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The effect of combined use of herbicide and growth retardants as well as diversified mineral fertilization on weed infestation of spring wheat

Wpływ łącznego stosowania herbicydu i antywylegaczy oraz zróżnicowanego nawożenia mineralnego na zachwaszczenie łanu pszenicy jarej

Summary. This thesis presents the results of the research aiming at determination of the weed control efficacy of the herbicide Lintur 70 WG (dicamba + triasulfuron) applied alone or in combination with growth regulators Antywylegacz Płynny 675 SL (chlormequat chloride) and Cerone 480 SL (ethephon) under different mineral fertilization conditions in a spring wheat crop. A two-factorial field experiment was conducted at the Czesławice Experimental Farm, belonging to the University of Life Sciences in Lublin, over the period 2010–2013. The obtained study results, compared to the treatment where the herbicide was applied without growth retardant, the weed control efficacy was significantly reduced when the herbicide was applied with the addition of Antywylegacz Płynny 675 SL, whereas combined application of the herbicide and the growth retardant Cerone 480 SL did not cause significant changes in weed infestation. The increase in mineral fertilizer rate contributed to increase number and dry weight of weeds compared to the treatment with standard fertilization.

Key words: spring wheat, weed infestation, herbicide, growth regulators, fertilization, biodiversity

INTRODUCTION

The concept of sustainable agricultural development is based, among others, on limited the use of plant protection means to the necessary minimum to ensure satisfactory results [Mrówczyński and Roth 2009, Haliniarz 2013]. Chemical protection is the most popular method for regulating the weeds occurring in the field of common wheat (*Triticum aestivum*). Undesirable species i.e. weeds compete with wheat for space, light, nutrients and water. They threaten crops mainly in the initial stages of growth and development, but they can do much damage during the whole vegetation season [Haliniarz 2010, Marczewska-Kolasa and Kieloch 2012].

Plant lodging, that hinders harvesting and has a negative impact on the yield and quality, is also a considerable problem in wheat growing. In order to reduce the risk of lodging, retardants are used, which reduces the synthesis of gibberellins responsible for the elongation growth of plants [Matysiak et al. 2013, Rademacher 2000]. Additionally, retardants increase the intensity and productivity of photosynthesis, stimulate the root growth, have beneficial effect on the uptake of nutrients and transport of assimilates within the plant [McCarty et al. 2002, Grzyś et al. 2007, 2012, Espindula et al. 2009]. Application of retardant along with the appropriate fertilization makes the cultivated plants more competitive in relation to weeds. Moreover, support with appropriate herbicides minimizes the risk of unwanted flora. The use of each plant protection treatment is costly, time-consuming and adversely affects the soil structure [Arvidsson 2001, Nowak et al. 2014]. Machines moving through the field destroy the crumbling structure and cause excessive thickening of deeper soil layers, even to a depth >0.9 m [Arvidsson 2001]. The combined use of a herbicide and retardant raises the problem of proper adjustment of the treatment date, since herbicides should be used in early stages of plant development, while the retardant should be applied much later [Marczewska-Kolasa and Kieloch 2012].

The aim of the study was to assess the effectiveness of weed control using the herbicide Lintur 70 WG (dicamba + triasulfuron) applied separately or along with the growth regulators: Antywylegacz Płynny 675 SL (chlormequat chloride) and Cerone 480 SL (ethephon) at two levels of fertilization.

MATERIAL AND METHODS

The field experiment was carried out in 2010–2013 in the Experimental Farm in Czesławice (51°18'23"N, 22°16'2"E), belonging to the University of Life Sciences in Lublin. The experiment was established on podzolic soil developed from loess counted to the good wheat complex. The arable layer was characterized by slightly acid reaction – pH in 1 mol KCl 5.9–6.0, and 1.48% content of humus. The abundance of individual elements was: phosphorus – 29.2 mg per 100 g of soil, potassium – 23.7 mg for 100 g of soil and magnesium – 8.5 mg for 100 g of soil.

The total rainfall during the 2010 growing season of spring wheat was higher than the long-term mean by almost 180.0 mm, in the years 2011–2013 it was at the level of 506.3–566.9, while in 2014 it was similar to the long-term mean (Tab. 1). The average air temperatures in all the growing seasons and during the harvest of spring wheat grain were very similar to one another, but at the same time they were higher than the long-term mean.

The two-factorial experiment was set up using the split-plot method in four replications, on the plots measuring 2.7 m × 10.0 m.

Table 1. Rainfall and air temperature in the growing seasons during the period 2010–2013 ascompared to the long-term means (1963–2010) according to the Meteorological Station at Czesławice

Years	Month												Total
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
	Rainfall (mm)												
2010	41.9	53.3	11.6	29.0	116.2	58.4	84.8	147.1	137.5	11.1	546	325	778.0
2011	35.8	23.3	15.8	33.9	53.1	83.5	160.0	36.7	4.1	23.0	1.2	35.9	506.3
2012	38.4	20.6	9.9	31.6	44.3	74.9	101.2	48.5	40.4	110.7	29.0	17.4	566.9
2013	60.3	30.0	37.6	53.2	103.3	108.3	44.3	26.6	49.5	7.3	60.6	13.7	594.7
Mean 1963–2010	30.3	29.2	31.3	42.4	63.5	72.7	80.0	69.5	59.5	45.6	41.0	36.9	601.9
Temperature (ºC)													Mean
2010	–8.3	–2.0	2.2	8.8	13.9	17.5	20.8	20.0	11.9	4.8	6.3	–5.4	7.5
2011	–1.4	–4.1	2.6	10.2	13.4	18.5	18.2	18.5	14.6	7.5	2.3	1.4	8.5
2012	–2.1	–7.5	4.3	9.2	14.6	17.1	20.8	18.2	14.6	7.7	5.0	–3.4	8.2
2013	–4.4	–1.3	–2.6	7.4	14.9	18.1	18.7	18.7	11.3	9.5	4.9	1.7	8.1
Mean 1963–2010	–3.0	–1.7	1.8	7.7	13.6	16.5	18.3	17.7	13.1	7.9	2.9	–1.3	7.8

The study factors included:
I. Variants of chemical protection of the field:
H – control, in which Lintur 70 WG was applied separately,
H/A – herbicide Lintur 70 WG (dicamba + triasulfuron) applied at stage BBCH 21-22 and Antywylegacz Płynny 675 SL (chlormequat chloride) applied at stage BBCH 31-32,
H+A – herbicide Lintur 70 WG introduced in combination with Liquid Retardant 675 SL at stage BBCH 30,
H/C – herbicide Lintur 70 WG used at the stage BBCH 21-22 and retardant Cerone 480 SL (ethephon) applied at stage BBCH 31-32,
H+C – herbicide Lintur 70 WG introduced in combination with liquid retardant Cerone 480 SL at stage BBCH 30.
II. Level of mineral fertilization:
a. Standard fertilization – 176 kg·ha^{-1} ammonium nitrate, 109 kg·ha^{-1} triple superphosphate, 100 kg·ha^{-1} potassium salt (N – 60 kg ha^{-1}, P – 22 kg ha^{-1}, K – 50 kg ha^{-1}),
b. Intensive fertilization – 353 kg ha^{-1} ammonium nitrate, 206 kg ha^{-1} triple superphosphate, 200 kg ha^{-1} potassium salt (N – 120 kg ha^{-1}, P – 42 kg ha^{-1}, K – 100 kg ha^{-1}).

Phosphate and potassium fertilizers in all variants were applied 2–3 days before spring wheat sowing. On objects with standard fertilization, nitrogen was supplied before sowing, while on objects with intensive fertilization, additional 25 kg N ha^{-1} was introduced during the shooting phase. Cultivation operations were carried out in spring, before sowing, as recommended. Agrotechnical treatments invelved harrowing, seasoning the soil with a cultivating unit consisting of a cultivator and a string roller as well as with mineral fertilization, after which fertilizers were mixed with the soil using medium harrow. The seed was treated with Raxil Gel 206 (tiuram + tebuconazole) at a dose of 0.5 l per 100 kg of grain and sown at the beginning of April at the dose of 230 kg ha^{-1}. Chemical protection against fungal diseases consisted in the application of Tilt Plus 400 SC fungicides (propiconazole + fenpropidin) at a dose of 1.0 dm^3 ha^{-1} and Amistar 250 SC (azoxystorbine) at a dose of 1.0 dm^3 ha^{-1}, while against pests used Fastac 100 EC (alpha-cypermethrin) in a dose of 0.12 dm^3 ha^{-1}.

Weed infestation was determined by the quantitative-weight method in the wax maturity phase of winter wheat (BBCH 83-85). The species composition of weeds, their number and air-dry mass were determined. The research area was established in two random places on each plot by means of a 1 m × 0.5 m frame. Species nomenclature of weeds was given after Mirek et al. [2002].

The number and air-dry mass of weeds was processed statistically by means of variance analysis (ANOVA). FR – ANALWAR 5.2 statistical software was used for calculations. Significance of differences between mean values was determined on the basis of Tukey's test at the significance level of α = 0.05. Species diversity was assessed on the basis of the number of species and by means of Shannon index of general diversity (H) according to the formula [Shannon 1948]:

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

where:
s – number of species,
p_i – ratio of the number of individuals of i-th species to the total population of all individuals on a sample area,
ln – natural logarithm.

In addition, the Simpson dominance index (D) was calculated according to the formula [Simpson 1949]:

$$D = \sum_{i=1}^{S} (p_i)^2$$

where:

p_i – ratio of the number of individuals of i-th species to the total population of all individuals on a sample area.

RESULTS

When assessing weed infestation of wheat, it was found that the use of Lintur 70 WG herbicide in combination with Antywylegacz Płynny 675 SL (H+A) significantly increased the number of weeds present on 1 m^2 of spring wheat field by respectively 53% compared to the object, on which Lintur 70 WG was applied alone (control object) and by about 59% compared to other variants of chemical protection (Tab. 2). The air-dry mass of weeds did not differ significantly between objects, on which the retardant was applied. However, a significant increase in weed biomass (by 38%) was observed on the H+A object in comparison to the control object, on which only the herbicide (H) was applied (Tab. 3).

Table 2. Number of weeds per 1 m^2 in the spring wheat

Chemical protection	Fertilization		Mean
	standard	intensive	
Lintur 70 WG (H)	60.2	53.9	57.1
Lintur 70 WG Antywylegacz Płynny 675 SL (H/A)	48.3	63.4	55.8
Lintur 70 WG + Antywylegacz Płynny 675 SL (H + A)	69.5	105.5	87.5
Lintur 70 WG Cerone 480 SL (H/C)	51.8	55.2	53.5
Lintur 70 WG + Cerone 480 SL (H + C)	56.8	54.6	55.7
Mean	57.3	66.5	–
$LSD_{0.05}$	for fertilization		8.55
	for chemical protection		20.20
	for interaction		13.75

The level of mineral fertilization significantly differentiated the evaluated parameters of weed infestation. Increased doses of mineral fertilizers caused an increase in the number of weeds (by 16%) in relation to standard fertilization (Tab. 2). Similar relationships were observed when examining the air-dry mass of weeds. Under the influence of intensive fertilization, this parameter increased by over 10% compared to standard fertilization.

In both variants of mineral fertilization, the most considerable weed infestation occurred on plots, where the herbicide was applied in combination with Antywylegacz Płynny 675 SL (H+A) (Tab. 2, 3). In the conditions of standard fertilization, significantly less weeds were recorded on this object after application of herbicide and chlormequat chloride following the dates recommended by the manufacturer (H/A), while in intensive fertilization, a smaller number of weeds was demonstrated on all other experimental objects (Tab. 2). The increase in mineral fertilization resulted in a significant increase in the number of weeds on both objects using the Antywylegacz Płynny 675 SL. In standard fertilization conditions, statistically proven reduction of air-dry weed mass, in comparison to the object, where herbicide was introduced along with Antywylegacz Płynny 675 SL (H + A), was demonstrated after application of the herbicide Lintur 70 WG (H) and the herbicide together with Cerone 480 SL retardant (H + C), while in intensive fertilization, significantly lower biomass of weeds was recorded on the control object and after separate application of the herbicide and retardant Cerone 480 SL (H/C) (Tab. 3).

Table 3. Dry weight of weeds per 1 m^2 in spring wheat

Chemical protection	Fertilization		Mean
	standard	intensive	
Lintur 70 WG (H)	24.58	25.99	25.29
Lintur 70 WG Antywylegacz Płynny 675 SL (H/A)	28.22	34.34	31.28
Lintur 70 WG + Antywylegacz Płynny 675 SL (H + A)	31.52	38.09	34.81
Lintur 70 WG Cerone 480 SL (H/C)	30.32	24.02	27.17
Lintur 70 WG + Cerone 480 SL (H + C)	24.67	31.49	28.08
Mean	27.86	30.79	–
$LSD_{0.05}$	for fertilization for chemical protection for interaction		2.49 7.86 6.61

In the conducted experiment, 31 species of short-lived and 8 long-term weeds were found. The object, on which Lintur 70 WG herbicide was used along with Antywylegacz Płynny 6775 SL, revealed the greatest diversity of weeds, while the least number of species was found when these preparations were applied separately (Tab. 4). In all variants of fertilization and chemical protection, the most numerous was *Echinochloa crus-galli*. The exception was the H + A object, on which *Chenopodium album* dominated. In variants with chemical protection and retardants, *Gnaphalium uliginosum* was completely eliminated from the field, but there were such species as: *Myosotis arvensis*, *Geranium pusillum*, *Chamomilla suaveolens*, *Thlaspi arvense*, *Lamium amplexicaule*, *Solanum nigrum*, *Conyza canadensis*, *Lapsana communis*, *Papaver rhoeas* and *Cerastium arvense*. Among studied variants of chemical protection of the field, the largest indicator of Shannon's diversity and at the same time, the Simpson's least dominance was observed on plots treated with Lintur 70 WG in combination with Cerone 480 SL.

Table 4. Species composition and number of weeds per 1 m^2 in the spring wheat crop depending on chemical protection

Species	Chemical protection				
	H	H/A	H + A	H/C	H + C
I. Short-lived					
Echinochloa crus-galli	19.4	14.9	15.7	12.1	12.6
Chenopodium album	10.0	8.8	24.1	10.3	11.6
Viola arvensis	8.6	9.5	15.0	10.8	6.0
Galinsoga parviflora	3.8	1.8	6.5	2.2	3.9
Capsella bursa-pastoris	2.0	2.3	3.2	1.9	2.3
Galeopsis tetrahit	0.5	0.3	0.6	0.1	0.9
Galinsoga ciliata	0.4	0.2	0.8	0.5	0.2
Veronica arvensis	0.4	0.2	0.5	0.4	0.5
Apera spica-venti	0.4	0.3	1.0	0.4	0.7
Matricaria maritima subsp. *inodora*	0.4	0.2	0.2	–	0.4
Galium aparine	0.2	0.2	0.5	0.2	0.5
Polygonum convolvulus	0.2	0.1	0.6	–	0.7
Stellaria media	0.2	–	0.2	0.2	0.6
Veronica persica	0.1	0.2	0.5	0.6	0.2
Avena fatua	0.1	0.1	0.5	0.8	0.2
Gnaphalium uliginosum	0.1	–	–	–	–
Polygonum lapathifolium subsp. *lapathifolium*	0.1	0.2	0.9	–	0.3
Polygonum aviculare	0.0*	0.0	0.1	0.1	0.2
Setaria pumila	0.0	0.0	0.2	0.1	0.3
Vicia hirsuta	0.0	0.1	0.0	0.1	0.0
Anchusa arvensis	0.0	–	0.3	0.1	0.2
Urtica urens	0.0	–	0.0	–	–
Myosotis arvensis	–**	0.1	0.4	–	0.2
Geranium pusillum	–	–	0.1	0.0	0.0
Chamomilla suaveolens	–	0.0	–	–	0.0
Thlaspi arvense	–	–	0.6	–	0.1
Lamium amplexicaule	–	0.0	0.2	0.1	0.0
Solanum nigrum	–	–	0.0	0.0	–
Conyza canadensis	–	–	–	0.0	–
Lapsana communis	–	–	0.0	–	–
Papaver rhoeas	–	–	–	0.0	–
Number of weeds I	46.9	39.5	72.7	41.0	42.6
Number of species I	21.0	21.0	27.0	22.0	25.0
II. Perennial					
Elymus repens	5.9	13.1	12.2	9.6	10.0
Cirsium arvense	2.3	1.5	0.8	1.3	1.4
Equisetum arvense	0.8	0.7	0.6	0.9	0.6
Plantago intermedia	0.4	0.5	–	0.2	0.5
Taraxacum officinale	0.2	0.1	0.1	0.2	–
Stachys palustris	0.2	0.3	0.6	0.2	0.2
Artemisia vulgaris	0.1	–	0.1	–	0.0
Cerastium arvense	–	–	–	–	0.0
Number of weeds II	9.9	16.2	14.4	12.4	12.7
Number of species II	7.0	6.0	6.0	6.0	7.0
Total number of species (I + II)	28	27	33	28	32

* Species occurring at less than 0.1 per m^2, ** Species not occurring

Table 5. Species composition and number of weeds per 1 m^2 in the spring wheat crop depending on the level of fertilization

Species	Standard fertilization	Intensive fertilization
I. Short-lived		
Echinochloa crus-galli	14.4	15.5
Chenopodium album	11.4	14.5
Viola arvensis	8.9	11.0
Galinsoga parviflora	4.1	3.2
Capsella bursa-pastoris	2.5	2.2
Galeopsis tetrahit	0.6	0.3
Apera spica-venti	0.6	0.5
Galinsoga ciliata	0.5	0.3
Polygonum convolvulus	0.3	0.3
Galium aparine	0.3	0.3
Avena fatua	0.3	0.4
Stellaria media	0.3	0.2
Veronica arvensis	0.3	0.5
Veronica persica	0.3	0.4
Matricaria maritima subsp. *inodora*	0.3	0.2
Polygonum lapathifolium subsp. *lapathifolium*	0.2	0.4
Anchusa arvensis	0.2	0.0
Polygonum aviculare	0.1	0.1
Myosotis arvensis	0.1	0.2
Thlaspi arvense	0.1	0.2
Setaria pumila	0.1	0.2
Vicia hirsuta	0.1	0.0
Geranium pusillum	0.0*	0.0
Gnaphalium uliginosum	0.0	–
Chamomilla suaveolens	0.0	–
Urtica urens	0.0	0.0
Lapsana communis	0.0	–
Papaver rhoeas	0.0	–
Lamium amplexicaule	–**	0.1
Solanum nigrum	–	0.0
Conyza canadensis	–	0.0
Number of weeds I	46.0	51.0
Number of species I	27.0	27.0
II. Perennial		
Elymus repens	7.6	12.7
Cirsium arvense	1.9	1.0
Equisetum arvense	0.8	0.6
Stachys palustris	0.4	0.3
Plantago intermedia	0.2	0.4
Artemisia vulgaris	0.1	0.0
Taraxacum officinale	0.1	0.1
Cerastium arvense	–	0.0
Number of weeds II	11.1	15.1
Number of species II	7.0	8.0
Total number of species (I + II)	34.0	35.0

* Species occurring at less than 0.1 per m^2, ** Species not occurring

In comparison to standard fertilization, the intensification of fertilization resulted in the reduction of the Shannon diversity index for the weed community (Fig. 1), despite the same number of species on both objects (Tab. 5). This resulted from larger number of dominant weed species on these plots, which also influenced the Simpson domination index (Fig. 2). On object, where intensive fertilization was applied, the species such as *Lamium amplexicaule*, *Solanum nigrum*, *Erigeron canadensis*, *Cerastium arvense* appeared that did not occur on objects with standard fertilization (tab. 5). After applying increased doses of fertilizers, there were no species such as: *Gnaphalium uliginosum*, *Chamomilla suaveolens*, *Lapsana communis* and *Papaver rhoeas*.

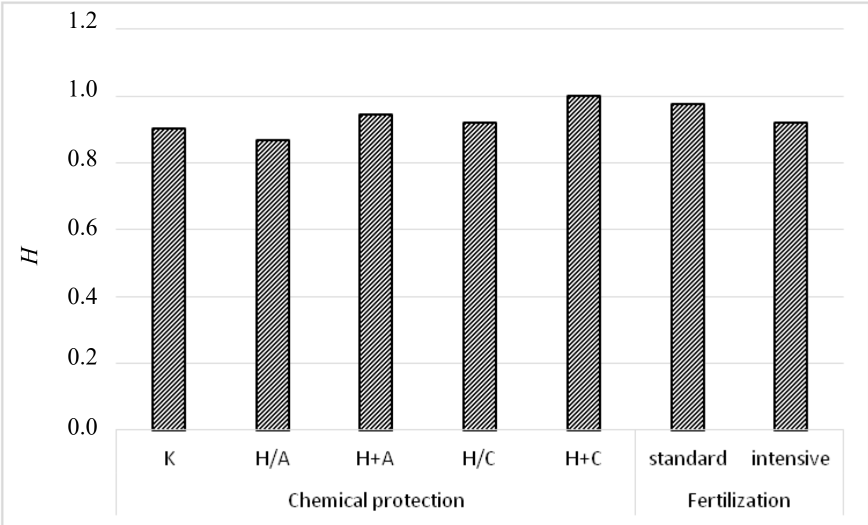

Fig. 1. Shannon's (H) diversity index of weed community in spring wheat

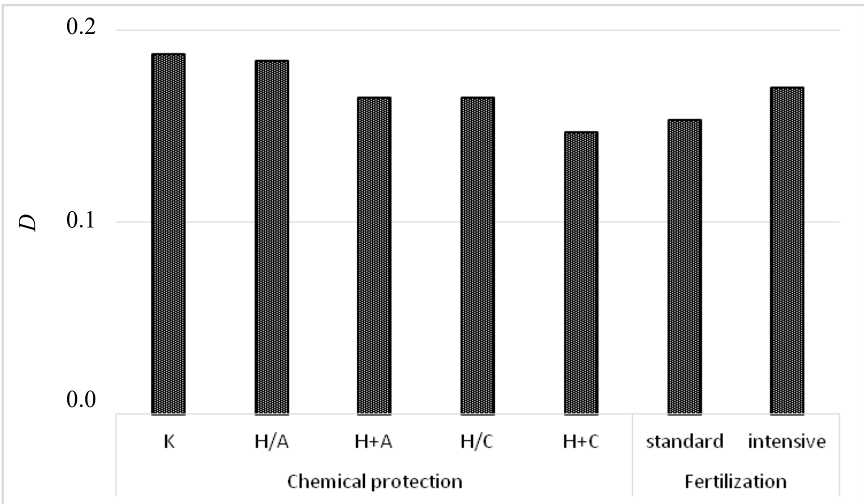

Fig. 2. Simpson's (D) dominance index of weed community in spring wheat

DISCUSSION

In agricultural practice, more and more often attention is paid to the growing costs of production and the effectiveness of preparations for the care of the field. Therefore, many scientific studies have been devoted to the optimization of the plant protection products use, so as to reduce the cost of treatment while maintaining its maximum effectiveness [Pietryga and Drzewiecki 2000, Krawczyk 2006, Marczewska-Kolasa and Kieloch 2009, Miziniak 2011]. The studies showed high effectiveness of Lintur 70 WG herbicide applied along with Cerone 480 SL retardant, whereas the use of herbicide with Antywylegacz Płynny 675 SL resulted in much worse effects. The results of other authors also indicate that the effectiveness of the use of mixtures of herbicides with growth regulators depends mainly on the type of biologically active substances of these preparations [Miziniak and Praczyk 2007, Marczewska-Kolasa and Kieloch 2009, Miziniak 2014]. Many examples of these preparations combinations indicate their satisfactory herbicidal effectiveness, lack of phytotoxic effects on the crop, prevention of cereal lodging and positive effect on the yield of crop as well as its structure [Marczewska-Kolasa and Kieloch 2009].

Miziniak [2014] analyzed the herbicidal effectiveness of combined and separate use of Axial 100 EC herbicide (pinoxaden) with retardants: Antywylegacz Płynny 725 SL, Moddus 250 EC and Regalis 10 WG in winter wheat. Statistically, no differences were found between the assessed objects, however, there was a tendency to increase the herbicidal effectiveness of the mixture of pinoxaden with chlormequat chloride (CCC) compared to the separate application of these agents. Similar relationship was recorded in the same studies on objects, where Axial 100 EC was introduced in combination with ethyl trinexapac (Moddus 250 EC).

In the research by the authors, the application of herbicide together with retardant reduced the number of dominant species of the *Poaceae* family. Similarly, Miziniak and Praczyk [2007] in their research obtained a higher degree of *Apera spica-venti* destruction under the influence of herbicide Puma Universal 069 EW in combination with retardants (CCC, calcium prohexadione) in relation to the separate application of these agents in the field of winter wheat. The same trend was observed after application of Huzar 05 WG herbicide (iodosulfuron). Moreover, the mixture of iodosulfuron with retardants was more effective in reducing the number of such weeds as: *Matricaria inodora*, *Papaver rhoeas*, *Thlaspi arvense*, *Veronica persica* and *Viola arvensis* than the separate use of herbicide and growth regulators.

Studies of many authors do not confirm the presented results and indicate that the intensification of mineral fertilization reduces the weed infestation of crop plants [Blecharczyk et al. 2000, Klikocka 2000, Bujak and Frant 2006, Kraska and Pałys 2006, Deryło 2009]. Deryło [2009], when analyzing the weed infestation in durum wheat, found that the level of mineral fertilization (90 and 120 kg N ha^{-1}) did not significantly differentiate the number and air-dry matter of weeds, however, a decrease in the value of these parameters under the influence of increased dose of nitrogen fertilizer, could be observed.

CONCLUSIONS

1. The studies have shown that the combined use of a herbicide with a retardant depends on the active substance of the preparations. Application of Lintur 70 WG herbicide and Cerone 480 SL retardant did not affect the wheat field weed infestation, where-

as the use of the herbicide along with Antywylegacz Płynny 675 SL resulted in an increase in the number and air-dry weight of weeds.

2. In the field of spring wheat, the dominant species were: *Echinochola crus-galli*, *Chenopodium album* and *Viola arvensis*. The most significant indicator of Shannon's diversity characterized the object, on which Lintur 70 WG was used along with the Cerone 480 SL retardant.

3. Increasing the doses of mineral fertilizer caused an increase in the number and air-dry weight of weeds in comparison to the object fertilized as a standard. Greater weed infestation resulted from the increase in the number of dominant weed species.

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Streszczenie. W pracy przedstawiono wyniki badań, których celem było określenie skuteczności chwastobójczej herbicydu Lintur 70 WG (dikamba + triasulfuron) stosowanego samodzielnie lub łącznie z regulatorami wzrostu (Antywylegacz Płynny 675 SL (chlorek chloromekwatu) oraz Cerone 480 SL (etefon)) w warunkach zróżnicowanego nawożenia mineralnego w łanie pszenicy jarej. Dwuczynnikowe doświadczenie polowe przeprowadzono w latach 2010–2013 w Gospodarstwie Doświadczalnym w Czesławicach, należącym do Uniwersytetu Przyrodniczego w Lublinie. Otrzymane wyniki badań wykazały, iż w porównaniu z obiektem, na którym aplikowano herbicyd bez antywylegacza, istotne zmniejszenie efektywności chwastobójczej stwierdzono, stosując herbicyd z dodatkiem Antywylegacza Płynnego 675 SL, natomiast łączna aplikacja herbicydu z antywylegaczem Cerone 480 SL nie spowodowała istotnych zmian zachwaszczenia łanu. Zwiększenie dawek nawozu mineralnego przyczyniło się do wzrostu liczby oraz powietrznie suchej masy chwastów w porównaniu z obiektem nawożonym standardowo.

Słowa kluczowe: pszenica jara, zachwaszczenie, herbicyd, regulatory wzrostu, nawożenie, bioróżnorodność

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