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The effect of catch crops cultivated in accordance with the agri-environment scheme on weed infestation of spring wheat stand

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ABSTRACT

The aim of the conducted study was to assess the effect of two types of stubble catch crops (a mixture of legumes and white mustard) as well as varied nitrogen fertilization on weed infestation of a spring wheat stand depending on the adopted tillage system. Weed infestation assessed at the tillering phase of spring wheat showed the lowest number of weeds in direct sowing after the mixed legume catch crop. The next assessment of weed infestation performed at the flowering phase of spring wheat showed that the lowest number of weeds was found in direct sowing immediately after the catch crop of a mixture of legumes and white mustard for the complete nitrogen fertilization rate. The lowest weed dry weight was recorded in conventional tillage after a mixture of legumes for the complete nitrogen fertilization rate and after white mustard for a reduced nitrogen fertilization rate.

Keywords: cultivation measures; cereals; *Triticum aestivum*; weed control; yield

An increase in the share of cereals in the cropping structure results mainly from economic considerations. However, excessively frequent culture of the same group of crops, particularly on the same field over a longer time period, may lead to reduced yielding in the successive years (Sieling et al. 2007). Researchers assume, that among all cereals wheat is the most responsive in yield reduction resulting among other things from the plant auto-toxic effect (Fomsgaard 2006). A major cause for such a situation is attributed to an increased weed infestation of the stand and soil (Poggio 2005, Blecharczyk et al. 2007). For this reason new solutions are being searched for in order to potentially eliminate this adverse phenomenon. Cultivation of various catch crops may be one of the methods to control weed infestation and improve yielding. According to Wojciechowski (2009), the degree to which weed infestation is limited depends to a considerable extent on the type of the used catch crop. In the opinion of Wojciechowski (2009), the dominant species include lacy phacelia, white mustard, oilseed radish and other Brassicaceae. However, in the opinion of those authors we should rather focus on legumes, mainly thanks to their high biological and fertilization value.

Another factor having a strong effect on agrophytocenosis is connected with all types of tillage simplifications, as they promote the development of different growth and development conditions for crop plants and weeds. Particularly the introduction of reduced tillage may lead to an increase in the number of weeds or periodical disappearance of certain species (Fried et al. 2008, Gruber et al. 2012).

The status and degree of weed infestation may also affect mineral fertilizers (especially nitrogen), dose, method of application (foliar or soil application), formulation (solution or in solid form), as

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well as the availability of the nutrients (Bischoff and Mahn 2000, Yin et al. 2006). In the opinion of Blecharczyk et al. (2007), the use of higher mineral fertilizer application rates may result in the reduced quantity and dry weight of weeds. An opposite opinion was presented by Blackshaw (2005) as well as Ross and Acker (2005), who showed increased weed infestation rates in stands of spring wheat under the influence of increased nitrogen rates.

The aim of this study was to assess the effect of two types of catch crops (a mixture of legumes vs. white mustard) and nitrogen fertilization on weed infestation in the spring wheat stand depending and yielding on the adopted tillage system.

MATERIAL AND METHODS

Investigations were conducted in the year 2011 and 2012 at the Agricultural Experimental Station in Swojec, belonging to the Wrocław University of Environmental and Life Sciences (51°07'N, 17°08'E). The experiment was established on medium-heavy soil (alluvial soil composed of loamy sand strongly underlain with slightly loamy sand) on a good rye complex. Spring wheat cv. Tybalt was grown after forecrop of winter wheat and fore-forecrop of winter rape. Analyses were conducted based on a three-factorial experiment established in a split-plot design in four replications. The first degree factor comprised different catch crops: the control (no catch crop), the catch crop of white mustard (*Sinapis alba*), the catch crop of a mixture of legumes ((*Pisum sativum* ssp. *arvense*) + (*Vicia faba* var. *minor*)). *S. alba* cv. Bardena was sown at 20 kg/ha, while the mixture of *P. sativum* ssp. *arvense* cv. Roch – at 100 kg/ha + *V. faba* var. *minor* cv. Neptun – at 130 kg/ha. The second factor comprised different tillage methods in the spring period: direct sowing of spring wheat into mulch, conventional tillage (ploughing), and reduced tillage (disc harrow). The third experimental factor was nitrogen fertilization (ammonium nitrate) at a complete application rate (1N) and reduced by 50% ($^1/_2$ N). Third row factor was a varied nitrogen fertilization. Two doses of nitrogen were used: recommended for spring wheat (1N) – 120 kg/ha (40I + 40II + 40III), reduced by half: ($^1/_2$ N) – 60 kg/ha (40I + 20II). Nitrogen was used in three terms: I – before sowing of spring wheat, the second: II – at the stage of shooting (31–32 BBCH) and III – in the phase of earing (49 BBCH). Fertilizers (ammonium nitrate), in solid form in the first term was applied to the soil, and in the following as top dressing.

Weed infestation of spring wheat during the growing season was evaluated twice. For the first time in early tillering stage (21 BBCH) by the quantitative and qualitative method on the surface of 0.2 m^2 (four replications per plot). Dominant species of weeds were also determined. The second evaluation was performed within flowering spring wheat (65 BBCH) by the quantity-weight method on the surface of 0.5 m^2 (2 replications). Thus populations of weed species were defined, giving the total number of weeds and their total dry weight per unit area. In the experiment, the Chwastox Trio 540 SL (a.i. mecoprop; MCPA; dicamba) herbicide was used in dose 1.5 L/ha, at the end of tillering of spring wheat (29 BBCH).

Recorded results were subjected to the analysis of variance, where boundary differences were determined using the Tukey's test at the significance level $\alpha = 0.05$. Before analysis of variance results were transformed using a square root transformation. The paper presents data after transformation, the results of the transformed data and the value of *LSD* (least significant difference).

RESULTS AND DISCUSSION

Literature sources do not present definite opinions on the effect of catch crops on weed infestation of crop stands. According to some authors catch crops may reduce weed infestation in crop stands (Hauggard-Nielsen et al. 2001). In contrast, Woźniak (2005) in his study found no significant changes in weed infestation of a spring wheat stand following different catch crops. In turn, within this study a highly advantageous effect was observed for the applied catch crops in terms of the limitation of the number of weeds in the spring wheat stand (Tables 1 and 2). At the tillering phase in spring wheat the lowest number of weeds was recorded after the catch crop with the mixture of legumes and it was by 15.8% lower than in the culture with no catch crops and by 11.1% lower than after the catch crop of *S. alba* (Table 1). In comparison to the culture with no catch crop a significant reduction (by 12.7%) of weed infestation was recorded (Table 2). The applied catch crops also considerably limited dry weight of weeds, with the lowest dry matter of weeds recorded

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Table 1. Weed infestation of spring wheat on tillering phase (2011–2012)

Treatment	Spring cultivation set	Weeds density (No./m^2)	Density of dominant weeds (No./m^2)				
			BRSNA	CHEAL	LAMAM	VIOAR	Others
Without catch crop	direct seeding	5.5	4.0	3.0	1.7	2.0	1.9
	disking	8.6	6.0	2.1	2.2	3.6	2.7
	ploughing	8.8	6.1	2.7	2.8	3.1	1.8
Mustard catch crop	direct seeding	4.9	2.2	2.3	0.8	1.5	2.6
	disking	8.8	5.7	2.3	3.6	3.5	2.9
	ploughing	8.0	5.0	2.6	3.6	3.3	1.7
Mixture catch crop	direct seeding	3.7	1.3	2.1	0.6	1.5	1.3
	disking	7.5	4.9	2.1	2.6	3.1	2.5
	ploughing	8.1	5.5	2.3	2.8	3.1	1.8
$LSD_{0.05}$		0.7	0.5	0.8	0.6	ns	ns
Mean for treatment							
Without catch crop		7.6	5.4	2.6	2.2	2.9	2.1
Mustard catch crop		7.2	4.3	2.4	2.6	2.8	2.4
Mixture catch crop		6.4	3.9	2.2	2.0	2.6	1.9
$LSD_{0.05}$		0.4	1.0	ns	0.3	ns	ns
Direct seeding		4.7	2.5	2.4	1.0	1.7	1.9
Disking		8.3	5.5	2.2	2.8	3.4	2.7
Ploughing		8.3	5.4	2.5	3.0	3.2	1.8
$LSD_{0.05}$		0.4	0.6	ns	0.3	0.6	0.6

BRSNA – *Brasica napus*; CHEAL – *Chenopodium album*; LAMAM – *Lamium amplexicaule*; VIOAR – *Viola arvensis*; ns – non-significant; *LSD* – least significant difference

in the culture after a mixture of legumes being by 11.1% lower than after *S. alba* and by 36.0% lower than in the culture with no catch crop (Table 3).

Results of this study are not confirmed by those reported by Haramoto and Gallandt (2005) and Ngouajio et al. (2003), who recommended particularly species from the family Brassicaceae in controlling weed infestation. In the opinion of Gruber et al. (2012), reduced tillage, particularly direct sowing, may contribute to increased weed infestation of arable fields. In turn, Sekutowski and Smagacz (2010) were of an opinion that reduced tillage, including direct sowing, has no effect on the level of weed infestation of crops.

The results of this study showed the effect of direct sowing on the limitation of the number of weeds in the spring wheat stand (Tables 1 and 2). At the tillering phase in spring wheat weed infestation of the stand was by 69.1% lower than after the application of conventional tillage and by 43.4% lower than following the use of disking (Table 1). In turn, at the stage of flowering in spring wheat the differences in weed infestation of the stand amounted to 42.2% and 47.5% (Table 2). An opposite situation was found for dry weight of weeds (Table 3).

The spring wheat stand was infested basically by only 4 weed species, i.e. *Chenopodium album*, *Lamium amplexicaule*, *Viola arvensis* and *Brasica napus* var. *oleifera*. Of these 4 species only *B. napus* var. *oleifera* was found to be the most numerous in the spring wheat stand, particularly in reduced and conventional tillage. It was found within this study that the applied catch crops markedly reduced the incidence of only *B. napus* var. *oleifera*, while they had no marked effect on the limitation of infestation with other weed species. In contrast, it results from a study by Moyer et al. (2007) that the used catch crops significantly reduced the incidence of *Ch. album*. Studies conducted by Yin et al. (2006) showed that higher application rates of mineral fertilizers most typically reduce the number and air dry weight of weeds. This finding was partly confirmed in this study, in which the application of the complete nitrogen fertilization rate

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Table 2. Density of weeds (m^2) (2011–2012)

Cultivation measures	Fertilization	Catch crops				Mean for cultivation measures
		without catch crop	mustard	mixture	mean	
Direct seeding	½ N	4.0	3.0	2.8	3.2	3.2
	1 N	4.8	2.5	2.5	3.3	
	mean	4.4	2.8	2.6	–	
Ploughing	½ N	5.7	4.8	5.5	5.7	5.6
	1 N	6.0	5.8	4.8	5.5	
	mean	5.9	5.3	5.6	–	
Disking	½ N	6.6	6.8	5.8	6.4	6.1
	1 N	5.9	5.7	5.7	5.8	
	mean	6.2	6.3	5.8	–	
Mean for fertilization	½ N	5.4	4.9	5.0	5.4	–
	1 N	5.5	4.7	4.3	4.8	
Mean for catch crops		5.5	4.8	4.7		–

LSD – least significant difference; $LSD_{0.05}$ for: I – catch crops; II – cultivation measures; III – fertilization N; I – 0.4; II – 0.4; III – 0.3; I × II – 0.5; I × III – ns; II × III – ns; I × II × III – 0.7; ns – non-significant; 1 N – complete nitrogen rate; 1/2 N – reduced nitrogen rate by 50%

contributed to a reduction of the weeds number (by 5.8%). The differences were statistically valid only for the number of weeds (Tables 2 and 3). This is consistent with the results of studies by Blackshaw (2005), although he believes that weeds affect not only the quantity but also the way of nitrogen introduction.

The use of *S. alba* intercrop while performing the disc harrow procedure resulted in less weed infestation restriction of spring wheat. In this phase, the execution of ploughing before sowing of spring wheat and covering its intercrop always resulted in increased weed infestation. Also in the flowering stage of spring wheat smallest weed

Table 3. Dry mass of weeds (g/m^2) (2011–2012)

Cultivation measures	Fertilization	Catch crops				Mean for cultivation measures
		without catch crop	mustard	mixture	mean	
Direct seeding	½ N	3.2	3.0	1.5	2.6	2.5
	1 N	3.7	2.0	1.6	2.4	
	mean	3.5	2.5	1.5	–	
Ploughing	½ N	2.1	1.2	2.1	1.8	1.7
	1 N	2.1	1.6	1.1	1.5	
	mean	2.1	1.4	1.8	–	
Disking	½ N	2.4	1.9	1.8	2.0	1.8
	1 N	1.4	1.4	1.8	1.6	
	mean	1.9	1.6	1.8	–	
Mean for fertilization	½ N	2.6	2.0	1.8	2.1	–
	1 N	2.5	1.7	1.5	1.9	
Mean for catch crops		2.5	1.9	1.6		–

LSD – least significant difference; $LSD_{0.05}$ for: I – 0.6; II – 0.4; III – ns; I × II – 0.7; I × III – ns; II × III – ns; I × II × III – 0.8; 1 N – complete nitrogen rate; 1/2 N – reduced nitrogen rate by 50%

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Table 4. Grain yield of spring wheat (t/ha) (2011–2012)

Cultivation measures	Fertilization	Catch crops				Mean for cultivation measures
		without catch crop	mustard	mixture	mean	
Direct seeding	½ N	4.80	5.17	6.07	5.35	5.44
	1 N	5.09	5.36	6.13	5.52	
	mean	4.94	5.27	6.10	–	
Ploughing	½ N	5.57	5.53	6.52	5.88	5.89
	1 N	5.64	5.65	6.42	5.90	
	mean	5.61	5.59	6.47	–	
Disking	½ N	5.44	5.68	6.18	5.77	6.04
	1 N	6.16	6.09	6.67	6.31	
	mean	5.80	5.88	6.43	–	
Mean for fertilization	½ N	5.27	5.46	6.26	5.66	-
	1 N	5.63	5.70	6.41	5.98	
Mean for catch crops		5.45	5.58	6.34	–	

LSD – least significant difference; $LSD_{0.05}$ for: I – 0.11; II – 0.12; III – 0.10; I × II – 0.21; II × III – 0.18; I × II × III – ns; 1 N – complete nitrogen rate; 1/2 N – reduced nitrogen rate by 50%

infestation was found after using intercrop with leguminous mixture used as mulch and full dose of nitrogen applications.

Conducted studies revealed positive mixture influence on spring wheat grain yield, that was 13.6% greater than after *S. alba* forecrop, and 16.3% greater than shown in the crop without stubble catch crops (Table 4). Wojciechowski (2009) proved that wheat grain yields increased on average by 8.7% in comparison to cultivation without catch crops, and 11.5% greater than after mustard cultivation. Of the high value of leguminous also informs Sarunaite et al. (2006).

Among all the spring tillage systems, disking affected crops most preferably. Spring wheat grain yield was 2.5% higher than after ploughing, and 11.0% greater in comparison to shown in direct sowing. Woźniak and Soroka (2014) believe, however, that the lowest yields are obtained in the reduced tillage. The adverse effects of direct seeding on yielding were also reported by Arvidsson et al. (2014).

In each cultivation treatment, reduced dose of nitrogen caused a decrease in spring wheat yielding on average of 5.4%, but it should be noted that in stubble catch crops after the mix, this difference was only 2.3%.

At the tillering phase in spring wheat the best results in the limitation of weed infestation were observed following the catch crop of the legume mixture left in the field until spring as mulch. In turn, the use of *S. alba* as a catch crop had the weakest effect on controlling weed infestation of the spring wheat stand. Also at the stage of flowering in spring wheat the lowest weed infestation of the stand was observed following the catch crop of the legume mixture and the application of the complete nitrogen fertilization rate. The lowest dry weight of weeds was obtained from conventional culture, in which the legume mixture was applied as the catch crop together with the complete nitrogen fertilization rate.

In conclusion, weed infestation of the spring wheat stand was markedly limited by the applied catch crops. The mixture of legumes proved to be the most effective in the control of weed infestation in the spring wheat stand. The greatest reduction of weed infestation in the spring wheat stand at the simultaneous increase in weed dry weight was observed after direct sowing in comparison to conventional and reduced tillage. The application of the nitrogen fertilization rate reduced by 50%, irrespective of the used catch crop, resulted in an increased weed infestation of the spring wheat stand; however, these differences were statistically non-significant. The lowest weed infestation of the spring wheat stand was found after the use of mulch of the legume mixture and for the complete nitrogen fertilization rate, while it was greatest

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after the catch crop of *S. alba* for the nitrogen rate reduced by 50%. The lowest dry weight of weeds was recorded in conventional tillage with the mulch of the legume mixture and the complete nitrogen application rate. The yield of spring wheat most preferably affected: of stubble catch crops – legumes, of spring cultivation measures – reduced tillage. Reduction by half nitrogen fertilization caused a reduction in yields.

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