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THE INFLUENCE OF SHORT CROP ROTATIONS, MONOCROP AND REDUCED SOIL TILLAGE ON WEED POPULATION DYNAMICS

Vytautas SEIBUTIS, Virginijus FEIZA

Lithuanian Institute of Agriculture
Instituto al. 1, Akademija, Kėdainiai distr., Lithuania
E-mail: vytautas@lzi.lt

Abstract

The field experiment was conducted at the Lithuanian Institute of Agriculture in Central Lithuania from 2006–2007 to determine the influence of short crop rotations and reduced soil tillage on weed population dynamics. The treatments were as fallows: Factor A – soil primary tillage systems: 1. Conventional (ploughing). 2. Stubble cultivation to 10–12 cm depth. Factor B – short crop rotations: 1. Spring oil-seed rape-spring barley-winter wheat. 2. Winter wheat-spring rape. 3. Winter wheat (monocrop).

The experimental results revealed that weed densities varied either between crop rotations or between different soil tillage systems used. The application of reduced tillage was found to have successively increased the total number of annual and perennial weeds. By applying reduced tillage, the highest weed incidence was noted in the stands of spring oil-seed rape and winter wheat (three-course crop rotation) where the number of weeds increased on average by 287 and 176%, respectively, compared to conventional tillage. Renouncement of conventional tillage in the two-course crop rotation for spring oil-seed rape crop and winter wheat monocrop led to an increase in the total number of weeds on average by 157 and 116%, respectively.

The total number of weeds in stubble cultivation treatments before herbicide application was higher by 21% and before harvest 42% as compared to conventional tillage. In the crop rotation (winter wheat-spring rape) the quantity of short-lived weeds increased by 43%, compared with the three-course crop rotation and monocrop. Ploughing increased the total weed population in spring barley (three course-crop rotation) and winter wheat stand (two-course crop rotation) before harvest on average by 153 and 115%, respectively.

Key words: weeds, short crop rotations, monocrop, soil tillage.

Introduction

Crop diversification provides more control opportunities and disrupts the life cycle of weeds and thus their reproductive potential. Crop rotations including cereal and oilseed crops allow for greater herbicide choice over years. Annual and perennial forages, especially when grown in rotation with annual grain crops, can be an effective strategy to reduce weed populations. Different crops are naturally planted at different times of the year and this can significantly affect weed populations. Systematically changing planting dates and crop species prevents any one weed species from developing into a major problem /Derksen et al., 2002/.

Tillage has been a major agricultural weed control technique for several decades, so the development of conservation tillage systems that advocate no-tillage or reduced tillage has significant implications for growers. Tillage affects weeds by uprooting, dismembering, and burying them deep enough to prevent emergence, by changing the soil environment and so promoting or inhibiting the weeds germination and establishment, and by moving their seeds both vertically and horizontally /Clements et al., 1996; Hatzler, Owen, 1997/. Crop rotation may be an effective practice for controlling serious weeds because it introduces conditions that affect weed growth and reproduction, which may greatly reduce weed density /Derksen et al., 1993; Blackshaw et al., 1994/. A long-term rotation study that compared continuous winter wheat production with winter wheat grown in rotation with canola, flax, or fallow found that the major difference in weed populations was between monoculture winter wheat and the more diverse rotations /Blackshaw et al., 2001/. Therefore, the practice of rotating crops and herbicides has proved to be successful in influencing weed populations and improving crop production /Al-Issa, Samarah, 2006/, and given the increased attention paid to agroecosystem biodiversity, adopting weed management strategies that promote weed species diversity could be encouraged /Clements et al., 1994/. 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 /Velykis, Satkus, 2006/.

The objective of the research is to estimate the influence of short crop rotations and reduced soil tillage on the incidence of weeds.

Materials and Methods

Site and soil description. The stationary field experiment set up in 2005 is located at the Lithuanian Institute of Agriculture in Dotnuva. The soil of the experimental site is a sandy loam *Endocalcari-Endohypogleyic cambisol,* with a content of humus of 2.05–2.65%, available phosphorus 157 mg kg^{-1} and potassium 254 mg kg^{-1} of soil, ph 7.0–7.5.

Experimental design. Experiments were performed according to the following design: Factor A – soil primary tillage systems: 1. Conventional tillage system: autumn ploughing (20–22 cm depth) with a reversible 4-body "Kverneland" plough in combination with a compactor. Pre-sowing tillage: shallow seed bed preparation with KLG-4.0 (2–5 cm depth). 2. Autumn stubble cultivation (10–12 cm depth) with a stubble cultivator "Rau-5" consisting of disc coulters in combination with a heavy spiked roller; Factor B – short crop rotations: 1. Spring rape-spring barley-winter wheat; 2. Winter wheat-spring rape; 3. Winter wheat (monocrop).

The experiment involved the following crops: spring rape (*Brasica napa* L.) cv. 'Maskot', seeding rate 6.0 kg ha^{-1}, spring barley (*Hordeum vulgare* L.) cv. 'Luokė', seeding rate 4.0 million seeds ha^{-1}, winter wheat (*Triticum aestivum* L.) cv. 'Širvinta', seeding rate 4.5 million seeds ha^{-1}. All crops were grown every year in four replicates. Winter wheat stands were sprayed at BBCH 25–29 with Granstar 0.015 g ha^{-1} (Tribenuron methyl 750 g a.i. l^{-1}) and mixture with Starane 0.4 l ha^{-1} (fluroksipir 180 g. a.i. l^{-1}), spring barley – at BBCH 28–30 with Duplosan Super 1.2 l ha^{-1} (mekoprop-P + MCPA + dichlorprop-P 130 + 160 + 310 g a.i. l^{-1}), spring rape – at BBCH 11–14 with Butisan 400 2.5 l ha^{-1} (metazachlor 400 g a.i. l^{-1}).

Experimental methods and assessments. The number of weeds and species was determined during each year after crop emergence, prior to herbicide application and before harvesting. Weed biomass dry weights were recorded before harvesting. Assessments were done in 0.25 m^2 fixed plots, in four places per plot. The data of the number and mass of weeds for evaluation of statistically significant differences were transformed according to the formula: $Y=\sqrt{x+1}$ The experimental data were processed by ANOVA (* – 95 %, ** – 99 % probability level) /Tarakanovas, Raudonius, 2003/.

Results and Discussion

At the beginning of the trials (2006) weed incidence in spring barley crop in conventional tillage and stubble cultivation systems was identified by 3.2 and 2.3 times less, than in 2007, when spring barley was grown after spring rape (Figure1). Our previous field trial showed that short rotations when at least one course in the rotation sequence was oil-seed rape are less favourable for weed control /Seibutis, Deveikytė, 2006/.

The weed flora in both tillage systems was dominated by annual weeds (4–11 species) as compared with the perennial (0–3 species) weeds. In all crops (spring rape, spring barley, winter wheat) among the short-lived weeds the following species prevailed: *Chenopodium album* L., *Sinapis arvensis* L. *Viola arvensis* Murr., *Fallopia convolvulus* L., *Galium aparine* L. Among perennial weeds *Cirsium arvence* (L.) Scop., prevailed, less abundant were *Sonchus arvensis* L., *Elytrigia repens* L. and the lowest occurrence was recorded of *Stachys palustris* L. According to literature /Rusu et al., 2006/ the maximum weed densities in the crop rotation were recorded in the case of perennial dicotyledonous weeds (C*onvolvulus arvensis* and *Cirsium arvense*).

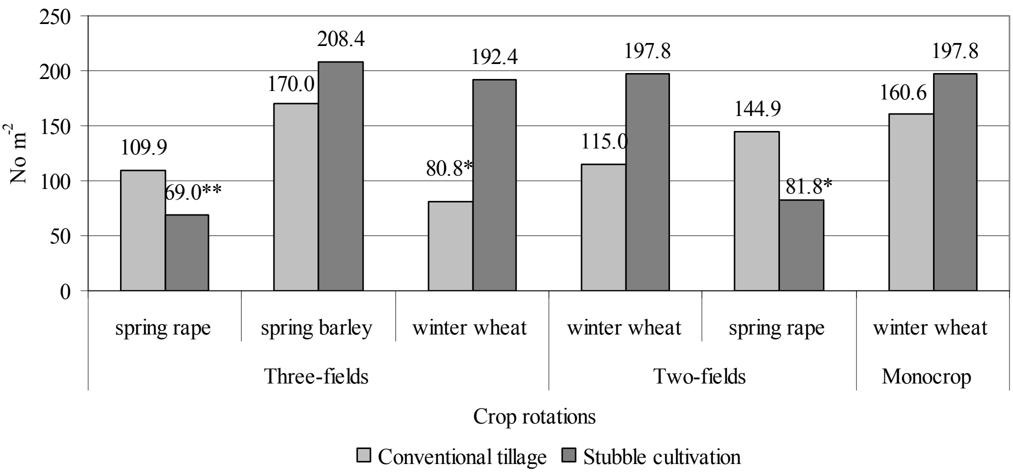

Figure 1. Weed density in different short crop rotations before herbicide application, * – significant at P < 0.5; ** – significant at P < 0.1

Experimental data revealed that the total number of weeds in stubble cultivation treatments before herbicide application was higher by 21% and before harvest 42% as compared to the conventional tillage. Nakamoto et al. (2006) argues that he amount of weed increased in minimum soil tillage system treatment, compared with the conventional system (annually ploughed plot).

In 2006–2007, the quantity of short-lived weeds in the three-course crop rotation and monocrop was very similar in conventional (ploughing) cultivation system, except for the two-course crop rotation. In the mentioned crop rotation (winter wheat-spring rape) the quantity of short-lived weeds increased by 43%, compared with the three-course crop rotation and monocrop (Figure 2).

The largest differences in short-lived weeds' infestation between crop rotations were in the stubble cultivation treatment. The highest short-lived weed incidence was noted in all spring rape crops.

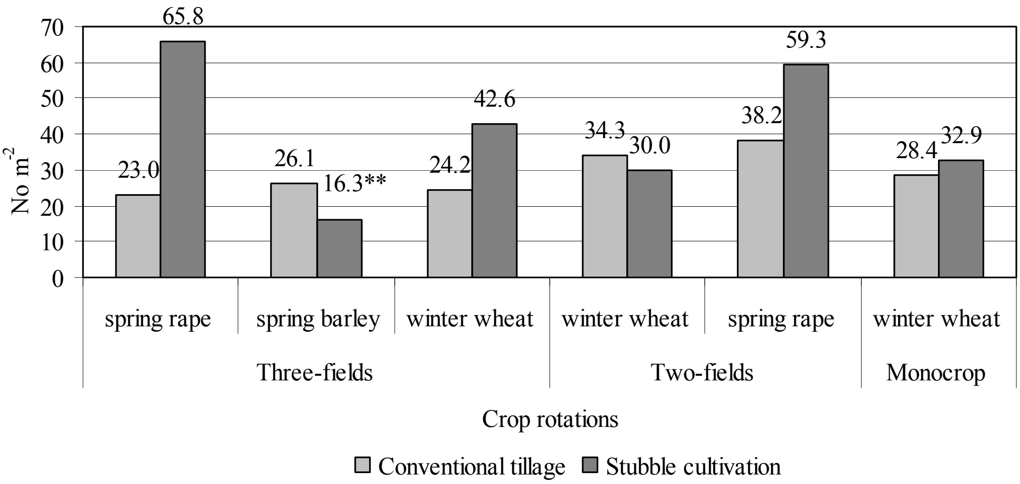

Figure 2. The quantity of short-lived weeds in different short crop rotations before harvest, * – significant at P < 0.5; ** – significant at P < 0.1

Ploughing increased the total weed population in spring barley and winter wheat stand (two crop rotations) on average by153 and 115%, respectively. Similar data can be found in literature. Ploughing increased the population of annual weeds compared to reduced tillage systems, density and air-dry weight of perennial weeds in spring wheat and spring rape were significantly higher under direct drilling than after ploughing /Deveikytė et al., 2006/.

Perennial weeds were more abundant in the reduced tillage treatment than in the ploughed soil (Figure 3). Researchers determined that long-term reduced soil tillage increased weed infestation (15.1–26.0%) in barley crop /Stancevičius et al., 2003/. Our experiment suggests that the perennial weed density was the highest in spring barley, (when spring barley was grown after spring rape), spring rape crops and in winter wheat monocrop.

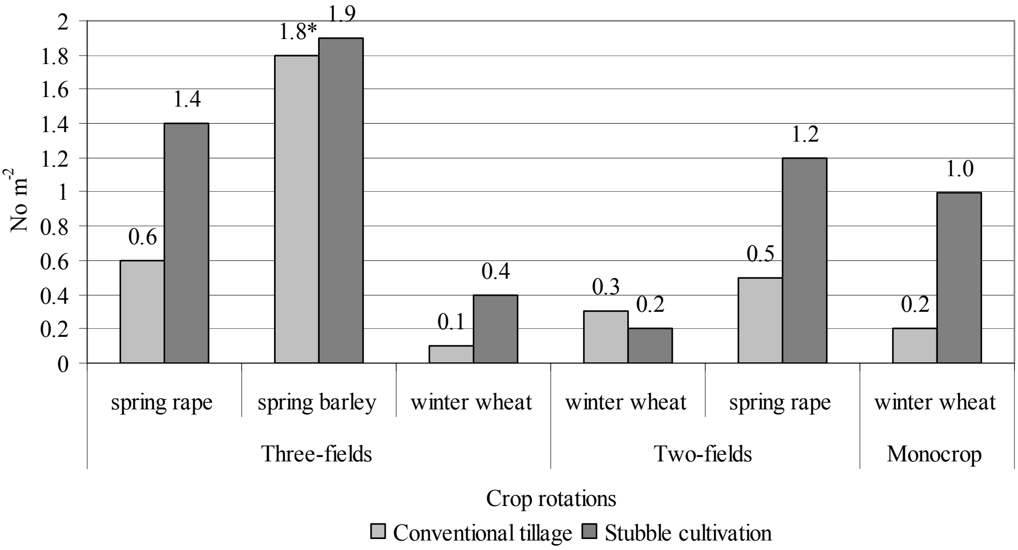

Figure 3. The quantity of perennial weeds in different short crop rotations before harvest, * – significant at $P < 0.5$; ** – significant at $P < 0.1$

Averaged experimental data from the 2006–2007 period indicate that among all the crops the absolutely highest air-dry weight of weeds was recorded in spring rape stand, and varied between 20.2 – 41.6 g m^{-2} (Figure 4).

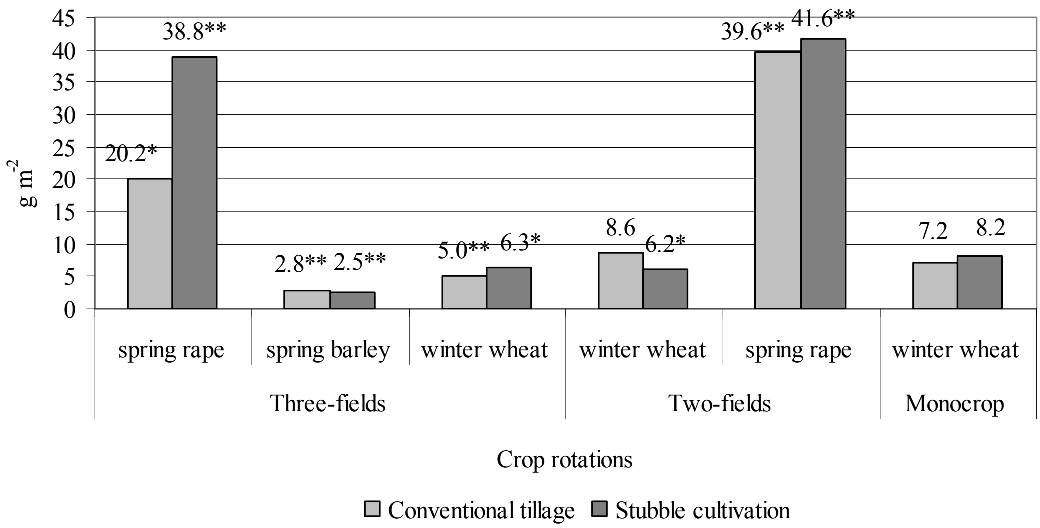

Figure 4. Weed air-dry weight in different short crop rotations before harvest, * – significant at $P < 0.5$; ** – significant at $P < 0.1$

However, in the rest of the crops the air-dry weight of weeds either in a deep ploughed or in a shallow cultivated soil was found similar and varied from 2.8 to 8.6 g m^{-2}.

Conclusions

1. The total number of weeds in stubble cultivation treatments before herbicide application was higher by 21% and before harvesting by 42% as compared to conventional tillage.

2. In the crop rotation (winter wheat-spring rape) the quantity of short-lived weeds increased by 43%, compared with the three-course crop rotation and monocrop.

3. The highest density of perennial weeds was in spring barley, (when spring barley was grown after spring rape), spring rape crops and in winter wheat monocrop.

4. Ploughing increased the total weed population in spring barley (three course-crop rotation) and winter wheat stand (two-course crop rotation) before harvest on average by 153 and 115%, respectively.

5. The total density and air-dry weight of weeds in spring rape were significantly higher either in a deep ploughed or in a shallow cultivated soil.

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