Agronomy Research **4**(Special issue), 353–357, 2006

The influence of short crop rotations on weed community composition

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Abstract. Field experiments were designed to evaluate the effect of crop rotations on weed density and species composition. An 8-year study was initiated in Dotnuva (Lithuania) in 1997 on an Endocalcari-Endohypogleyic Cambisol. Ten crop rotations: peas–winter wheat–sugar beet–spring barley, peas–winter wheat–spring barley, peas–winter wheat-winter wheat, sugar beet-spring barley-winter wheat, sugar beet-peas-winter wheat, sugar beet-spring barley-peas, sugar beet-spring barley-spring rape, peas-winter wheat, sprig barley-sugar beet, winter rape-winter wheat and spring barley monocrops were investigated. It was revealed that weed densities varied between rotations. In winter wheat crops in all crop rotations the density of *Fallopia convolvulus* was high but there was less *Lamium purpureum, Myosotis arvensis* and *Stellaria media* at the end than at the beginning of crop rotations. The density of *Elytrigia repens* was high in most crop rotations investigated. The exception was crop rotations where sugar beet was involved, compared to a four-course rotation. The largest total of annual and perennial weeds was recorded in winter wheat, when the crop was grown after peas and winter rape. In all crop rotations, in the stands of spring barley the amount of *Lamium purpureum, Tripleurospermum perforatum* and *Taraxacum officinale* was 13–18% lower compared with the spring barley monocrop. Annual broad-leafed weeds in the spring barley monocrop were more numerous than in a four-course rotation but less numerous than in the other crop rotations.

Key words: crop rotation, monocrop, weed density, species

INTRODUCTION

Crop rotations that alternate different crop species generally interrupt disease and weed growth cycles, thus improving crop yields (Karlen et al., 1994). Weed populations were more influenced by the preceding crop and by the timing of herbicide application than by the tillage system (Thomas et al., 1996; Streit et al., 2003). Crop rotation is an effective tool for weed management by changing the pattern of disturbance, which diversifies selection pressure. This diversification prevents the proliferation of weed species well suited to the practices associated with a single crop (Buhler, 2002). By extending the area of cereals from 50% to 100 %, weed weight in barley stands increased 3 times and the number of weeds by 1/3 (Petrauskas, 1999). In the crop rotations with 50, 67, 83 and 100% of cereals, 33.0, 37.2, 33.8 and 39.8 weeds m^{-2} were found in winter wheat before harvesting; their weight corresponded to 15.6, 16.4, 13.5 and 19.1 g m^{-2}, respectively (Magyla, 1997). The lowest weed incidence was found in wheat grown after peas: an average number was 20.4 weeds m^{-2}, and weed weight was 42.2 g m^{-2} (Petrauskas, 1999). Continuous cropping generally results in the least diversity in weed species, whereas crop rotation usually increases weed diversity (Liebman & Dyck, 1993). Continuous winter wheat facilitated a dense downy brome infestation to develop over time (Blackshaw et al. 2001).

The aim of this investigation was to study the influence of short crop rotations on weed community composition in the stands of winter wheat and spring barley.

MATERIALS AND METHODS

Research on the shortening of crop rotations was conducted at the Lithuanian Institute of Agriculture in Dotnuva during the period of 1997–2004. The soil of the experimental site is Endocalcari-Endohypogleyic Cambisol. The experiment was composed of 10 short crop rotations (2–4 courses) and two monocrops. In total 30 rotations-members (Table 1).

Table 1. Experimental design.

Crop rotation No.	Course No. and plant species	Crop rotation No.	Course No. and plant species	Crop rotation No.	Course No. and plant species
I	1. Peas 2. Winter wheat 3. Sugar beet 4. Spring barley	II	1. Peas 2. Winter wheat 3. Spring barely	III	1. Peas 2. Winter wheat 3. Winter wheat
IV	1. Sugar beet 2. Spring barley 3. Winter wheat	V	1. Sugar beet 2. Peas 3. Winter wheat	VI	1. Sugar beet 2. Spring barley 3. Peas
VII	1. Winter oilseed rape 2. Winter wheat	VIII	1. Peas 2. Winter wheat	IX	1. Sugar beet 2. Spring barley 3. Spring oilseed rape
X	1. Spring barley 2. Sugar beet	XI	Sugar beet (mono culture)	XII	Spring barley (mono culture)

Two monocrops (sugar beet and s. barley) were continuously grown for four years. For an additional four-year cycle the plots of monocrops were counter changed.

Plot size in cereals was 45.5 m^2. The plots were replicated four times. Replication treatments were arranged randomly. Only mineral fertilisers were applied: for wheat - $N_{80}P_{40}K_{30}$, barley -$N_{70}P_{40}K_{30}$, peas -$P_{40}K_{40}$, sugar beet - $N_{150}P_{60}K_{120}$, winter oilseed rape -$N_{120}P_{60}K_{90}$, and for spring oilseed rape -$N_{90}P_{60}K_{60}$. Phosphorus and potassium fertilisers were applied in the autumn, before ploughing; nitrogen was applied in spring.

Herbicides were used for all crops. Winter wheat and spring barley were sprayed with Granstar (15 g ha^{-1}) mixed with Starane (0.4 l ha^{-1}). Weed biomass (number and air-dry weight of weeds) was assessed at ripening stage (BBCH 73). The assessments were made using a 0.25 m^2 frame by picking weeds in four places for each replication.

Analyses of variance were performed to test the treatment effect by using the standard ANOVA test, completed by Statistica 5.0. Weed weight data were transformed to $Y = \sqrt{x+1}$.

RESULTS AND DISCUSSION

During the 1997–2004 periods the number of weeds depended on the shortening of crop rotations, specificity of preceding crops and on meteorological factors.

In the rainy years of 1998 and 2000 the number of weeds identified in winter wheat crops at ripening stage was on average 28.8 weeds m^{-2} and 26.1 weeds m^{-2}, respectively, and in the dry year of 1999 – 6.7 weeds m^{-2}.

Table 2. Weed composition in crop rotations, (weeds m^{-2}), in 1997–2004.

Crop	Weed species							Total	Air-
Rotations[x]	*Viola arvensis*	*Fallopia convolvulus*	*Tripleurospermum perfor.*	*Veronica arvensis*	*Cirsium arvense*	*Elytrigia repens*	Other	amount m^{-2}	dry weight g m^{-2}
P-**W**-SB-B	3.9[1]	0.3	1.5	1.1	0.2	1.1	6.2	14.3	3.9
	0.6[2]	1.7	0.2	0.6	0.2	1.0	2.1	6.4	1.1
P-**W**-B	5.6	0.2	1.4	1.6	0.0	0.9	5.7	15.1	7.3
	4.2	0.5	0.2	0.6	0.7	3.7	4.3	14.2*	4.7
P-**W**-W	7.8	0.3	2.4	1.3	0.1	3.3	6.3	21.5*	7.0
	6.6	0.3	0.2	1.0	1.0	8.3	5.3	22.7**	6.7*
P-W-**W**	3.8	0.8	0.9	7.3	1.2	3.6	12.5	30.1**	10.9**
	4.8	6.0	0.4	6.0	0.2	5.6	8.4	31.4**	7.3*
SB-B-**W**	3.8	0.2	1.0	2.6	0.3	0.3	5.0	13.2	5.8
	4.0	0.3	0.1	2.0	0.2	0.5	4.6	11.7	3.1
SB-P-**W**	2.7	0.2	1.6	2.1	0.1	0.4	5.4	12.5	4.1
	2.0	0.3	0.7	1.1	0.4	0.7	4.0	9.2	2.0
WR-**W**	7.9	0.2	0.6	2.4	0.2	8.3	5.9	25.5**	13.8**
	5.9	0.4	0.4	1.0	0.2	9.1	4.9	21.9**	10.4**
P-**W**	1.8	1.8	1.2	2.1	0.2	3.5	7.4	18.0	5.9
	4.6	2.2	1.4	1.4	0.3	5.5	4.3	19.7**	6.3*
P-W-SB-**B**	2.6	0.4	1.2	3.5	0.2	0.1	7.5	15.5	1.9
	0.5	1.8	0.0	1.4	0.3	0.8	2.5	7.3	1.5
P-W-**B**	0.7	1.6	1.6	3.7	0.6	4.4	7.9	20.5*	3.8
	0.8	1.8	1.2	1.8	0.5	4.8	6.9	17.8**	2.9
SB-**B**-W	1.4	0.7	0.7	3.4	0.2	0.0	8.5	14.9	1.4
	1.4	0.8	0.7	4.2	0.2	0.0	6.4	13.7*	1.0
SB-**B**-P	0.8	1.4	1.2	2.1	0.4	0.2	6.2	12.3	1.7
	0.7	1.9	1.0	1.7	0.5	0.1	6.2	12.1	1.1
SB-**B**-SR	0.4	1.8	1.3	3.0	0.1	0.7	9.9	17.2	2.0
	0.3	2.0	0.2	3.6	0.8	1.5	11.0	19.4**	2.4
B-CB	0.3	0.6	0.8	4.4	0.1	0.2	9.4	15.8	1.4
	0.3	0.5	0.6	3.5	0.1	0.1	7.6	12.7*	1.0
B	0.3	0.5	1.3	4.2	0.1	0.8	10.4	17.6	1.8
	0.4	0.4	0.0	1.3	0.4	1.0	4.4	7.9	2.4

[1]- Weed incidence at the beginning of rotations, [2]- the weed incidence at the end of rotations; *, ** - differences significant at 5 %, 1 % level, respectively.

[x] – Rotations are indicated using the first letters of crops: W – wheat, B – barley, P – pea, SB – sugar beet, WR – winter rape, SR – spring rape.

According to averaged experimental data, the number of weeds significantly increased in the crop rotation P-W-W composed solely of wheat, in which 2/3 of the total crop area was occupied by spiked cereals (Table 2).

At the end of rotations a similar weed infestation level was identified for the two-course crop rotation winter oil-seed rape-wheat, in which the number of weeds was 21.9 weeds m^{-2} and air-dry weight amounted to 10.4 g m^{-2}.

When alternating winter cereals with spring cereals, the number of weeds and species diversity of separate weeds declined by up to 25% (Hald, 1999). When wheat was grown after barley (IV three-course crop rotation) the number of weeds at the end of the rotation was accordingly 19%, 47% and 63% lower, and air-dry weight of weeds was lower by 26.2%, 70.2% and 57.5% compared with wheat growing after peas, winter rape or as a monocrop.

The following species among the short-lived weeds prevailed in the winter wheat stand: *Viola arvensis* L., *Fallopia convolvulus* (L.) Löve, *Tripleurospermum perforatum* Merat) M. Lainz, *Veronica arvensis* L., *Stellaria media* L., *Polygonum aviculare* L. Among perennial weeds *Elytrigia repens* (L.) Nevski prevailed; less abundant were *Cirsium arvense* (L.) Scop., *Stachys palustris* L.

During spring barley ripening stage the largest number of weeds (35.9 weeds m^{-2}) was recorded in the extremely wet year of 2000, whereas the least number of weeds (5.1 and 6.4 weeds m^{-2}) was identified in the warm years of 1997 and 1999. Among the short-lived weeds the following species prevailed in s. barley: *V. arvensis*, *F. convolvulus*, *T. perforatum* and *S. media*. Among the perennial weeds the most prevalent species in the crop rotations were *E. repens* and *Taraxacum officinale* F.H.Wigg; less prevalent were *C. arvense*, *S. palustris*, and the least prevalent was *Plantago major* L. When increasing the area of cereal grown in the crop rotation (peas-wheat-barley and sugar beet-barley-wheat), the number of weeds in the stand of barley increased significantly. However, when barley was grown as a monocrop (after 4 years of sugar beet monocrop) the number of weeds was 7.9 m^{-2} and the air-dry weight was 2.4 g m^{-2}. Our results agree with those obtained by other researchers (Petrauskas, 1999).

CONCLUSIONS

By increasing cereal area in a crop rotation from 33 to 50 and 67 %, the weed incidence in winter wheat tended to increase. Short rotations with peas or winter rape as preceding crops of winter cereals are less favourable for weed control. Spring barley grown in a crop rotation composed of 2/3 of spiked cereals was the most heavily weed-infested. Inclusion of spring rape in the crop rotations was adverse in terms of weed reduction in barley.

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