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# Non-chemical weed control in sugar beet crop under an intensive and conservation soil tillage pattern: II. Crop productivity

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**Abstract.** The experiment was conducted with a silty loam (*Hipogleyic Luvisol (Calcaric)*) at the Experimental Station of the Lithuanian University of Agriculture during 2004-2005. The soil was of neutral pH, medium rich in humus, phosphorus and with a low content of potassium. The aim of the experiment was to establish the influence of soil tillage intensity, living and straw mulch on sugar beet yield and quality: root ramification, sucrose, sodium, potassium and alpha amino nitrogen contents. The soil of the trial was tilled (factor A) intensively (loosening, ploughing) (IT) and minimally (conservation tillage - loosening) (CT). Non-chemical weed control (factor B) was applied: hand weeding, twice (control variant) (HW); spring barley (SBM), annual ryegrass (ARM), white mustard (WMM), spring oilseed rape (SRM) living mulches and winter wheat straw mulch (WSM).

According to the results of the experiment, at lower temperature and average precipitation vegetation conditions (2004), a significantly higher yield of sugar beet roots was found in intensively tilled soils. In conditions of higher temperatures and uneven rainfall distribution (2005) we observed converse results. Different soil tillage had no significant influence on the quality of the roots; however, sugar beet roots were more ramified in the intensively tilled soil. The allopathic and choking properties of annual ryegrass decreased sugar beet crop yield, sucrose content and increased the amount of sodium in the roots. The highest sugar beet crop productivity was observed in the following conditions: hand weeded, covered by straw or in the plots with oil seed rape living mulch.

**Key words**: non-chemical weed control, intensive and conservation soil tillage, sugar beet crop, mulch, yield, quality

## INTRODUCTION

Reduced primary soil tillage systems have not been investigated enough in Lithuania, especially under non-chemical weed control conditions. Reduced tillage (conservation tillage) may be used for sugar beet crops. Often mouldboard ploughing is changed to discs or chisel ploughing. The mulch of crop residues on the soil surface may reduce evaporation; rainfall may lead to surface hardening. Shallow tillage may reduce yield and/or increase the ramification of sugar beet roots (Draycott, 2006). However, reduction of soil tillage intensity may have no significant influence on the yield of many crops (Ekeberg, 1993; Håkansson et al., 1998; Hao et al., 2001; Ozpinar, 2006; Głąb and Kulib, 2008). Reduced tillage may lead to increased diversity of weed species, weed seed population (Carter and Ivany, 2006) and total weed plant population (Ozpinar, 2006), especially of perennials (Munkholm et al., 1998; Draycott, 2006). In some trials the increase of weed number had a negative influence on crop yield (Børresen, 1993). However, other results have shown the opposite (Campbell et al., 1998).

Living mulches can reduce water runoff and erosion (Babalola et al., 2007). They have also been shown to increase the population of organisms which are natural enemies of some crop pests (Hartwing & Ammon 2002) and control weeds (Hartwing, 1977). Some living mulches compete for nutrients and water with the main crop (Echtenkamp and Moomaw, 1989) and may reduce the yield of crops. Mulches of ryegrass and rape may influence the negative balance of nitrogen in soil , however, clover and mustard shown opposite results (Marcinkeviciene, 2003).

The influence of live mulches in conditions of different soil tillage for sugar beet crop stills has not been investigated in Lithuania. So, the main targets of our tests were to choose species of plants for living mulching and to investigate their influence on sugar beet crop productivity and quality.

## MATERIALS AND METHODS

The experiment was conducted with a silty loam (*Hipogleyic Luvisol (Calcaric)*) (WRB, 2006) at the Experimental Station of the Lithuanian University of Agriculture during 2004–2005. The soil was of neutral pH, medium rich in humus, phosphorus and with a low content of potassium.

The soil of the trial was tilled (factor A) intensively (control variant) (IT) and minimally (conservation tillage) (CT). Non-chemical weed control (factor B) was applied: hand weeding, twice (control variant) (HW); spring barley (SBM), annual ryegrass (ARM), white mustard (WMM), spring oilseed rape (SRM) live mulches and winter wheat straw mulch (WSM).

Sugar beet root yield and quality were determined in samples taken from an area of 3.6 $m^2$ per each treatment plot. Side roots were eliminated from the root-crop and this was cut to analysis length (1 cm diameter). Root-crops were washed. The yield results of clean roots are presented in this article.

The ramification of sugar beet roots was estimated by counting ramified roots in each sample and these were recalculated into percentages. Analyses of sugar beet root quality were made in the laboratory of the Kėdainiai sugar factory (‘Danisco Sugar Kėdainiai’) by the express methods. The trial data were analysed by ANOVA.

The weather conditions during sugar beet vegetations are presented in Fig. 1.

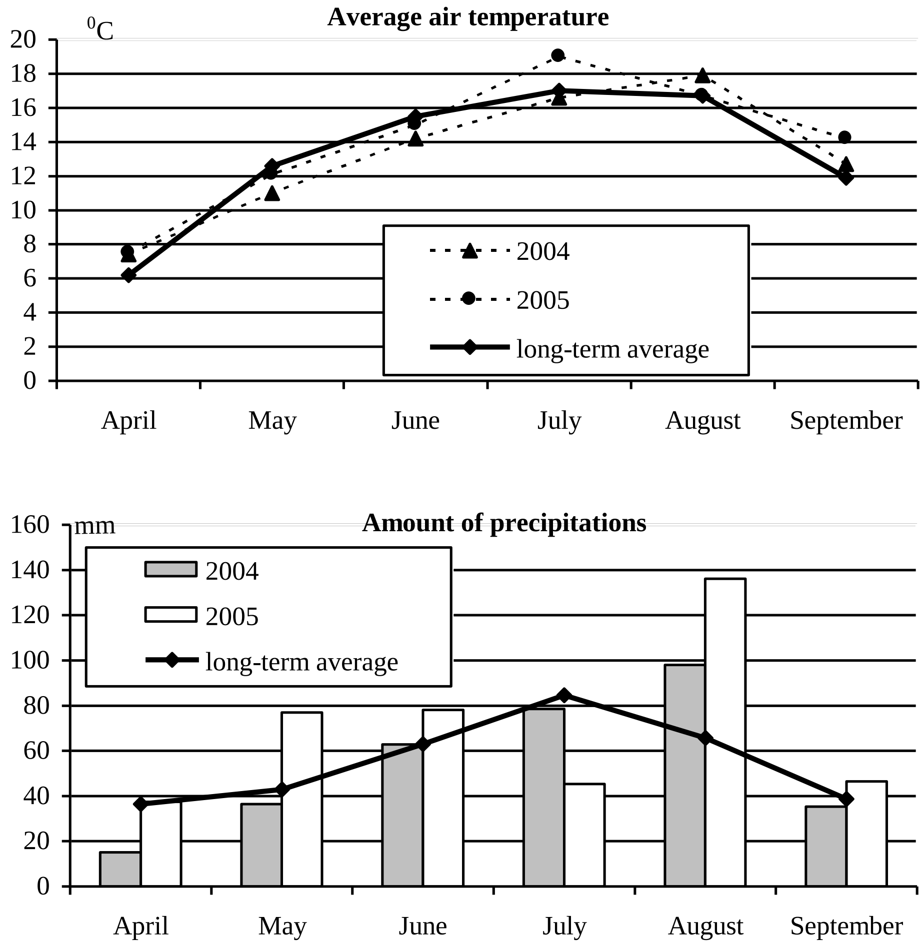


**Fig. 1.** Average air temperature and amount of precipitation during sugar beet cultivation. Kaunas Meteorological Station, 2004–2005.

## RESULTS AND DISCUSSION

In 2004, which was colder and drier than usual, vegetation soil tillage systems had a significant influence on sugar beet root yield. A significantly higher yield was observed in conditions of IT (Table 1). The density of crop varied by up to 160 th. ha$^{-1}$ plants and had no effect on root yield. In Lithuania the usual density of the crop is about 80-90 th. ha$^{-1}$ plants (Romaneckas, 2004) but we increased this for higher beet and weed yields. Different soil tillage methods had no effect on sugar beet roots quality. Similar results of different soil tillage intensity were established in our other trials (Šarauskis et al., 2003; Romaneckas et al., 2006).

**Table 1.** Sugar beet yield and quality under different soil tillage (influence of factor A). Lithuanian University of Agriculture Research Station.

| Treatment | Index | | | | | | |
|---|---|---|---|---|---|---|---|
| | Density of crop th. $ha^{-1}$ | Rootyield t $ha^{-1}$ | Root ramification % | Potassium mmol 100 $g^{-1}$ | Sodium mmol 100 $g^{-1}$ | α -amino nitrogen mg 100 $g^{-1}$ | Sucrose content % |
| | | | | 2004 | | | |
| IT | 156.49 | 48.86 | 9.3 | 4.11 | 0.37 | 4.87 | 16.71 |
| CT | 162.56 | 40.28* | 6.6 | 3.58 | 0.35 | 4.67 | 16.78 |
| **$LSD_{05}$** | **31.42** | **6.59** | **3.4** | **0.79** | **0.18** | **0.92** | **1.10** |
| | | | | 2005 | | | |
| IT | 89.21 | 27.40 | 39.8 | 3.89 | 0.48 | 12.3 | 15.61 |
| CT | 114.82* | 43.43* | 14.3* | 3.94 | 0.66* | 13.8 | 15.56 |
| **$LSD_{05}$** | **18.41** | **12.58** | **9.61** | **0.35** | **0.14** | **1.96** | **1.47** |

Note: IT – intensive soil tillage system; CT – conservation soil tillage system
* - significant difference from control at 95 % probability level. Control treatment – IT.

**Table 2.** Sugar beet yield and quality under different weed control methods (influence of factor B). Lithuanian University of Agriculture, Research Station.

| Treatment | Index | | | | | | |
|---|---|---|---|---|---|---|---|
| | Density of crop th. $ha^{-1}$ | Root yield t $ha^{-1}$ | Root ramification % | Potassium mmol 100 $g^{-1}$ | Sodium mmol 100 $g^{-1}$ | α -amino nitrogen mg 100 $g^{-1}$ | Sucrose content % |
| | | | | 2004 | | | |
| HW | 175.00 | 63.24 | 12.70 | 4.01 | 0.27 | 4.60 | 17.44 |
| SBM | 153.09 | 40.00* | 5.60 | 3.98 | 0.51 | 5.80 | 16.07* |
| ARM | 131.48* | 29.44* | 7.25 | 3.32 | 0.58* | 5.05 | 15.70* |
| WMM | 154.32 | 37.78* | 6.30 | 3.80 | 0.27 | 4.20 | 16.95 |
| SRM | 169.76 | 42.90 | 6.95 | 3.83 | 0.30 | 4.40 | 16.80 |
| WSM | 173.46 | 54.08 | 8.90 | 4.15 | 0.22 | 4.55 | 17.50 |
| **$LSD_{05}$** | **25.19** | **22.59** | **8.22** | **1.02** | **0.28** | **1.54** | **0.899** |
| | | | | 2005 | | | |
| HW | 122.22 | 46.30 | 4.8 | 4.01 | 0.62 | 12.6 | 15.86 |
| SBM | 109.26 | 20.14 | 27.6 | 3.46 | 0.60 | 10.4 | 15.85 |
| ARM | 109.72 | 27.51 | 14.4 | 4.10 | 0.83 | 13.0 | 15.16 |
| WMM | 86.57 | 29.63 | 51.0* | 4.46 | 0.56 | 14.0 | 15.33 |
| SRM | 95.88 | 42.89 | 40.8* | 3.87 | 0.38 | 16.9 | 15.48 |
| WSM | 88.42 | 46.02 | 24.9 | 3.58 | 0.44 | 11.2 | 15.86 |
| **$LSD_{05}$** | **36.64** | **26.70** | **35.6** | **0.61** | **0.37** | **7.96** | **1.003** |

Note: HM – hand weeding; SBM – spring barley living mulch; ARM – annual ryegrass living mulch; WMM – white mustard living mulch; SRM – spring rape living mulch; SM – straw mulch
* - significant difference from control at 95 % probability level. Control treatment – HM.

In 2005, during warmer and wetter conditions we found more significant differences between factors than in 2004. Conservation soil tillage significantly influenced higher crop density and that had an affect on higher root yield , less root ramification and higher amounts of sodium (Table 1).

According to the average data of non-chemical weed control methods use (factor B), in 2004 the living mulch of annual ryegrass (ARM) decreased sugar beet crop density (Table 2). The allopathic effect of ryegrass spp. has also been observed in other trials (De Gregorio & Ashley, 1986). In addition, the ryegrass was cut more than the other kinds of living mulches, so this operation may increase sugar beet plant losses.

Living mulches of spring barley (SBM), annual ryegrass (ARM) and white mustard (WMM) significantly decreased the yield of sugar beet roots in comparison with hand weeding (HW). Living mulches compete for nutrients and water with the main crop and this can reduce yields (Echtenkamp & Moomaw, 1989). On the other hand, when cover crops are turned over into the soil, they contribute nutrients to the main crop, so that less chemical fertilizer is required (Brophy et al., 1987), but it is a slower effect. living mulch of annual ryegrass increased the amount of sodium and decreased sucrose content in the roots. In 2005 there was lower influence of non-chemical weed control methods than in 2004. However, higher sugar beet roots ramification was observed in WMM and SRM plots.

## CONCLUSIONS

Under lower temperature and average precipitation conditions (2004), a significantly higher yield of sugar beet roots was found in intensively tilled soils. Under conditions of higher temperatures and uneven rainfall distribution (2005) we observed the converse results. Different soil tillage had no significant influence on the quality of the roots; however, sugar beet roots were more ramified in intensively tilled soil. The allopathic and choking properties of annual ryegrass decreased sugar beet crop yield and sucrose content, and increased the amount of sodium in the roots. The highest sugar beet crop productivity was observed in the following conditions: hand weeded, covered by straw or in plots with oil seed rape living mulch.

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