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The effect of agricultural management systems on the weed incidence in cereals

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Abstract. Two field trials were carried out at the Lithuanian Institute of Agriculture's Joniskelis Research Station on an *Endocalcari-Endohypogleyic Cambisol.* The experiments were designed to identify the effects of legume pre-crops and intercrops as well as the impact of their biomass incorporated as green manure on the weed incidence in succeeding cereals. The effects of legume pre-crops red clover, sown lucerne, and vetch and oats mixture on the incidence of weeds were determined by their weed incidence and the cereal crop's suppressive power that formed under its effect. Undersown intercrops (*Trifolium pratense* L., *Lolium multiflorum* Lam., *Dactylis glomerata* L.), reduced the number of weeds in cereals (on average 13.9%). During the cereal post-harvest period red clover performed best at suppressing weeds, and its positive effect persisted in the year following incorporation of intercrops biomass. The effect of intercrops as post-crops (*Raphanus sativus* L., *Sinapis alba* L.) on weed incidence in the cereal crop depended upon the weather conditions that determined intercrop emergence time and intensity of plant development.

Key words: weed infestation, legume pre-crops, intercrops, clay loam

INTRODUCTION

In sustainable farming practices, the accepted approach is that weed management involves the whole cropping system (Lazauskas, 1990). Cropping sequences that provide varying patterns of resource competition, allelopathic interference, soil disturbance and mechanical damage provide an unstable environment that prevents the proliferation and dominance of a particular weed (Bond & Grundy, 2001; Hatcher & Melander, 2003). Progress in cultural methods of weed control has included the use of novel weed-suppressing intercrops and the identification of specific crops' traits for weed suppression (Liebman & Staver, 2001). We hypothesize in this study that weed infestation will be reduced in cropping systems which include plant diversity and intercrops.

MATERIALS AND METHODS

Two different bifactorial field trials were carried out at the Lithuanian Institute of Agriculture's Joniskelis research station on an *Endocalcari-Endohypogleyic Cambisol.* An experiment to identify the impact of legumes as preceding crops, and incorporating their biomass i into the soil as green manure on the infestation of weeds in cereal, was conducted according to the following design: factor A. Preceding crops for sequence: winter wheat (1st crop): winter wheat or spring barley (2nd crop): red clover (*Trifolium*

pratense L.), sown lucerne (*Medicago sativa* L.), vetch and oat mixture (*Vicia sativa* L., *Avena sativa* L.), factor B. Organic manure: 1. 1st crop without manures, 2. 1st crop: green manure (Tables 1, 2). The effects of intercrops as well as the effects of their biomass incorporated as green manure on the weed infestation in cereals was investigated following the experimental design: factor A: Cereal backgrounds: winter wheat, spring barley, factor B. Intercrops: 1. Without intercrop; 2. Oil radish (*Raphanus sativus* L.); 3. White mustard (*Sinapis alba* L.); 4. Red clover; 5. Cock's foot (*Dactylis glomerata* L.); 6. Italian ryegrass (*Lolium multiflorum* Lam.) (Table 3). The next year spring barley was grown on both backgrounds. The number of weeds and species was determined during tilling stage before application of herbicides (BBCH 27−29), during milky stage (BBCH 75−77) of cereals and before intercrop incorporation, while the weed air-dried mass (weight), was determined only during the milky stage. Accounting was done in 0.25 m^2 fixed plots, four places in each plot. Accounting data for the number and mass of weeds for evaluation of statistically significant differences were transformed according to the formula: $\sqrt{x+1}$ The experimental data were processed by ANOVA and STAT ENG (** $P < 0.01$ and * $P < 0.05$).

RESULTS AND DISCUSSION

The effects of legume pre-crops and their biomass incorporated as green manure. The number and species composition of weeds that emerged in spring during wheat tilling stage depended on the species of the pre-crop. The lowest number of weeds in wheat crop was identified after clover; the difference, compared with lucerne and vetch and oats mixture as pre-crops, was 33.9 and 24.0% lower (Table 1). When winter wheat was grown after clover, the dominant weed species were *Lamium purpureum* L. (23.6 m^{-2}) and *Tripleurospermum perforatum* M.Laiz. L. (9.9 $m^{-2)}$. However, after lucerne, the soil accumulated more nitrogen and labile humic acids (Maiksteniene, Arlauskiene, 2004), which resulted in the occurrence of nitrophilous weeds *Stellaria media* (L.) Vill. (12.5 m^{-2}), *Galium aparine* L. (7.2 m^{-2}), *Veronica arvensis* L. (7.3 m^{-2}) in wheat crops. During wheat milky stage the differences between pre-crops backgrounds equalised. Under the effect of incorporation of legume pre-crops biomass as green manure, the greatest increase in weed incidence occurred after vetch and oats mixture (36.7 %). This was determined by weed seed (*S. media*, *Fallopia convolvulus* (L.) A. Löve, *T. perforatum*, *V. arvensis*) that got into the soil with the mixture's biomass that was incorporated as green manure. The highest total air-dried mass of weeds was recorded in the treatments where best plant nutrition conditions were created: after lucerne and clover, and after incorporation of biomass of all crops as green manure. However, in the wheat crop grown after lucerne, a lower biomass per weed (compared with clover background) was determined by the higher wheat suppressive power (productive density 382–413 plants m^{-2}, yield 5.36 – 5.80t ha^{-1}). When winter wheat is continuously grown, poorer phytosanitary growth conditions are created, which result in the appearance of ecological niches and the availability of extra environmental resources, which are effectively exploited by weeds (Table 2). During wheat milky stage, the number of weeds remained similar to that in the first year. However, the highest number of weeds was found after the vetch and oats mixture and incorporation of its biomass as green manure.

Table 1. The effects of legume pre-crops and green manure on the weed infestation in winter wheat, 1997, 1998, 2000.

Preceding crops (A)	Green manure (B)	Winter wheat growth stage		
		BBCH 27-29	BBCH 75-77	
		weeds m^{-2}	weeds m^{-2}	weight g m^{-2}
Red clover	Without manures	56.1	22.0	7.81
	Clover aftermaths	70.1	24.1	8.45
Sown lucerne	Without manures	84.9*	30.2	12.51
	Lucerne aftermaths	84.9*	26.5	13.65
Vetch and oat mixture	Without manures	72.5	19.9	5.88
	Mixture green mass	78.9	27.2	11.31

Table 2. The effect of preceding crops and green manure on weed infestation in continuous winter wheat or changing species of cereal, 1998, 1999, 2001.

Preceding crops (A)	Green manure (B)	Winter wheat			Spring barley		
		cereals growth stage					
		BBCH 27-29	BBCH 75-77		BBCH 27-29	BBCH 75-77	
		weeds m^{-2}	weeds m^{-2}	weight g m^{-2}	weeds m^{-2}	weeds m^{-2}	weight g m^{-2}
Red clover	Without manures	65.2	20.4	10.7	46.1	10.7	7.0
	Clover aftermaths	69.7	18.9	13.9	47.3	10.4	3.3
Sown lucerne	Without manures	99.5*	26.2*	23.1	53.2	11.8	4.2
	Lucerne aftermaths	109.2*	22.7	20.8	47.8	12.0	2.6
Vetch and oat mixture	Without manures	74.2	27.8*	15.3	53.8	17.1	3.1
	Mixture green mass	78.3	29.9*	25.9	52.7	16.7	3.6

In continuously grown wheat, weeds better exploited the positive potential of the pre-crop of lucerne than in the first year. Here the air-dried mass of weeds was the highest, especially that of *G. aparine*, *S. media*, *L. purpureum*, *T. perforatum.* When wheat was replaced by spring barley, part of the wintering annual weeds specific to winter cereals did not have the chance to emerge and the weed incidence was lower by 39.3% compared with continuously grown wheat. Changes occurred in weed species composition: apart from the dominant *L. purpureum*, *S. media*, niches were occupied by the weeds specific to spring cereals *Chenopodium album* L., *Thlaspi arvense* L. and others. The lowest number of weeds was found in barley on the background of clover. The total air-dry mass of weeds depended not so much on the number of and incidence of weeds as on the environmental resources and weed growth stage.

The effects of intercrops and incorporation of their biomass as green manure. All undersown intercrops tended to reduce weed number in cereals: on average it was 13.9% lower than a control treatment. When after cereal harvesting undersown and post-crops intercrops were grown, the number of weeds varied annually and depended on the amount of precipitation and distribution during the autumn period, intercrops' emergence time, density and competitive power. Correlation analysis showed that with an increase in aboveground mass of intercrops, the total number of weeds and that of annual ones tended to decline ($r = -0.65^*$; $r = -0.64^*$, respectively). The greatest reduction in weed incidence occurred after undersown intercrops: after wide-leafed legume red clover more than 52.5%, after narrow-leafed legumes –cock's foot and Italian ryegrass, - 42.3 and 26.4%, respectively, compared with the plot without

intercrops. The more abundant emergence of some weed species in intercrops grown as succeeding crops, might have been promoted by the use of drill coulters to loosen soil.

After incorporation of the intercrop's biomass, the most prevalent weeds in barley in spring were *G. aparine* (15.4–29.2 weeds m^{-2}) and *F. convolvulus* (3.7–13.5 weeds m^{-2}). In continuously grown barley, 23.5% more weeds emerged compared with barley grown after winter wheat. However, when spring barley was grown after winter wheat, the weed species composition changed and the regularities were not as distinct. The effect of the measures used on weed incidence revealed itself at the end of the barley growing season (Table 3).

Table 3. The effects of intercrops and their green material on the incidence of weeds as affected by continuous growing of cereals, and by the change of cereal species, 2002-2004.

Intercrop (B)	Background - winter wheat (A)			Background - spring barley (A)		
	spring barley growth stage					
	BBCH 27-29	BBCH 75-77		BBCH 27-29	BBCH 75-77	
	weeds m^{-2}	weeds m^{-2}	weight g m^{-2}	weeds m^{-2}	weeds m^{-2}	weight g m^{-2}
Without intercrop	73.4	50.0	3.98	95.4**	70.4**	10.23**
Oil radish	65.8	41.8	3.82	98.4**	61.9	6.21
White mustard	76.6	49.5	3.86	77.6	54.7	6.21
Red clover	66.9	34.4	2.33	81.3	41.7	3.05
Cock's foot	75.4	44.6	4.66	98.5**	57.4	5.41
Italian ryegrass	73.1	57.2	8.30**	80.9	55.4	8.89**

There were significant negative correlations between the number of weeds and intercrops biomass and nitrogen content introduced with it (r = -0.62*; r = -0.67*, respectively). On both cereal backgrounds in the years of intercrops effect, the number of weeds declined (except for the effect of Italian ryegrass on wheat background). Much lower weed incidence was recorded after red clover (36.9%). Under its effect the incidence of *G. aparine* (26.7%), *V. arvensis* (57.9 %) and *Elytrigia repens* (L.) Nevski (45.7 %) declined.

Nitrogen incorporated with intercrops biomass tended to increase barley grain yield (r = 0.56*), which amounted to 5.02–5.54 t ha^{-1} and its competitive power against weeds. The greatest reduction in weed air-dried biomass occurred after red clover (62.2 %). Cereals suppressed *G. aparine*, *L. purpureum*, *V. arvensis*, *S. media*.

CONCLUSIONS

The effects of legume pre-crops red clover, sown lucerne, and vetch and oats mixture and their biomass incorporated as green manure on the incidence of weeds were determined by their weed incidence and the cereal crop's suppressive power that formed under its effect.

Undersown intercrops (*Trifolium pratense* L., *Lolium multiflorum* Lam., *Dactylis glomerata* L.) reduced the number of weeds in cereals (in average 13.9%). During the cereal post-harvest period, clover performed best at suppressing weeds, and its positive effect persisted into the year following the incorporation of intercrops biomass. The

effect of intercrops as post-crops on weed incidence in cereals depended on the weather conditions, which determined intercrop emergence time and development.

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