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Influence of crop rotations and reduced tillage on weed population dynamics under Lithuania's heavy soil conditions

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Abstract. Experiments to study the weed population dynamics in cereals, under conditions of expanded winter crop proportion in rotations and reduced soil tillage, were carried out on a clay loam *Gleyic Cambisol* at Joniskelis Research Station of the Lithuanian Institute of Agriculture. Variations were as follows: A. Crop rotations with different proportions of winter and spring crops: 1. Without winter crops; 2. Winter crops 25%; 3. Winter crops 50%; 4. Winter crops 75%; 5. Winter crops 100%, growing annual and perennial grasses, spring and winter wheat, triticale and barley; B. Soil primary tillage systems: 1. Conventional (ploughing). 2. Reduced (ploughing after grasses, ploughless after cereals) were investigated. The results of investigations show that increasing the proportion of winter crops in rotations during a four-year rotation resulted in reduction of perennial weeds in the cereal crops; however, the content of annual weeds was higher. The prevalent annual and perennial (14.7% of total number) weeds spread in spring cereals (wheat, triticale, barley) were more dangerous to crops than to the weed species found in winter cereals. Perennial weeds amounted to only 6.9% in winter cereals. The perennial weeds recorded in cereals were only 3.9-18.0% at the beginning of crop growing season, depending on crop rotation, however before crop harvest they reached 24.2−52.1%. When growing cereals with reduced soil tillage, the number of perennial weeds was 2.4 times higher; annual weeds, somewhat lower, and the air-dried biomass of all weeds was 44.5% higher compared to conventional tillage.

Key words: crop rotations, soil tillage, spring and winter cereals, weed infestation

INTRODUCTION

Weed infestation is an important factor that affects not only the harvest of crops but also conditions of environmental protection. The productivity of crops is mostly influenced by the species of weeds, the intensity of their development and conditions of spreading. The conditions of environmental protection are influenced by the intensity of chemical and mechanical weed control. When choosing the structure of crops, it is always necessary to evaluate the competition of plants in agrocenoses (Hatcher & Melander, 2003). Therefore, using the innate suppressive power of crops, it is possible to increase the productivity significantly, and diminish both weed control expenses and harm to the environment.

Many cereals are grown in Lithuania's fertile clay loams, especially winter cereals, because the yield of winter crops is generally larger and more constant than that of the spring crop yield. However, by increasing proportions of cereals for crop rotations, the incidence of weeds also increases. Winter crops are more effective at

choking out the most damaging rootstock, and at offsetting perennial weeds, however, most weeds spreading in winter crops are annuals. (Maiksteniene, 1997; Spokiene & Povilioniene, 2003). Therefore, crop rotations are an important constituent of weed control systems as a preventive measure.

Weed incidence variation in crop-fields and possibilities for weed control depend on the chosen soil tillage system. The influence of the soil tillage to weed incidence is affected by soil conditions, biological features of crops, outspreading species of weeds and other factors (Boström & Fogelfors, 1999; Walter et al., 2002). A recent trend in Lithuania, as in other countries, is sustainable reduced soil tillage. However, it is possiblele that soil tillage is restricted by the spread of weeds, especially perennial ones (Lauringson et al., 2000; Stancevicius et al., 2000). The object and purposes of the research are to estimate the influence of crop rotations with different proportions of winter and spring crops and reduced soil tillage on the incidence of weeds in cereals growing in clay loams.

MATERIALS AND METHODS

Cropping systems. Experiments were performed according to the following design: **Factor A. Crop rotations with different proportions of winter and spring crops:** 1. Without winter crops (1). Vetch (*Vicia sativa* L.*)* and oats (*Avena sativa* L.); (2). Spring wheat (*Triticum aestivum* L.); (3). Spring triticale (x*Triticosecale* Wittm.); (4). Spring barley (*Hordeum vulgare* L.). 2. 25% winter crops (1). Red clover (*Trifolium pratense* L.) and timothy (*Phleum pratense* L.); (2). Spring wheat; (3). Spring triticale; (4). Spring barley). 3. 50% winter crops (1). Red clover and timothy; (2). Winter wheat (*Triticum aestivum* Host.*)*; (3). Spring triticale; (4). Spring barley). 4. 75% winter crops (1). Red clover and timothy; (2). Winter wheat; (3). Winter triticale (x*Triticosecale* Wittm.*)*; (4). Spring barley). 5. 100% winter crops (1). Red clover and timothy; (2). Winter wheat; (3). Winter triticale; (4). Winter barley (*Hordeum vulgare* L.)). **Factor B. Primary tillage systems:** 1. Conventional (ploughing). 2. Reduced (ploughing after grasses, no ploughing - after cereals) were investigated. All crops were grown every year in four replicates. Herbicides with selective action were applied in cereals. The soil was ploughed at 23−25 cm depth and, in the case of ploughless tillage,soil was loosened by a stubble breaker at the same depth.

Experimental methods and assessments. Weed incidence was determined twice in the cereals during the growing period,during tilling stage before application of herbicides (BBCH 27−29) and during milky stage (BBCH 75−77); the biomass of dry material was determinedonly 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 (* − 95 %, ** − 99 % probability level) (Tarakanovas, 1999).

RESULTS AND DISCUSSION

The effect of crop rotations with different proportions of winter and spring crops on the spread of weeds in cereals. When increasing the number of winter crops

in the structure of rotation, the total average number of weeds during the crop tilling stage was also increasing. When only winter crops were grown, there were significantly more (26.9%) weeds in the crops than in the spring crop rotation (Table 1). The spread of annual weeds, which made up to 82.0−96.1% of the total number, was even more distinct because of the increase in winter crops. Having 50% or more winter crops in the rotation significantly increased the amount of annual weeds, but decreased the amount of perennial weeds.

Table 1 . Effect of winter crop proportion in rotations and soil tillage on weed infestation in cereals. Average data of 1999−2002.

Treatment	Weeds m^{-2}			Air-dried biomass of weeds g m^{-2}
	total number	annual	perennial	
Proportion of winter crops %				
0	74.0	60.7	13.4	38.0
25	64.4	56.8	7.6*	27.9
50	80.3	72.8*	7.3*	28.5
75	84.9	79.4*	5.5*	22.8
100	93.9*	90.2*	3.6*	33.3
Soil tillage systems				
Conventional	77.2	72.4	4.8	24.8
Reduced	81.7	71.6	10.2**	35.3**

The number of perennial weeds increased from 2.6 to 5.2 times during the milky stage, compared with the tilling stage (3.9−18.0% of total number). The average number of perennial weeds was much smaller when winter crops prevailed in the rotation structure. At the end of the crop growing season,, there were 13.7−39.4 unit's m^{-2} of perennial weeds, accounting for 24.2−52.1% of the total weed biomass. The smallest (22.8 g m^{-2}) air-dried weed biomass in the cereals was in the crop rotation with 75% winter crops. At the final tilling stage of the 2002 crop rotation of spring cereals (wheat, triticale and barley), the prevailing annual weeds were (*Thlapsi arvense* L. − 17.5%, *Fumaria officinalis* L. − 16.3%, *Galium aparine* L, − 14.6%, *Chenopodium album* L. − 12.3%); perennial weeds accounted for an average of 14.7% of the total amount (102 unit's m^{-2}). In winter cereals (wheat, triticale and barley) more annual weeds prevailed: (*Stellaria media* (L.) Will. − 36.0%, *Veronica arvensis* L. − 10.9%, *Viola arvensis Murray* − 8.3%, *Galium aparine* L. − 7.7%; perennial weeds *Cirsium arvense* (L.) Scop., *Sonchus arvensis* L., *Elytrigia repens* (L.) were less prevalent (6.9%).

In Lithuania, weed damage is evaluated in scores (from 1 to 10). Control of weeds becomes necessary when malignancy of weeds prevailing in crops reaches 4-10 on the scale (Spokiene & Povilioniene, 2003). During the final rotation year, damage in spring cereals was in the 4-10 range, and malignancy reached 86.5%; in winter cereals, it was 57.7%. When evaluating the effect of winter crops it could be said that increasing the prevalence of winter cereals in the crop structure to 75% especially including those that have a stronger ability to choke out weeds, would diminish the damage to crops, because they would limit the spread of perennial and other damaging weeds.

Effect of soil tillage systems on weed incidence in cereals. According to the total and annual weed average during crop rotation investigated, the soil tillage systems

didn‘t affect the incidence of weeds during their tilling stage. However, with reduced soil tillage, there were 2.1 times more perennial weeds, but the air-dried biomass of weeds in the end of crop growing was 42.3% larger, compared with conventional tillage (Table 1). During the final year of rotation, because of reduced soil tillage the average in the cereals was 2.4 times, and in spring cereals - 3.6 times, but in winter cereals - 35.7% more of perennial weeds, than in conventional tillage (Table 2). The air-dried biomass of weeds, using reduced soil tillage system at the end of crop rotation average made 54.2 g m^{-2} and was 44.5% larger, in comparison with conventional tillage. After evaluating the effect of the reduced soil tillage on the weed incidence, one could say that reduced tillage is more suitable for winter cereals, that have a more powerful choking power against weeds, than for the spring crops.

Table 2. Effect of soil tillage on weed changes in cereal crops over four-year rotation. Average data in 1999 and 2002.

Soil tillage system	Cereals	Weeds m^{-2}					
		total number		annual		perennial	
		crop rotation year					
		first	final	first	final	first	final
Conventional	spring	57.4	94.4	55.5	88.1	1.9	6.3
	winter	62.5	145.5	62.1	134.3	0.4	11.2
	averaged	59.5	114.9	58.1	106.6	1.4	8.3
Reduced	spring	62.9	107.6	56.1	85.0	6.8	22.6
	winter	64.7	129.8	61.7	114.6	3.0	15.2
	averaged	63.6	116.4	58.3	96.8	5.3	19.6

CONCLUSIONS

When increasing the proportion of winter cereal crops in the structure of crop rotation, annual weeds are more extensive than perennials. Crop rotations with prevailing winter crops as a means for decreasing weed incidence became most effective when they choked out the more damaging and especially the perennial weeds.

Reduced soil tillage caused a marked outspread of perennial weeds in the cereals and an increase in weed biomass, in comparison with conventional soil tillage. The outspread of perennial weeds, when employing reduced soil tillage, was smaller in winter cereals than in spring ones, because winter crops were choking weeds more effectively.

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