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THE EFFECT OF INTERCROPPING ON WEED INFESTATION OF A SPRING BARLEY CROP CULTIVATED IN MONOCULTURE

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Abstract

This paper presents the results of a study carried out in the years 2005–2007 in the Bezek Experimental Farm near the city of Chełm, Poland, on heavy mixed rendzina soil. The effect of intercropping, using red clover (cv. Dajana) and white clover (cv. Astra), on weed infestation of a spring barley crop was studied. The species composition of weeds in the spring barley crop changed to a small extent under the influence of the application of clover intercropping, whereas the population size of particular species showed large fluctuations. In the spring barley crop with the red clover intercrop, *Sonchus arvensis* occurred in greatest numbers among dicotyledonous weed species. In the barley crop with white clover and without intercrop, *Viola arvensis* and *Sonchus arvensis* were the dominant dicotyledonous species. *Setaria pumila* was the dominant monocotyledonous species in all the treatments. Intercropping using red and white clover clearly limited the growth and development of weeds. The red clover intercrop in the spring barley crop better reduced the infestation with dicotyledonous weeds and also significantly reduced the number of monocotyledonous weeds and the total number of weeds, whereas the white clover intercrop limited only the number of monocotyledonous weeds. The application of the herbicide Chwastox Extra 300 SL significantly reduced the fresh weight of weeds found in the spring barley crop. The presence of the intercrop resulted in different total numbers of weeds in particular treatments. Intercropping distinctly limited the occurrence of the following weed species: *Sonchus arvensis, Fallopia convolvulus, Melandrium album, Amaranthus retroflexus, Veronica arvensis* and *Medicago lupulina.* The investigated intercrop species also reduced the biomass of weeds. The application of the herbicide did not differentiate the number of monocotyledonous weeds, which resulted from the application of Chwastox Extra 300 SL that controls only dicotyledonous species.

Key words: weed infestation, intercropping, weed control

INTRODUCTION

Many authors indicate the limiting effect of intercropping on the number and weight of weeds. Intercrops compete with weeds for living space, light, nutrients and water. Some intercrop species release allelopathic compounds which limit the occurrence of weeds (Duer, 1997; Oleszek, 1994; Wanic et al. 2004). At the same time, intercrops do not usually affect changes in the species composition of weed infestation. The strength of the impact of intercrops depends on their type and main crop species. Intercropping used for the ploughing-in of the intercrop or for soil mulching improves soil conditions; however, it may cause increased weed infestation of succeeding crops (Duer, 1996). The use of intercrops is more beneficial than of stubble crops due to the longer period of their remaining in the field and their joint effect, together with cereal crops, against weed development (Wanic et al. 2005). Intercrops are a factor reducing nitrogen losses in the soil and improving the organic substance balance. The also perform the phytosanitary role, limiting the incidence of diseases and pests of crop plants. They allow biological activity to be maintained and also reduce soil erosion processes (Malicki and Michałowski, 1994; Duer, 1996).

According to many authors, appropriately selected herbicides may perform an important role in weed infestation reduction. The introduction of herbicides increases the effectiveness of weed control; it is also a factor which allows negative effects of simplifications in crop rotation to be partially reduced (Kuś et al. 1993; Deryło, 2004).

The aim of the present study was to determine the effect of intercropping on weed infestation of a spring barley crop on rendzina soil in the climatic conditions of south-eastern Poland.

METHODS

The experiment was carried out in the years 2003–2005 in the Bezek Experimental Farm near the city of Chełm, Poland, run by the University of Life Sciences in Lublin. The experimental plot was located on medium heavy mixed rendzina soil, formed from chalk rock with the granulometric composition of medium silty loam. This soil had a neutral pH, very high content of P – 342.1 and K – 278.9, very low magnesium content – 16 (values expressed in $mg \times kg^{-1}$ of soil), very high organic carbon content – over 3.5%, and it was classified as IIIb soil valuation class and defective wheat complex.

The experiment was conducted in a randomized block design, in four replications, with the plot area of $12m^2$. Tillage was performed in accordance with generally accepted agricultural practice recommendations. Seeds dressed with the seed dressing Panoctine 300 LS (a biologically active substance – guazatine in the form of acetate) were sown at an amount of 3.5 million seeds per 1ha. After sowing spring barley, intercrops in the form of red clover cv. Dajana (20 $kg \times ha^{-1}$) or white clover cv. Astra (10 $kg \times ha^{-1}$) were sown manually. The experimental factors were as follows: intercrop species and the method of weed infestation control in the spring barley crop. In the intensive protection variant, the following plant protection agents were used: Chwastox Extra 300 SL 3.0 $l \times ha^{-1}$ (MCPA), – (25-29 in the BBCH scale) – the intercrop at the 3-tiller stage, Alert 375 SC 1.0 $l \times ha^{-1}$ (flusilazole + carbendazim) – (20-29 in the BBCH scale), Tango 500 SC 0.8 $l \cdot ha^{-1}$ (tridemorph + epoxiconazole) – (30-39 in the BBCH scale), whereas in the basic variant no herbicide was applied. The plots without intercrop were the control treatment. The following doses of mineral fertilisers were applied: N – 60 $kg \times ha^{-1}$; P – 17.5 $kg \times ha^{-1}$; K – 41.5 $kg \times ha^{-1}$. Phosphorus and potassium fertilisers as well as 30 kg of $N \times ha^{-1}$ were applied pre-sowing. The remaining part of the nitrogen dose was applied at the shooting stage. Before the harvest of spring barley, the weed infestation was determined using the quantitative gravimetric method. The number and species composition of weeds as well as the fresh weight of the above-ground parts of weeds were determined, based on the sampling sites marked out by a frame with sides of 1m × 0.25 m, in four randomly selected places on each plot.

The obtained results were statistically analysed by means of variance analysis. The mean values were compared by means of least significant differences using the Tukey test.

Nomenclature of weed species followed M i r e k et al. (2002).

RESULTS

The weed species composition in the spring barley crop changed to a small extent under the influence of the application of clover intercropping. In the barley crop, 32 weed species were found, including 26 dicotyledonous and 6 monocotyledonous ones. The population size of particular species showed large fluctuations (Tab. 1). In the spring barley crop with the red clover intercrop, a total of 26 weed species were found, including 21 dicotyledonous and 5 monocotyledonous ones. Among the dicotyledonous species, *Sonchus arvensis* occurred in greatest numbers, accounting for 10.7% of total weed species. In the group of monocotyledonous plants, *Setaria pumila* was predominant, with its percentage share accounting for as much as 55.8% of all the species (Tab. 1). In the barley crop with the white clover intercrop, 25 weed species were found. Among the 19 dicotyledonous species, *Viola arvensis* predominated (11.3% of the community); *Sonchus arvensis* also occurred in great numbers (8.9% of total weeds). In the crop without intercrop, 25 dicotyledonous and 5 monocotyledonous weed species were found; *Sonchus arvensis* was found most frequently, and *Viola arvensis* also occurred with significant intensity (Tab. 1).

In all the treatments, *Setaria pumila* was the dominant monocotyledonous species. The weed infestation reduction on the plots with the red and white clover intercrops resulted primarily from the limitation of the occurrence of *Setaria pumila* by, respectively, 32.7 and 33.2% as well as of *Echinochloa crus-galli* by 44.6 and 41.7%, compared to the treatment without intercrop. Intercropping eliminated *Thlaspi arvense, Plantago major, Gypsophila muralis, Cerastium holosteoides, Melilotus alba* from the community. The reduced numbers of dicotyledonous species can be seen in particular in the spring barley crop with the red clover intercrop. Thanks to its application, the weed infestation with species such as, among others: *Sonchus arvensis, Viola arvensis, Stellaria media, Myosotis arvensis,* was limited. The white clover intercrop contributed to the reduction in the occurrence of weeds such as: *Sonchus arvensis, Melandrium album, Amaranthus retroflexus* and *Medicago lupulina* (Tab. 1).

In the spring barley crop without herbicide application, a total of 31 weed species were found, including 25 dicotyledonous and 6 monocotyledonous ones, whereas in the treatments with the herbicide, this number was 27 species, including 22 dicotyledonous and 5 monocotyledonous ones. In this treatment, a clear reduction in the number of the following species can be seen: *Fallopia convolvulus, Stellaria media, Chenopodium album, Cirsium arvense, Papaver rhoeas, Medicago lupulina, Amaranthus retroflexus,*

Table 1
Species composition and number of weeds per 1 m² of a spring barley crop before harvest, depending on intercrop species (mean for the years 2005-2007).

Species	Intercrop		
	control without intercrop	red clover	white clover
Dicotyledonous			
1. *Sonchus arvensis* L.	8.5	4.4	4.7
2. *Convolvulus arvensis* L.	1.0	1.8	1.5
3. *Viola arvensis* Murray	3.9	1.5	5.9
4. *Fallopia convolvulus* (L.) Á. Löve	2.6	1.4	2.0
5. *Galium aparine* L.	2.1	1.2	2.0
6. *Matricaria maritima* subsp. *indora* (L.) Dostál	1.0	1.1	2.6
7. *Melandrium album* (Mill.) Gracke	1.0	0.5	0.3
8. *Stellaria media* (L.) Vill.	2.2	0.5	2.5
9. *Cirsium arvense* (L.) Scop.	0.3	0.5	0.0
10. *Chenopodium album* L.	0.8	0.4	1.1
11. *Polygonum aviculare* L.	0.6	0.3	0.8
12. *Veronica persica* Poir.	0.1	0.3	0.4
13. *Anagallis arvensis* L.	0.3	0.2	0.6
14. *Lamium amplexicaule* L.	0.3	0.2	0.4
15. *Amaranthus retroflexus* L.	0.4	0.2	–
16. *Myosotis arvensis* (L.) Hill	0.4	0.2	0.7
17. *Veronica arvensis* L.	0.2	0.1	0.1
18. *Papaver rhoeas* L.	0.3	0.1	0.4
19. *Medicago lupulina* L.	0.4	0.1	0.1
20. *Artemisia vulgaris* L.	–	0.1	–
21. *Capsella bursa–pastoris* (L.) Medik.	0.1	0.0	0.2
22. *Thlaspi arvense* L.	0.1	–	–
23. *Plantago major* L. s. str.	0.1	–	–
24. *Gypsophila muralis* L.	0.1	–	–
25. *Cerastium holosteoides* Fr. emend. Hyl.	0.0	–	–
26. *Melilotus alba* Medik.	0.0	–	–
Total dicotyledonous	26.8	15.1	26.3
Number of dicotyledonous species	25	21	19
Monocotyledonous**			
1. *Setaria pumila* (Poir) Roem. & Schulz.	31.9	21.3	21.5
2. *Avena fatua* L.	0.7	1.5	0.9
3. *Elymus repens* (L.) Gould	0.2	0.4	0.7
4. *Apera spica-venti* (L.) P. Beauv.	0.2	0.0	0.6
5. *Echinochloa crus-galli* (L.) P. Beauv.	2.4	0.0	1.4
6. *Equisetum arvense* L.	–	–	0.0
Total monocotyledonous	35.4	23.2	25.1
Number of monocotyledonous species	5	5	6
Total weeds	62.2	38.3	51.4
Total number of species	30	26	25

0.0 – population size under 0.1
** with *Equisetum arvense*

Table 2
Species composition and number of weeds per 1 m^2 of a spring barley crop before harvest, depending on the weed control method (mean for the years 2005-2007).

Species	Weed control	
	without herbicide	with herbicide
Dicotyledonous		
1. *Sonchus arvensis* L.	5.9	5.8
2. *Viola arvensis* Murray	3.4	4.1
3. *Fallopia convolvulus* (L.) Á. Löve	3.1	0.9
4. *Stellaria media* (L.) Vill.	2.6	0.9
5. *Matricaria maritima* subsp. *indora* (L.) Dostál	1.8	1.3
6. *Convolvulus arvensis* L.	1.8	1.0
7. *Galium aparine* L.	1.5	1.9
8. *Chenopodium album* L.	1.3	0.5
9. *Polygonum aviculare* L.	0.7	0.4
10. *Melandrium album* (Mill.) Gracke	0.8	0.5
11. *Myosotis arvensis* (L.) Hill	0.6	0.3
12. *Anagallis arvensis* L.	0.5	0.2
13. *Cirsium arvense* (L.) Scop.	0.5	0.0
14. *Papaver rhoeas* L.	0.4	0.1
15. *Lamium amplexicaule* L.	0.3	0.2
16. *Medicago lupulina* L.	0.3	0.0
17. *Amaranthus retroflexus* L.	0.3	0.1
18. *Veronica persica* Poir.	0.1	0.4
19. *Capsella bursa-pastoris* (L.) Medik.	0.1	0.1
20. *Thlaspi arvense* L.	0.1	-
21. *Artemisia vulgaris* L.	0.1	-
22. *Gypsophila muralis* L.	0.1	-
23. *Veronica arvensis* L.	0.0	0.3
24. *Plantago major* L. s. str.	0.0	0.0
25. *Melilotus alba* Medik.	0.0	-
26. *Cerastium holosteoides* Fr. emend. Hyl.	-	0.0
Total dicotyledonous	26.3	19.1
Number of dicotyledonous species	25	22
Monocotyledonous**		
1. *Setaria pumila* (Poir) Roem. & Schulz.	24.3	25.5
2. *Echinochloa crus-galli* (L.) P. Beauv.	1.5	1.1
3. *Avena fatua* L.	1.0	1.0
4. *Elymus repens* (L.) Gould	0.3	0.6
5. *Apera spica-venti* (L.) P. Beauv.	0.3	0.2
6. *Equisetum arvense* L.	0.0	-
Total monocotyledonous	27.4	28.4
Number of monocotyledonous species	6	5
Total weeds	53.7	47.5
Number of species	31	27

0.0 – population size under 0.1
** with *Equisetum arvense*

Table 3
Number of dicotyledonous weeds per 1 m^2 of a spring barley crop before harvest (mean for the years 2005-2007).

Intercrop	Weed control method		Mean
	without herbicide	with herbicide	
Red clover	18.8	11.3	15.1
White clover	31.7	20.8	26.3
Without intercrop	28.3	25.3	26.8
Mean	26.3	19.1	–
$LSD_{0.05}$	Intercrops 8.1; weed control method 5.5		

Table 4
Number of monocotyledonous weeds per 1 m^2 of a spring barley crop before harvest (mean for the years 2005-2007).

Intercrop	Weed control method		Mean
	without herbicide	with herbicide	
Red clover	23.1	23.3	23.2
White clover	29.6	20.6	25.1
Without intercrop	29.4	41.3	35.4
Mean	27.4	28.4	–
$LSD_{0.05}$	Intercrops 8.7		

Table 5
Total number of weeds per 1 m^2 of a spring barley crop before harvest (mean for the years 2005-2007).

Intercrop	Weed control method		Mean
	without herbicide	with herbicide	
Red clover	41.9	34.6	38.3
White clover	61.4	41.4	51.4
Without intercrop	57.7	66.6	62.2
Mean	53.7	47.5	–
$LSD_{0.05}$	Intercrops 12.7		

Table 6
Fresh weight of weeds per 1 m^2 of a spring barley crop before harvest (mean for the years 2005-2007).

Intercrop	Weed control method		Mean
	without herbicide	with herbicide	
Red clover	92.1	66.8	79.5
White clover	83.0	62.8	72.9
Without intercrop	121.6	68.5	95.1
Mean	98.9	66.0	–
$LSD_{0.05}$	Weed control method 27.3		

Anagallis arvensis, Convolvulus arvensis, Polygonum aviculare, Myosotis arvensis and *Lamium amplexicaule* (Tab. 2).

In the treatments without chemical protection, a significantly larger number of dicotyledonous weeds was found compared to the plots treated with Chwastox Extra 300 SL. Red clover was the intercrop which better reduced the infestation with dicotyledonous weeds; a significantly smaller number of dicotyledonous weeds was found on the plots with red clover compared to the treatment with white clover and without intercrop (Tab. 3).

Both red clover and white clover significantly limited the number of monocotyledonous weeds before the spring barley harvest compared to the treatment without intercrop. The application of the herbicide did not differentiate significantly the number of monocotyledonous weeds (Tab. 4). The total number of weeds in the spring barley crop before the harvest was significantly lower in the treatments with the red clover intercrop compared to the treatment with white clover and the treatment without intercrop (Tab. 5). The application of the herbicide Chwastox Extra 300 SL significantly decreased the fresh weight of weeds found in the spring barley crop (Tab. 6).

DISCUSSION

The presented results of the study partially confirm the data contained in literature relating to the significant role of cover crops in weed infestation control (Hauggaard-Nielsen et al. 2001; Jensen et al. 2005; Wanic et al. 2005). Differences in their effect are dependent on soil and climatic conditions as well as cereal species. Kuś and Jończyk (2000) as well as Pawłowski and Woźniak (2000) indicate the beneficial effect of intercrops on certain physical, chemical and biological properties of the soil environment, which in turn results in an improvement of growth and development conditions, and what follows, better possibilities of competing with weeds.

The introduction of red and white clover intercrops in this experiment clearly limited the growth and development of weeds. The presence of the intercrop resulted in different total numbers of weeds in particular treatments. The largest amount, 30 species, was found in the spring barley crop without intercrop, whereas in the treatments with the intercrops it was from 25 to 26 species. Thus, intercropping contributed to the impoverishment of the species composition of the weed community in spring barley. It clearly reduced the incidence of the following weeds: *Sonchus arvensis, Fallopia convolvulus, Melandrium album, Amaranthus retroflexus, Veronica arvensis* and *Medicago lupulina.* Similar observations were made by Wanic et el. (2004). On the other hand, Wanic et al. (2005) present results in which weed communities in treatments with intercropping, in relation to barley grown in pure culture, were marked by greater species diversity. Both intercrops reduced the population size of weeds, but red clover was more effective in this respect. Malicki and Szymona (1980/81) demonstrated that intercropping reduces the number and air-dry weight of weeds. Hauggaard-Nielsen et al. (2001) and Wanic et al. (2005) also confirm the limiting effect of intercrops on the growth and development of weeds in a spring barley crop. It results both from the competitive effect of intercropping on weeds and from the effect of allelopathic nature. The strength of this impact depends in particular on the selection of intercrop species. Opposite results were obtained by Kuraszkiewicz and Pałys (2003) who demonstrated that intercropping did not affect significantly the number and weight of weeds before cereal harvest. Feledyn-Szewczyk and Duer (2006) also presented results indicating the relatively low weed control activity of intercrops compared to weed control methods used in the conventional and integrated production systems.

Red and white clover intercrops significantly limited the number of monocotyledonous weeds. But the applied weed control methods did not differentiate the level of weed infestation with monocotyledonous weeds, which resulted from the application of the herbicide Chwastox Extra 300 SL that controls only dicotyledonous species.

Pawlonka (2008) presents results showing the weak response of barley to chemical protection against weeds. The greatest effect was obtained by applying a reduced dose ($3.0\ l \times ha^{-1}$) of the herbicide Chwastox Extra 300 SL. In the present experiment, a reduction in fresh weight of weeds in the spring barley crop was observed when chemical treatment was used. Deryło (2004) also found a similar correlation. The abovementioned author did not find any changes in the basic weed species composition under the influence of the applied herbicide, but mainly a decrease in their population.

CONCLUSIONS

1. The red clover intercrop in the spring barley crop significantly reduced both the number of monocotyledonous and dicotyledonous weeds as well as the total number of weeds, whereas the white clover intercrop limited only the number of monocotyledonous weeds.
2. Intercropping limited the occurrence of the following weeds: *Sonchus arvensis, Fallopia convolvulus, Melandrium album, Amaranthus retroflexus,*

Veronica arvensis, Medicago lupulina and *Setaria pumila.*

3. *Setaria pumila, Sonchus arvensis, Viola arvensis* were predominant in the spring barley crop and in the intercrops on rendzina soil.
4. The red clover intercrop better reduced the number and fresh weight of weeds in the spring barley crop on rendzina soil compared to the white clover intercrop.
5. In the protection of a spring barley crop using red and white clover intercropping, it is recommended to apply the herbicide Chwastox Extra SL 300, since it significantly limits the number and fresh weight of dicotyledonous weeds.

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Wpływ wsiewek międzyplonowych na zachwaszczenie łanu jęczmienia jarego uprawianego w monokulturze

Streszczenie

W pracy przedstawiono wyniki badań przeprowadzonych w latach 2005–2007 w Gospodarstwie Doświadczalnym Bezek niedaleko Chełma, na ciężkiej rędzinie mieszanej. Badano wpływ wsiewek międzyplonowych w postaci koniczyny czerwonej odmiana ‘Dajana’ i koniczyny białej odmiana ‘Astra’ na zachwaszczenie łanu jęczmienia jarego. Skład gatunkowy chwastów w łanie jęczmienia jarego w niewielkim stopniu ulegał zmianom pod wpływem zastosowania wsiewek międzyplonowych koniczyn, natomiast liczebność osobników poszczególnych gatunków ulegała znacznym wahaniom. W łanie jęczmienia jarego z wsiewką koniczyny czerwonej spośród gatunków dwuliściennych najliczniej wystąpił *Sonchus arvensis.* W uprawie jęczmienia z koniczyną białą i bez wsiewki dominującymi gatunkami dwuliściennymi były *Viola arvensis* oraz *Sonchus arvensis*. Dominującym gatunkiem jednoliściennym we wszystkich obiektach była *Setaria pumila*. Wprowadzenie wsiewek międzyplonowych w postaci koniczyny czerwonej i białej wyraźnie ograniczało wzrost i rozwój chwastów. Wsiewki międzyplonowe koniczyny czerwonej w łanie jęczmienia jarego lepiej ograniczały zachwaszczenie chwastami dwuliściennymi, zmniejszyły istotnie także liczbę chwastów jednoliściennych i ogółem zaś koniczyny białej tylko liczbę chwastów jednoliściennych. Zastosowanie herbicydu Chwastox Extra 300 SL istotnie zmniejszyło świeżą masę chwastów występujących w łanie jęczmienia jarego. Obecność wsiewki wpływała na zróżnicowaną ogólną liczbę chwastów w poszczególnych obiektach. Wsiewki międzyplonowe wyraźnie ograniczały występowanie następujących gatunków chwastów: *Sonchus arvensis, Fallopia convolvulus, Melandrium album, Amaranthus retroflexus, Veronica arvensis* i *Medicago lupulina.* Także biomasę chwastów redukowały badane gatunki wsiewek. Stosowanie herbicydu nie zróżnicowało liczby chwastów jednoliściennych, co wynikało z zastosowania Chwastoxu Extra 300 SL zwalczającego jedynie gatunki dwuliścienne.