sodium + antidote-mefenpirdiethyl, 100 + 25 + 250 g/l, OD), 100 g/ha	6	6
9. Caliber 75 (tyfensulfuron-methyl + trybenuton-methyl, 500 + 250 g/kg, WG), 50 g/ha	11	6
10. Prima (2-ethylhexyl ester 2,4-D + florasulam, 452,42 + 6,25 g/l, SE), 0,6 l/ha	8	6

All herbicides that studied had anti-duct orientation. Drugs destroying or suppressing dicotyledonous minor species created certain ecological niches that filled the grass weeds. Therefore, their number and weight compared to the ones under control increased on average by 11 and 18% respectively. However, sometimes sulfonylureas herbicides Laren Pro 60, Logran 75 WG, Granstar Pro 75 and Calibr 75 somewhat inhibited cereal weed species.

Hormonal herbicides Dialen Super 464 SL, 2,4-D, and Lontrel 300 were significantly better monitored by dicotyledonous minor and root-tiller species than sulphonylureas (Table 2). In addition, the former ones acted on weeds more intensively than the representatives of sulphonylureas.

The effectiveness of herbicide action on weeds can be estimated by decreasing the amount and weight of these plants in the crops. But the effect of the drug does not always coincide with the weediness indicators. Therefore, in order to evaluate the effectiveness of drugs it is firstly necessary to look at their influence on the weight of weeds, and then on their quantity.

Taking this methodical approach, herbicides can be classified according to their effectiveness on dicotyledonous minor species using the standard 2,4-D in the following order (by descent): Dialen Super 464 SL, 2,4-D, Lontrel 300, Calibr 75, Laren Pro 60, Prima, Peak 75 WG, Grodil Maxi OD, Granstar Pro 75, Logran 75 WG. Certain disadvantage of sulphonylureas is that they have not sufficiently influenced one of the most massive species – *Chenopodium album* L. Calibr 75, followed by Peak 75 WG, Laren Pro 60, Grodil Maxi OD, Granstar 75 were destructing this weed. The first one above reduced the number of *Chenopodium album* L. by 75%, and the latter one by only 15%. In our experiments Logran did not destroy this species at all. Xantproved to be resistant to Laren Pro 60, which became widely distributed in the fields of the region. In one of four experiments, they tested the effectiveness of herbicides in combating quarantine *Ambrosia artemisifolia* L. 2,4-D reduced the amount of this weed by 59%, Dialen Super 464 SL - 89%, Lontrel 300 - 98%, Laren Pro 60 - 54%. These drugs reduced the mass *Ambrosia artemisifolia* L., respectively, by 59, 95, 98 and 74%.

2. Comparison of the effectiveness of herbicides in spring barley crops

Herbicide	Comparison	Reducing the number and mass of weeds (in %) relatively to control (a) and to 2,4-D (b)								Crop yield (t/ha) in control	Crop yield (t/ha) in background herbicide	Difference of crop yield (t/ha) to 2,4-D
		number *				mass *						
		1	2	3		1	2	3				
2,4-D	a	+0,3	71,9	47,3	38,4	+34,1	69,1	79,7	66,4	2,99	3,39	
Dialen Super 464 SL	a	0,4	79,5	61,3	52,3	+21,2	84,8	71,0	63,9	2,39	2,60	
	b	-3,0	3,2	2,7	3,1	-3,0	8,2	-4,1	7,1			-0,19
Lontrel 300	a	1,1	67,1	71,2	43,6	+22,2	85,4	89,0	70,7	23,9	2,66	
	b	0,8	-15,9	12,7	-6,9	5,6	-0,3	7,5	6,3			-0,09
Laren Pro 60	a	13,0	71,5	63,1	48,0	+1,9	73,1	86,8	66,4	2,35	2,75	
	b	12,5	-11,2	-4,7	-1,7	-21,8	-9,0	4,3	4,4			-0,03
Granstar Pro 75	a	+12,2	44,4	46,4	3,3	+17,5	73,8	85,1	68,4	2,35	2,64	
	b	2,2	-39,1	-10,8	-17,4	22,9	-18,4	0,2	-0,6			0,01
Logran 75 WG	a	+22,1	39,4	46,6	20,8	+14,9	77,8	61,0	56,1	2,14	2,56	
	b	10,3	-47,2	-8,8	-24,6	-19,6	-15,0	-22,2	-11,5			0,11
Peak 75 WG	a	+31,3	61,6	30,2	23,2	+12,5	83,4	53,0	56,3	2,14	2,52	
	b	19,5	-25,0	-25,2	-22,2	-22,5	-9,4	-30,2	-11,3			0,07
Grodil Maxi OD	a	+26,6	58,6	39,2	27,7	+17,0	79,5	67,1	64,3	2,21	2,54	
	b	21,8	-29,9	-22,2	-22,6	-4,9	-13,6	-17,6	-11,0			-0,04

Calibr 75	a	+10,5	68,5	51,2	34,7	+14,8	80,9	84,1	67,8	2,72	3,14	
	b	17,4	-10,0	-6,8	-13,0	-31,6	-6,2	1,1	4,4			0,09
Prima	a	+20,4	67,2	47,8	35,6	+23,6	80,9	65,6	67,2	2,19	2,66	
	b	20,4	-10,8	3,4	-12,0	-0,2	-9,4	-7,8	-6,6			0,07

Note: 1 – grain annual; 2 – dicotyledonous fewyear; 3 – root-tiller

+ increased weediness relatively to control or 2,4-D

– reduction of the yield growth in relation to 2,4-D

The herbicides had a somewhat different impact on root-tiller species than on dicotyledonous minor species. In the ranking by efficacy, the drugs were positioned as follows: Lontrel 300, Laren Pro 60, Calibr 75, Granstar 75, 2,4-D, Dialen Super 464 SL, Prima, Grodil Maxi OD, Logran 75 WG, Peak 75 WG. But it is especially important to determine the effectiveness of chemical weeding in controlling the general amount of weed vegetation in agrophytocenoses of barley spring crops. Depending on the ratio of individual groups and even types of weeds, the effectiveness of the drugs can vary within certain limits. In the composition of our species, weed herbicides are by descent: Dialen Super 464 8b, Lontrel 300, Laren Pro 60, Calibr 75, 2,4-D, Granstar 75, Prima, Grodil Maxi OB, Peak 75 WG, Logan 75 WG.

In addition to the biological effectiveness of specific herbicides, it is even more important to determine the economic efficiency of chemicals, which is the size of the yield extra as a result of the use of drugs. There was no absolute resemblance between the biological and economic efficiency of herbicides. Therefore, drugs, which are more active in controlling weeds often do not provide adequate yield increase. For example, such powerful herbicides as Dialen Super 464 SL and Lontrel 300, which took the first and second place in general weediness reduction rate, were defeated by other drugs, in particular 2,4-D (according to yield extra, they fell behind respectively by 0,19 and 0.09 t/ha). This discrepancy is due to the fact that some herbicides have a significant stress on the culture. It is possible to assess the tolerance of a culture to one or another herbicide by analyzing the coefficients of weed damage, which show the size of yields extra, caused by the destruction of 1 ts or 1 ton of weed weights, recorded at the end of the crop's vegetation period [11]. To do this, use the formula:

$$K_b = \frac{V_h - V_k}{B_h - B_k}$$

where V_h and V_k are crop yields, respectively, in the herbicide and control options; B_h and B_k are a mass of weeds respectively in these options.

If a crop was indifferent to the impact of one or another herbicide, the values of K_b would be close to each other. All herbicides can be divided into three groups according to their sensitivity to spring barley: low tolerance, which can somehow suppress crop, the second - highly tolerant, which can stimulate a crop; the third - noticeably tolerant (indifferent) [12]. The first group includes herbicides, in which the values of K_b have Dialen Super 464 SL - 0,0874, Lontrel 300 - 0,0959, Laren Pro 60 - 0,0958. The second part includes Peak 75 WG - 0.2343 and Logran 75 WG - 0.2085. Most drugs belong to the third indifferent group: Grodil Maxi OD - 0,1242; 2,4-D-0,1279; Grandstar Pro 75 - 0,1383; Prima -0,1399; Calibr 75 - 0,1499.

After biological and economic efficiency, the third criterion for selecting the best herbicides among the options is the economic efficiency of using chemical means of controlling weeds [13]. Among the costs of chemical weeding, the most significant indicator is the herbicide application cost per hectare. The cost of most drugs at the current dollar rate fluctuated within 117 (Logran 75 WG) - 302 (Peak 75 WG) UAH / ha. Lontrel 300 (786 UAH / ha) clearly stood out due to its expensiveness. But the biggest impact on economic indicators has a size of yield increase, which is provided by a specific drug. The calculations showed that the largest contingent net income was provided by Logran 75 WG - 1789, Prima - 1779 and Calibr 75 - 1673 UAH / ha. The worst indicators were in the options with the introduction of Lontrel 300 and Dialen Super 464 SL - respectively 345 and 618 UAH / ha.

Conclusions

From the standpoint of agricultural and economic efficiency, the best herbicides in spring barley crops are Prima and Calibr 75. In crops with reduced weediness Logran 75 WG is preferred. In fields, polluted by the quarantine type of *Ambrosia artemisiifolia* L., it is necessary to use the highly effective Dialen Super 464 SL, despite the fact that it is not sufficiently tolerant to spring barley.

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