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Control of weeds in spring barley crops at different times of herbicide application

Abstract. Weeds can significantly reduce the yield of spring barley, so research is relevant to determine the optimal time for applying herbicides based on modern active substances to control a wide range of weeds. In this regard, the purpose of this study is to determine the effectiveness of the Kvelex preparation based on new active substances halauxifen-methyl and florasulam in comparison with Lancelot 450 WG against annual and perennial dicotyledonous weeds during introduction into various phases of crop development and weeds in spring barley crops. The leading approaches to solving this problem are conducting field studies to determine the biological effectiveness of herbicide variants and statistical methods (dispersion, correlation) to determine the accuracy and reliability of experimental data. As a result of the conducted studies, it was found out that in the case of contamination with annual weeds *Cenopodium album* L., *Polygonum convolvulus* L., *Amaranthus retroflexus* L., herbicide application is best carried out in the cotyledon phase – the first pair of real weed leaves, which corresponds to the BBCH 18 phase of spring barley. This provided the highest efficiency against these species at 95.5% for Kvelex and 94.4% – Lancelot, 450 WG. But at this stage, the effectiveness against *Cirsium arvense* (L.) and *Scop. Sonchus arvensis* L. is up to 94% and 86.6%, respectively. However, thistles are significantly suppressed and do not compete for the crop in the future, which facilitated a significantly higher yield of spring barley (4.5 t/ha for applying Kvelex and 4.42 t/ha for using Lancelot 450 WG) compared to options where herbicides were applied in the BBCH 25-30 phases of the crop. The materials of the study are of practical value for farmers in choosing the phase of development of weeds and crops when applying herbicides in spring barley crops

Keywords: Kvelex, Lancelot 450 WG, biological efficiency, yield

INTRODUCTION

Spring barley is one of the most common grain crops in Ukraine. Its area is stable in the range of 1.34-1.63 million hectares. Weeds are a significant factor in limiting the yield of this crop. According to the study by L. Pelekh, the most negative impact on the yield of spring barley begins from 30 days after germination of the crop. The presence of weeds in the range from 75 to 112 units/m^2 reduces crop yield by 49-62.4% [1].

The decrease in the yield of grain crops largely depends on the species diversity of weeds, the level of their presence, the situation with the soil and the environment, and the accepted methods of weed control [2; 3]. In addition to direct influence on the cultivated plant (reduced yield), weeds can also have an indirect effect, in particular, perform the function of a "reservoir" of mycotoxicogenic fungi, which are producers of mycotoxins that accumulate in the crop [4]. The most common and problematic weed species in the agrocenosis of spring barley in Ukrainian and European fields are yellow foxtail (*Setaria glauca* (L.) *Beauv.*), cockspur (*Echinochloa crus-galli* (L.) *Beauv.*), charlock mustard (*Sinapis arvensis* L.), red-root amaranth (*Amaranthus retroflexus* L.), white goosefoot (*Chenopodium album* L.), pale persicaria (*Polygonum lapathifolium* L.), wild buckwheat (*Polygonum convolvulus* L.), common ragweed (*Ambrosia artemisifolia* L.), white campion (*Melandrium album* (Mill.) *Garcke*), field pennycress (*Thlaspi arvense* L.), creeping thistle (*Cirsium arvense* (L.) *Scop.*), sow thistle (*Sonchus arvensis* L.), field bindweed (*Convolvulus arvensis* L.) [5-7].

Despite sufficiently investigated weed control measures, numerous herbicide-resistant weed genotypes are

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rapidly evolving in agricultural crops and chemical control capabilities are decreasing in many production systems [8; 9]. For example, Larran *et al.* [10] in their study indicate the distribution of populations of *Amarantus palmeri* resistant to herbicides of the glyphosate group and acetolactate synthase (ALS) inhibitors. Therefore, it is necessary to develop and test new active ingredients with different mechanisms of action on weeds to avoid resistance.

It is important to apply herbicides in time, as their use in later phases leads to poorer weed control and, as a result, to lower crop yields. In the studies of Polish researchers, the smallest increase in the yield of spring barley was conditioned by the introduction of herbicides in the BBCH 31 development phase compared to BBCH 25-26 [11]. The most harmful to spring barley are perennial species, in particular, *Cirsium arvense* (L.) *Scop.* and *Sonchus arvensis* L., *Convolvulus arvensis* L., *Elymus repens* L. To eliminate these weeds, it is important to select the phase when they are most sensitive to herbicides. In particular, Tavaziva *et al.* [12] indicate that growth and development of *C. Arvense* were most effectively suppressed when herbicide spraying was carried out during the development of four leaves on the largest shoot, which corresponds to 13 cm, and not 15-20, as recommended in the literature. To date, 498 biotypes of weeds that are resistant to various herbicides, including active substances from the groups of sulphurea, imidazolinones, and azoles have been identified [13; 14].

The purpose of this study is to investigate the effectiveness of Kvelex based on new active substances halauxifen-methyl and florasulam in comparison with Lancelot 450 WG in spring barley crops. The goal of the study is to determine the biological effectiveness of herbicides against dicotyledonous annual (catchweed, black nightshade, pale persicaria, wild buckwheat, white goosefoot, red-root amaranth, etc.) and perennial (creeping thistle and sow thistle) weeds for introduction into different phases of crop and weeds development.

MATERIALS AND METHODS

Studies to determine the effectiveness of herbicides against dicotyledonous annual and perennial weeds in spring barley crops were conducted for 3 years (2020-2022). For this purpose, a field small-scale experiment was conducted on the premises of the special subdivision "Agronomic Experimental Station" of NULES of Ukraine according to the following scheme (Table 1).

Table 1. Experiment scheme

No.	Variants	Drug consumption rates l/ha, kg/ha	BBCH culture development phase
1	Kvelex + Vivolt	0.05 + 0.4	15-20
2	Lancelot 450 WG + Vivolt	0.033 + 0.4	
3	Kvelex + Vivolt	0.05 + 0.4	22-28
4	Lancelot 450 WG + Vivolt	0.033 + 0.4	
5	Kvelex + Vivolt	0.05 + 0.4	30-32
6	Lancelot 450 WG + Vivolt	0.033 + 0.4	
7	Control	–	

Note: Kvelex – halauxifen-methyl 100 g/kg + florasulam 100 g/kg + cloquintoset-acids 70.8 g/kg (antidote); Lancelot 450 WG – florasulam 150 g/kg + aminopyralide 300 g/kg; Vivolt – ethoxylate + isodecyl alcohol (alpha-isodecyl-omega-hydroxypoli-oxyethylene). The working fluid consumption rate is 200 l/ha

The experiment is based on 4-fold repetition. Experiment area – 560 m^2. The area for each variant is 80 m^2. The placement of repetitions and variants in the experiment is randomised. The test preparations were applied with a Jacto pjb-16C satchel sprayer.

In the experiment, spring barley of the Sebastian variety was sown, the seeding rate was 4 million germinated seeds/ha, seeding depth – 3-4 cm, row spacing – 15 cm, predecessor – sunflower. Protection of the crop from diseases and pests is the same for all variants and included seed treatment before sowing with a mixture of Gaucho Evo 275 FS TN (clothianidine, 100 g/l + imidacloprid, 175 g/l) at a rate of 1.0 l/t and Lamardor Pro 180 FS TN (prothioconazole, 100 g/l + tebuconazole, 60 g/l + fluopyram, 20 g/l) at a rate of 0.5 l/t. Post-germination protection included a single application of the Falcon fungicide (tebuconazole, 167 g/l + triadimenol, 43 g/l + spiroxamine, 250 g/l) at a rate of 0.6 l/ha and Decis f-Lux insecticide (deltamethrin, 25 g/l) at a rate of 0.4 l/ha. The soil of the experimental plots is represented by typical medium-loamy chernozem.

To calculate the biological effectiveness of the studied herbicides, the equation was used [15; 16]:

$$E = \frac{100*(A-B)}{A} \quad (1)$$

where: E – biological efficiency of the herbicide, %; A – number of weeds in the control variant, units/m^2; B – number of weeds in the experimental variant, units/m^2;

Records of the number of weeds and the biological effectiveness of herbicides were carried out on Day 14, Day after each treatment and before harvesting separately for each type of weed.

Since the studied preparations were introduced into different phases of crop development, the number of weeds and the phase of their development before the introduction of herbicides significantly differed. The introduction of herbicides in the first term occurred in the BBCH 18 development phase of spring barley. The species saturation was up to 10 species per 1 m^2. All areas where the study was conducted had a strong level of contamination – from 77.8 to 90.5 units/m^2. The following crops were dominant: white goosefoot (*Chenopodium album* L.), wild buckwheat (*Polygonum convolvulus* L.), red-root amaranth (*Amaranthus retroflexus* L.; subdominant species were: catchweed (*Galium aparine* L.), pale persicaria (*Persicaria lapathifolia* L.), creeping thistle (*Cirsium arvense* (L.) *Scop.*); related species: chickweed (*Stellaria media* (L.) *Vill.*), black nightshade (Solanum nigrum), white campion (*Melandrium album* Mill.), sow thistle (*Sonchus arvensis* L.). Phases of development of dicotyledonous annual weeds – cotyledons – the appearance of the first pair of real leaves; dicotyledonous perennials – the rosette phase. Second-term drugs were introduced into the BBCH 25 development phase of the crop. The same types of weeds were present in the crops in the same proportions. The development phase of thistles was 8-10 leaves, other dicotyledonous weeds – from 4 to 6-8 leaves, depending on the species. The development phase of spring barley in the third period of herbicide application was BBCH 30. The species composition of weeds has not changed. The development phase of thistles was 10-12 leaves, dicotyledonous annual weeds – from 4 to 6-10 leaves, depending on the species. Figure 1 shows the species composition and average number of weeds present in spring barley crops at the time of application of the herbicides under study.

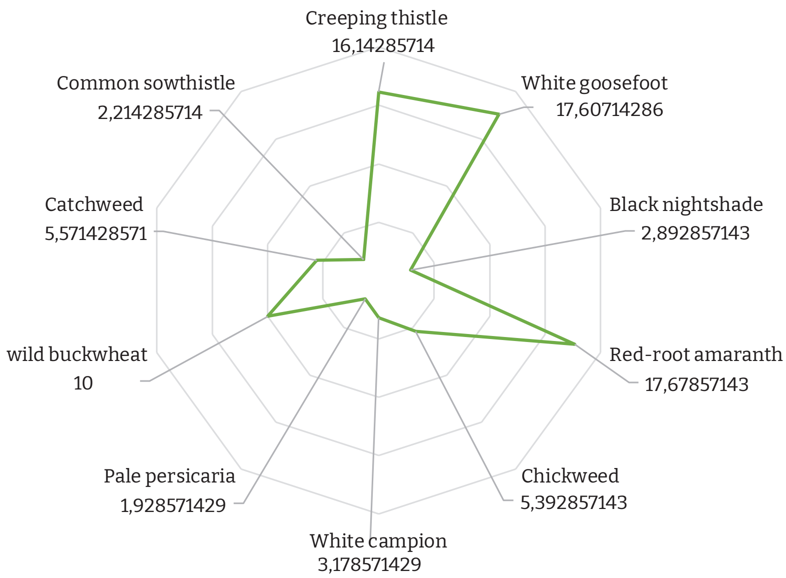

Figure 1. Species composition and number of weeds at the time of herbicide application

The yield of spring barley was determined in the phase of full ripeness of the crop by continuous harvesting from each site separately, bringing it to 100% purity and standard humidity.

Statistical analysis of the obtained data was performed using MS Office 365 Excel and Statistica 10 software suites.

RESULTS AND DISCUSSION

The first quantitative accounting of contamination of spring barley crops was carried out on Day 14 after the introduction of preparations. Their effect, depending on the time of application and the variant, had different degrees of severity. There was a significant decrease in the number of vegetative weeds and inhibition of the growth and development of not yet dead specimens. In the control variant, the increase in the number of weeds was 14.9% compared to the initial value. The number of weeds in the experimental variants was 22.3-32.3 units m^2 depending on the option. All variants had significant differences with the control. Further records noted a decrease in the number of weeds in crops with herbicidal variants. The lowest number of annual weeds 56 days after herbicide application was recorded for the use of drugs in the BBCH 18 phase of the crop, when the weeds were in the phase of cotyledon-first pair of real leaves. In this case, their number was 4.5 units/m^2 for Kvelex and 4.8 units m^2 for Lancelot 450 WG. When herbicides were applied in the later phases of crop development, the number of weeds was higher and amounted, respectively, to 7.8 and 10.3 units/m^2 for spraying in the BBCH 25 phase and 13.0 and 14.3 units/m^2 – BBCH 30 (Fig. 2).

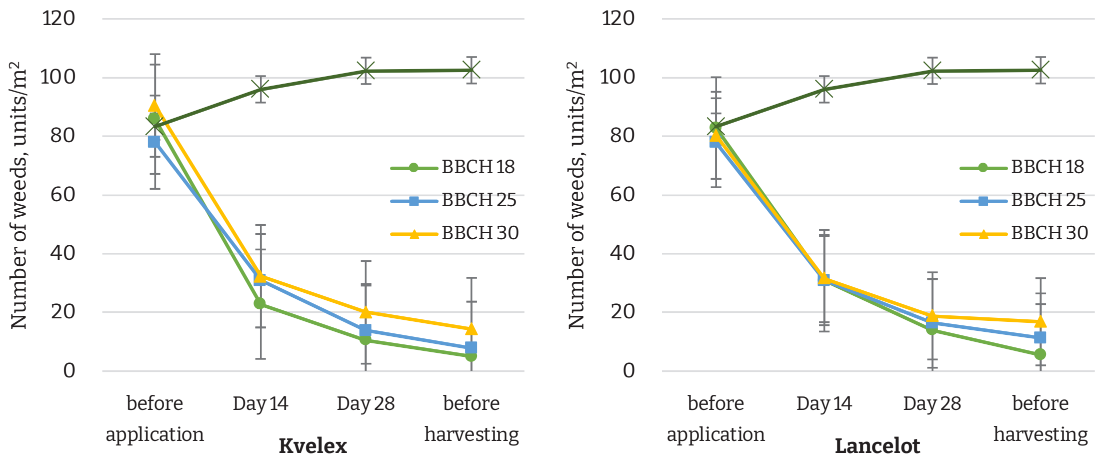

Figure 2. Dynamics of the number of weeds depending on the period of application of herbicides, units/m²

The biological effectiveness of the drugs in % was calculated for each type of weed. On Day 14 after applying herbicides, their overall biological effectiveness was in the range of 65.5-79.9% in the absence of a significant difference between the variants. However, the analysis for each type of weed separately showed significant differences between the variants depending on the application phase and the active substance of the drug. Significantly higher efficiency against perennial dicotyledonous rod-root weeds *Cirsium arvense* (L.) and *Sonchus arvensis* L. was noted when applying herbicides to later phases. When applying Kvelex and Lancelot 450 WG in the development phase of spring barley BBCH 25, their effectiveness against these weeds was 92.7 and 91.0%, respectively, and BBCH 25 – 95.8 and 90.0%, while the use of these drugs in the earlier stages of BBCH 18 in crops and the rosette phase in thistles provided significantly lower efficiency at the level of 76.1-69.7% (Table 2).

Table 2. Biological effectiveness of herbicides depending on the application period, %

Variant	Accounting period	Types of weeds										Total
		Cirsium arvense (L.) Scop.	*Chenopodium album* L.	*Solanum nigrum*	*Amaranthus retroflexus* L.	*Stellaria media* (L.) Vill.	*Melandrium album* Mill.	*Persicaria lapathifolia* L.	*Polygonum convolvulus* L.	*Galium aparine* L.	*Sonchus arvensis* L.	
BBCH 18												
1	Day 14	76.1	76.6	93.8	72.2	88.2	77.5	82.5	68.6	90.0	73.3	79.9
	Day 28	86.2	95.1	95.8	88.6	94.5	77.5	86.3	79.7	89.7	73.3	86.7
	before harvesting	**90.4**	**95.9**	**100.0**	**94.9**	**100.0**	**100.0**	**98.8**	**95.6**	**100.0**	**81.7**	**95.7**
2	Day 14	69.7	70.8	66.7	67.5	80.6	62.5	68.8	62.6	63.4	44.2	65.7
	Day 28	83.2	82.6	100.0	85.0	100.0	87.5	68.8	83.1	94.0	72.9	85.7
	before harvesting	**86.0**	**91.0**	**100.0**	**97.3**	**100.0**	**100.0**	**81.3**	**95.0**	**100.0**	**75.0**	**92.5**
BBCH 25												
3	Day 14	92.7	42.6	51.8	53.7	80.5	75.0	75.0	58.8	65.6	100.0	69.6
	Day 28	96.2	74.7	87.9	76.3	97.5	87.5	75.0	82.5	81.5	100.0	85.9
	before harvesting	**100.0**	**78.6**	**83.9**	**88.4**	**100.0**	**100.0**	**100.0**	**87.5**	**96.4**	**100.0**	**93.5**
4	Day 14	91.0	44.6	73.3	51.9	79.6	41.7	84.4	52.1	64.4	91.7	67.5
	Day 28	92.7	74.1	78.3	77.6	93.1	80.2	90.6	82.0	75.6	100.0	84.4
	before harvesting	**97.3**	**76.9**	**77.8**	**81.7**	**96.3**	**96.9**	**90.6**	**86.7**	**96.9**	**100.0**	**90.1**

Table 2, Continued

Variant	Accounting period	Types of weeds										Total
		Cirsium arvense (L.) Scop.	*Chenopodium album* L.	*Solanum nigrum*	*Amaranthus retroflexus* L.	*Stellaria media* (L.) *Vill.*	*Melandrium album* Mill.	*Persicaria lapathifolia* L.	*Polygonum convolvulus* L.	*Galium aparine* L.	*Sonchus arvensis* L.	
BBCH 30												
5	Day 14	95.8	42.9	52.5	54.1	85.2	50.0	93.8	60.4	60.6	100.0	69.5
	Day 28	96.7	67.9	78.3	68.0	91.4	81.3	100.0	73.0	77.0	100.0	83.4
	before harvesting	**99.2**	**76.0**	**74.2**	**77.4**	**91.4**	**75.0**	**77.1**	**82.2**	**96.9**	**100.0**	**84.9**
6	Day 14	90.0	42.6	57.5	47.1	78.8	60.8	71.9	57.5	61.4	87.5	65.5
	Day 28	93.9	71.0	58.4	61.3	96.9	80.4	96.9	80.2	68.1	90.0	83.0
	before harvesting	**96.3**	**65.2**	**66.8**	**61.3**	**96.9**	**76.8**	**62.5**	**82.4**	**96.4**	**100.0**	**80.5**
LSD_{05}	Day 14	9.6	12.5	$F_f<F_{05}$	14.5	$F_f<F_{05}$					28.1	$F_f<F_{05}$
	Day 28	7.2	15.4	$F_f<F_{05}$	12.6	$F_f<F_{05}$	33.1	$F_f<F_{05}$			26.4	$F_f<F_{05}$
	before harvesting	5.5	15.9	$F_f<F_{05}$	9.6	$F_f<F_{05}$					17.9	7.1

However, better control of annual weeds such as *Chenopodium album* L. and *Amaranthus retroflexus* L. was made by the preparations in the phase cotyledon-first pair of true leaves in weeds, which falls on the BBCH 18 phase in spring barley. In particular, against *Chenopodium album* L. the effectiveness of Kvelex introduced in the first term was 76.6%, against *Amaranthus retroflexus* L. – 72.2%, which is at the level of Lancelot 450 WG with indicators, respectively, 70.8% and 67.5%.

The analysis of variance did not reveal significant differences in the biological effectiveness of the studied herbicides against *Stellaria media* (L.) *Vill.*, *Melandrium album* Mill., *Persicaria lapathifolia* L., *Polygonum convolvulus* L. and *Galium aparine* L. However, it was also generally higher for the introduction of herbicides in the early stages of weed development. Notably, the weeds that were not destroyed were in a depressed state and lost their competitiveness to cultivated plants.

Records conducted on Day 28 generally showed an increase in the biological effectiveness of herbicides on all the studied variants to 83.0-86.7%, but no significant difference was found between them. Analysis for each type of weed separately confirmed previous trends in the effectiveness of drugs. Thus, the highest effectiveness of Kvelex against thistles *Cirsium arvense* (L.) and *Sonchus arvensis* L. was achieved by applying it in BBCH phases 8-12 of weed leaves and was 96.2-100.0%, and annual weeds – in the early stages of their development and was 77.5-95.8%.

At the time of the last accounting before harvesting spring barley, the number of weeds in the experimental plots decreased compared to the previous accounting. The surviving weeds were in neotenic form and were not able to significantly replenish the seed bank of the soil and cause damage to the crop, although some of them formed seeds.

As a result, the biological efficiency of herbicides introduced in the first term was the highest in the experiment and amounted to 95.7% for Kvelex and 92.5% – Lancelot 450 WG. The introduction of these drugs in the second term reduced their overall effectiveness, respectively, to 93.5% and 90.1%, but this decrease was not significant. The use of drugs in the third term significantly reduced their effectiveness to 84.9% and 80.5%. The high control of *Stellaria media* (L.) *Vill.*, *Melandrium album* Mill., *Persicaria lapathifolia* L., *Polygonum convolvulus* L., *Galium aparine* L. was shown by all the options, regardless of the time of application of drugs. However, in general, the introduction of herbicides in the early stages of development of these weeds provided higher biological efficiency and faster death. In fields that are significantly clogged with perennial root-and-shoot weeds (*Cirsium arvense* (L.) *and Sonchus arvensis* L.) it is more appropriate to use these drugs in the second term (BBCH 25 of spring barley and 8-10 leaves of thistle), which would provide almost 100% destruction of perennial weeds and quite effectively control annual species.

The yield of spring barley in the control version was 2.24 t/ha. The introduction of the studied drugs significantly increased the yield of the crop. The introduction of Kvelex and Lancelot 450 WG in the BBCH 18 phase of spring barley provided the highest yield increase, respectively, 101.1% and 97.7%. The use of these drugs in later phases of crop and weed development provided a smaller increase in crop yield: BBCH 25 – 94.3% and 89.3%; BBCH 30 – 86.8% and 85.8%. There was a close inverse correlation (r = -0.99) between crop yield and weed abundance, and a close direct correlation between herbicide yield and biological efficiency (r = 0.9). Thus, the use of herbicides at a later stage of crop development (BBCH 25-30) led to a significant decrease in the yield of spring barley compared to their use in the early stages (BBCH 18) (Fig. 3).

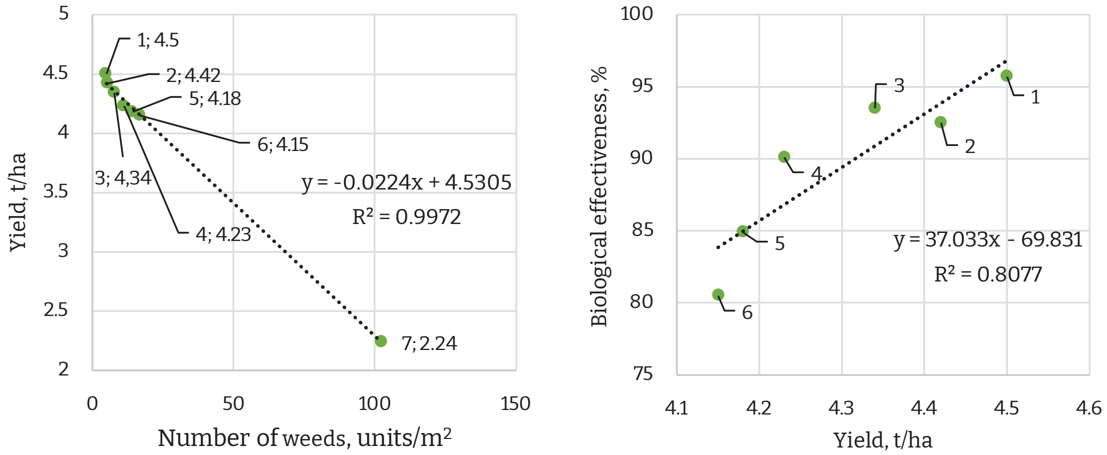

Figure 3. Spring barley yield and its dependence on the number of weeds and the biological effectiveness of herbicides

Note: 1, 2, 3, 4, 5, 6, 7 – experiment variant numbers, LSD_{05} = 0.16 t/ha

Thus, the results obtained differ from those of Tavaziva *et al.* [12] in the question of the effectiveness of herbicides against *Cirsium arvense* (L.) *Scop* at earlier stages of weed development (4 leaves). The highest efficiency in studies against this type of weed was achieved when 8-12 leaves are formed. Data were obtained on the high biological efficiency of Kvelex at a rate of 0.05 l/ha against *Polygonum convolvulus* L. and *Galium aparine* L. were consistent with the results obtained by M. Yanev [17]. Data on the biological effectiveness of Lancelot 450 WG vs. *Cirsium arvense* (L.) *Scop* at the level of 86-97.3%, depending on the application period, different from the results obtained by Zargar *et al.* [18], which indicate a small level of control of this weed.

The conclusions of the conducted studies are consistent with the data obtained by Kieloch & Marczewska-Kolasa [11], which indicate the highest yield of spring barley when applying herbicides at earlier stages of crop development and annual dicotyledonous weeds. Studies on the effectiveness of herbicides for applying spring barley to different phases of development and their impact on crop yield, conducted by other researchers [19; 20] in different soil and climatic zones, also provided similar results.

Reduction of spring barley yield in the presence of weeds in the range of 90-114 units/m² ranges from 85.8% to 101.1% depending on the timing of herbicide application, which is much higher than according to L. Pelekh [1], in whose studies this figure ranged from 49.0 to 62.4%. However, to evaluate these results, more research will be needed over more years to cover greater diversity in weather conditions.

CONCLUSIONS

The biological effectiveness of the studied drugs against annual and perennial weeds significantly depended on the time of their application. The highest effectiveness against some annual species was for the introduction of Kvelex and Lancelot 450 WG in the early stages of weed development and was, respectively, against: *Cenopodium album* L. – 95.9% and 91.0%; *Polygonum convolvulus* L. – 95.6% and 95.0%; *Amaranthus retroflexus* L. – 94.9% and 97.3%. Thus, in case of annual contamination with these species, it is advisable to apply herbicides during the formation of cotyledons-first pair of real leaves in weeds corresponding to the BBCH 18 phase of spring barley.

Better control of perennial species – *Cirsium arvense* (L.) *Scop.* and *Sonchus arvensis* L. was observed when introducing drugs in the second and third terms. Therefore, with a significant number of thistles, to completely eradicate them, it is advisable to use these drugs in the presence of 8-12 leaves in weeds, which corresponds to the BBCH 25-30 development phase of spring barley. The effectiveness of the drugs was almost 100%.

On control *Stellaria media* (L.) *Vill., Melandrium album* Mill., *Persicaria lapathifolia* L., *Polygonum convolvulus* L., *Galium aparine* L., the timing of drug administration did not affect.

Despite generally worse control of perennial weeds per application of Kvelex and Lancelot 450 WG in the BBCH 18 phase of spring barley, these variants provided a reliably high crop yield – at the level of 4.5 and 4.42 t/ha. Thus, to fully mitigate the harmful effects of weeds on the yield of spring barley, it is advisable to apply Kvelex and Lancelot 450 WG at the early stages of crop development, which will maximise the destruction of young weeds and significantly suppress perennial weeds.

Considering the high harmfulness of dicotyledonous and monocotyledonous perennial and annual weed species, studies to determine the biological efficacy and selectivity to the culture of tank mixtures of Kvelex and Lancelot 450 WG with graminicides based on pinoxaden and phenoxaprop-P-ethyl will be promising. Moreover, it is advisable to conduct experiments on the joint use of the studied herbicides with morphoregulators based on chlormequat chloride trinexapac-ethyl, calcium progexadione, mepiquat chloride, and ethephone for introduction into different phases of crop development.

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Контроль бур'янів у посівах ячменю ярого за різних термінів застосування гербіцидів

Анотація. Бур'яни можуть суттєво зменшити урожайність ячменю ярого, тому актуальними є дослідження щодо визначення оптимальних строків внесення гербіцидів на основі сучасних діючих речовин з метою контролювання широкого спектру бур'янів. У зв'язку з цим дана стаття спрямована на дослідження ефективності препарату Квелекс на основі нових діючих речовин галауксифен-метилу та флорасуламу порівняно з Ланцелот 450 WG проти малорічних та багаторічних дводольних бур'янів за внесення в різні фази розвитку культури та бур'янів в посівах ячменю ярого. Провідними підходами щодо вирішення цієї проблеми є проведення польових досліджень для визначення біологічної ефективності гербіцидних варіантів та статистичні методи (дисперсійний, кореляційний) – для визначення точності та достовірності експериментальної інформації. У результаті проведених досліджень з'ясовано, що в разі забур'яненості малорічними бур'янами *Cenopodium album* L., *Polygonum convolvulus* L., *Amaranthus retroflexus* L. та ін. обприскування гербіцидами найкраще проводити у фазу сім'ядолей – першої пари справжніх листків бур'янів, що відповідає фазі BBCH 18 ячменю ярого. Це забезпечило найвищу ефективність проти цих видів на рівні 95,5 % для Квелекс та 94,4 – Ланцелот, 450 WG. Але за цієї фази знижується ефективність проти *Cirsium arvense* (L.) *Scop.* та *Sonchus arvensis* L. до відповідно 94 % та 86,6 %. Проте, осоти суттєво пригнічуються та в подальшому не становлять конкуренції для культури, що дозволило отримати достовірно найвищу врожайність ячменю ярого (4,5 т/га за внесення Квелекс та 4,42 т/га за використання Ланцелот, 450 WG) порівняно з варіантами, де гербіциди вносили у фази BBCH 25-30 культури. Матеріали статті становлять практичну цінність для аграріїв щодо вибору фази розвитку бур'янів та культури під час внесення гербіцидів у посівах ячменю ярого

Ключові слова: Квелекс, Ланцелот, 450 WG, біологічна ефективність, урожайність