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# The influence of tillage system on diversities of soil weed seed bank

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**Abstract.** Field experiments with different soil tillage systems were conducted in 2003–2006 at the Lithuanian Institute of Agriculture. Investigations to evaluate effects of soil tillage regime on weed seed bank and distribution in the soil layers were made after four years of experimentation. A total of 17 weed species were found in the soil seed bank; 98 % - annual dicotyledonous. The most abundant weed species in the seed bank were *Chenopodium album*, *Lamium purpureum* and *Stellaria media.* The highest number of weed seed species was found in treatments with reduced and no-tillage treatments in a soil layer of 0–5cm. In deeper soil layers, 5–10, 10–20, no differences in species number of weed seeds were found.

**Key words**: tillage, soil seed bank, diversity

## INTRODUCTION

Weeds are a problem in most cropping systems; their control is essential for successful crop production. The goal of weed control is not only to preserve plants from yield loss, but also to minimize weed seed reserve in the soil. Tillage and herbicides are used for weed control, but the degree of control achieved may vary widely depending on weed species present, soil type, climatic condition, tillage method, etc. Thus, weed control often varies among locations and years (Derksen et al., 1993).

The weed seed bank develops in two ways: it increases in amount from those weed seeds which mature weed plants spread by wind and running water into soil, and decreases by the amount which germinates or is lost due to activity of soil fauna. Knowledge of the weed seed bank is crucial because it provides evidence of past field management and may allow forecasting future weed problems (Forcella, 1992).

The composition of a weed seed bank represents not only the coming weed flora but also the past – the history of the weed flora. The dates of the investigations of the weed seed bank show weed diversity better than does assessment of germinated weed, because some weeds are destroyed through agricultural practice (Jones, Maulden, 1999). Changes in the soil weed seed reserve depend on soil tillage, crop rotation, and implements of weed control. The influence on the weed seed bank in arable cropping systems of soil cultivation regime, crop rotations, fertilizer have been investigated (Cardina et al., 1996; Clements et al., 1996, Barberi et al., 1997; Barberi & Casio, 2001; Menalled et al., 2001; Benoit et al., 2003; Riemens et al., 2007).

Long-term cultivation and differing tillage systems produce important changes in the composition and density of soil seed banks (Lewis & Leguizamon, 1991; Cardina et al., 1991; Boccanelli & Lewis, 1994). The effect of different tillage systems becomes evident quickly. One point of view: different tillage systems rapidly produce differences in the density and composition of the soil seed bank and systems causing less soil disturbance allow the build up of larger and more diverse soil seed banks (Blackshaw et al., 1994; Buhler et al., 1994; Feldman et al., 1997). Others claim that most seeds are near the soil surface and the tillage method does not affect seed numbers (Unger et al., 1999), that weed control shows more influence than tillage system on weed seed bank size (Barberi et al., 1998), but weed community composition in the surface (0–15cm) layer seems more influenced by tillage system than by crop rotation (Barberi & Cascio, 2001). Under conventional soil tillage weed seeds are typically distributed homogeneously within the tilled layer (Ball, 1992), nonetheless in the organic system more than 48% of the total weed seed bank was concentrated in the upper 10 cm of the soil (Barberi et al., 1998).

The experiments reported in this paper have explored the effects of the tillage system on the distribution and diversity of soil seed banks. Investigation of weed seed banks in such a manner is new in Lithuania.

## MATERIALS AND METHODS

Stationary field experiments were conducted in 2003–2006 at the Lithuanian Institute of Agriculture in Dotnuva. The sequence of crops in rotation was the following: 1) field pea 2) winter wheat 3) spring wheat 4) spring barley. Soil was prepared according to the following trial design:

1. Stubble cultivation to 10–12 cm depth with mould board ploughing to 22–23 cm depth; tillage with precision seedbed cultivator before sowing, sowing with disc coulters drill "Saxonia" (CT);
2. Stubble cultivation to 10–12 cm depth; tillage with precision seedbed cultivator before sowing, sowing with disc coulters drill "Saxonia"(RT1);
3. Stubble cultivation to 10–12 cm depth; sowing with disc sowing aggregate DS-3 (RT2); non-selective herbicide (glyphosate) spray applied after harvesting.
4. No tillage; sowing with disc sowing aggregate DS-3 (NT1), non-selective herbicide (glyphosate) spray applied after harvesting.
5. No tillage; direct sowing with sowing aggregate 'Amazone' with rotary cultivator (NT2), non-selective herbicide (glyphosate) spray applied after harvesting.

The field experiment was arranged as a complete randomized block design in four replicates. Gross plot size was 10 x 20 m and net harvested plot size - 2.3 x 10 m. Herbicide Roundup Classic 3.0 L $ha^{-1}$ with 150 L $ha^{-1}$ water after harvesting when weeds and volunteer cereals germinated was used. Soil in the trial location is *Endocalcari-Endohypogleyic Cambisols*, sandy loam. Soil samples to determine the soil seed bank were taken in year 2006 in the beginning of the cereal growing season. Two soil cores of 20 cm depth (0–5, 5–10, 10–20cm) were randomly taken from each plot, using a 5cm diameter steel probe. Consequently, a total of 240 soil samples were collected for weed seed bank analysis. Samples were stored at 4$^{o}$C in the dark until processing (Lambelet & Haueter, 1984; Barberi & Cascio, 2001). Soil samples were

placed into sieves (screen size 0.25 mm) and soaked in water for 10 minutes to soften the soil. After soaking, the soil was placed under running tap water and hand manipulated to remove fine soil particles. After washing, the remaining contents were dried on filter paper in glass Petri dishes. The dried samples were passed through sieves with screen size ranging from 1.6 to 0.5 mm and the contents of each sieve were analysed. Weed seeds were counted and identified using a binocular with 8x magnification. Seed viability was determined by 'destructive crushing' of seed, using forceps during the extraction procedure (Rahman et al., 1995) Analysis of variance (ANOVA) was conducted on data (Tarakanovas & Raudonius, 2003).

## RESULTS AND DISCUSSION

A total of 17 species was recorded in the seed bank; 98 percent of seeds were annuals. The prevailing life cycle and relative density in the total seed bank of all weed species are shown in Table 1.

**Table 1.** Seed bank composition expressed as percentage of total weed seeds extracted at 0–5; 5– 10, and 10–20cm depth.

| Species | Soil layer, cm | | |
|---|---|---|---|
| | 0–5 | 5–10 | 10–20 |
| *Capsella bursa-pastoris* (L.) Medik. | 0.1 | 0.0 | 0.0 |
| *Chaenorhinum minus* (L.) Lange | 0.1 | 0.0 | 0.0 |
| *Chenopodium album* L. | 33.4 | 39.4 | 45.8 |
| *Cirsium arvense* (L.) Scop. | 1.3 | 0.6 | 0.4 |
| *Euphorbia helioscopia* L. | 0.2 | 0.1 | 0.0 |
| *Fallopia convolvulus* (L.)À. Löve | 0.4 | 1.4 | 0.7 |
| *Galium aparine* L. | 3.1 | 2.1 | 3.1 |
| *Lamium purpureum* L. | 26.9 | 25.4 | 22.0 |
| *Lapsana communis* L. | 2.4 | 3.6 | 0.4 |
| *Polygonum aviculare* L. | 0.1 | 0.0 | 0.0 |
| *Silene vulgaris* (Moench) Garcke | 0.3 | 0.4 | 0.4 |
| *Sonchus arvensis* L. | 0.5 | 0.1 | 0.0 |
| *Stellaria media* (L.) Vill. | 23.1 | 19.2 | 14.8 |
| *Thlaspi arvense* L. | 0.9 | 1.7 | 2.4 |
| *Tripleurospermum perforatum* (Merat.)M.Lainz. | 0.1 | 0.4 | 0.0 |
| *Veronica hederifolia* L. | 2.3 | 3.3 | 7.1 |
| *Viola arvensis* Murray | 3.6 | 2.3 | 3.0 |
| Total | 100.0 | 100.0 | 100.0 |

Major weed species included *Chenopodium album* (L.), *Lamium purpureum* (L.), and *Stellaria media* (L.), Vill. These species together accounted for 82.4–84% of the total weed seeds number in the seed bank, regardless of the experiment treatment. The large densities of these weeds in the seed bank indicate possible severe infestations if future weed management is inadequate, similar to the findings of Unger et al. (1999), who observed that the large number of *Amaranthus retroflexus* seeds resulted in high infestations during some years of his study. Other weed species of importance in the seed bank were *Veronica hederifolia* 2.3–7.1% of total seed bank, *Viola arvensis* - 2.3–3.6% and *Galium aparine* 2.1–3.1%. These results are in accordance with previous

studies, which indicated that the seed bank is composed of a few dominant weed species (Uremis et al., 2003). Vasileiadis et al., (2007), stated, that *Amaranthus* sp. was always one of the dominant species. That disagrees with our data; otherwise our data coincide with data of Pilipavicius (2004), who found that *Chenopodium album* and *Stellaria media* were dominant species in the weed seed bank. Most likely the presence of the dominant weed species in the seed bank depends on weed flora in the field.

The number of weed species detected in the seed bank was lower than that observed in studies of Barberi & Casio, 2001; Pilipavicius, 2004, but higher than that observed in those of Vasileiadis et al., 2007.

Weed species number differed among tillage systems, and species abundance decreased with soil depth; the effect was more pronounced in minimum and no tillage plots. The highest number of weed seed species was found in treatments with reduced and no-tillage treatments in a soil layer of 0–5 cm (Fig. 1).

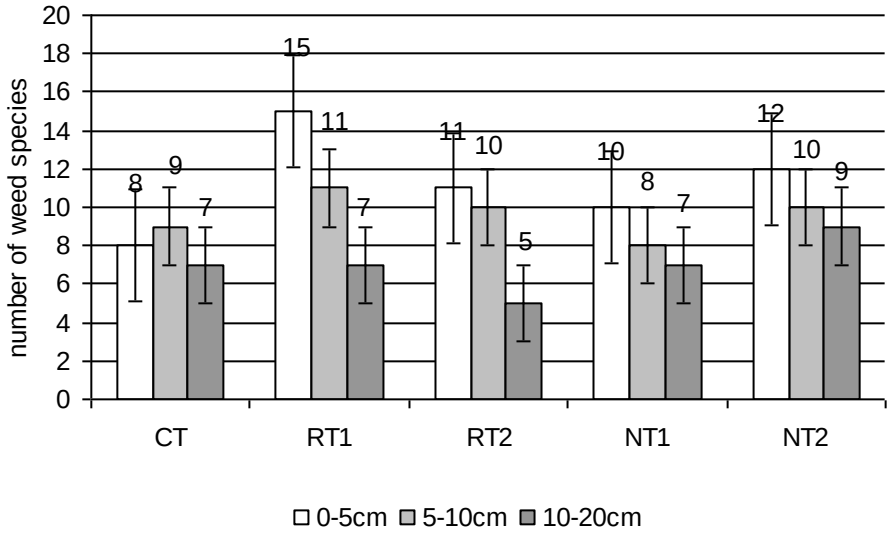


**Fig. 1.** Weed species number and standard deviation in different soil tillage treatments

CT – conventional tillage, 20-25cm depth, RT1 – reduced tillage 10 – 12 cm depth, Disc drill – machine, RT2 - reduced tillage 10 – 12 cm depth, glyphosate treatment NT1 – glyphosate, no- till, disc drill – machine, NT2 – glyphosate, no- till, rotary drill – machine.

In deeper soil layers 5–10, 10–20 cm we did not find any differences in number of weed seeds per species.

The ANOVA analysis showed that the total weed seed number in the seed bank in the soil surface (0–10 cm) and in deeper layers of soil (10–20 cm) were influenced by tillage system - lower total seed densities were found in the conventional tillage system (Table 2).

**Table 2**. Mean seed bank density (seeds $kg^{-1}$ soil) and *log+2* – transformed density (in parentheses) found at two soil depths as affected by tillage regime.

| Treatments | Layer, cm | |
|---|---|---|
| | 0–10 | 10–20 |
| Conventional tillage 20–25cm depth (CT) | 122.5 (2.08)a | 48.4 (1.70) a |
| Reduced tillage 10–12 cm depth, disc drill machine (RT1) | 214.6 (2.31)b | 74.6 (1.87) b |
| Reduced tillage 10–12 cm depth, rotary drill machine (RT2) | 193.3 (2.28)b | 33.9 1.55) c |
| No till disc drill – machine (NT1) | 142.6 (2.16)b | 41.6 (1.64) a |
| No- till, rotary drill – machine (NT2) | 161.5 (2.21)b | 40.1 (1.62)a |
| *SED* | (0.109)** | (0.084)** |

This result is similar to that reported by Barberi et al., 1998, but in contrast to Vasileiadis et al., 2007, who found that higher seed densities were found in the mouldboard plough system. These differences could be attributed to differences in initial density and composition of the seed bank (Vencill & Banks, 1994) and different soil and environmental conditions.

## CONCLUSIONS

1. A total of 17 weed species were found in the soil seed bank; 98 percent - annual dicotyledonous. The most abundant weed species in the seed bank were *Chenopodium album*, *Lamium purpureum* and *Stellaria media* composing more than 80 percent of the total amount of weed seeds.
2. The highest number of weed seed species was found in treatments with reduced and no-tillage treatments in a soil layer of 0–5cm; in more deep soil layers, 5–10, 10–20, no differences in species number of weed seeds were found.

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