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The influence of organic mulches on soil properties and crop yield

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Abstract. The application of organic mulches as a soil cover is effective in improving the quality of soil and increasing crop yield, especially in organic farming. The field experiment was carried out in the Pomological Garden of Lithuanian University of Agriculture in 2005–2008. The soil type – *Calc(ar)i- Endohypogleyic Luvisol.* Treatments: 1) without mulching; 2) chopped wheat straw; 3) peat; 4) sawdust; 5) grass.

The aim of this investigation was to evaluate the effect of different mulches on soil properties and crop yield.

All examined organic mulches significantly decreased soil temperature. Mulched plots also had higher soil moisture content throughout the experimental period. The highest soil moisture content was in plots mulched with peat or sawdust. The tendency of a higher amount of available phosphorus in the soil in mulched plots in 2005–2006 was established. The positive effect of grass mulch on available potassium in the soil was estimated.

Mulching decreased weed density. During all years of the experiment significantly higher crop yields were obtained in grass-mulched plots. Peat mulch significantly decreased weed number although it has a significant negative effect on crop yield.

Key words: organic mulch, soil properties, crop yield, organic farming

INTRODUCTION

Crops are influenced by a variety of factors when mulching is used. Weeds are an important factor determining crop yields, and mulches are important for weed control (Bilalis et al., 2002; Radics & Bognar, 2004; Jodaugienė et al., 2006). Mulch can have positive or negative effects on crops apart from its impacts on weeds. Mulches reduce water evaporation from soil and help maintain stable soil temperature (Lal, 1974; Ji & Unger, 2001; Kar & Kumar, 2007). Sønsteby et al. (2004) established increased amounts of phosphorus and potassium levels in crop leaves in plots mulched with wood chips. In 1963 Tukey & Schoff reported increased amounts of available soil P and K under mulches. They suggested that the release of nutrients from decomposing mulches (rapidly and slowly decomposing) might have a positive effect on the soil. Application of straw mulch (Sønsteby et al., 2004) and grass mulch (Cadavid et al., 1998) significantly increased the available phosphorus and potassium in the soil.

The influence of organic mulches on crop yield is unequal. Mulching improves plant growth, yield and yield quality (Sharma & Sharma, 2003; Singh et al., 2007). Gill et al. (1996) state that yield increase with mulching was also greater for the early

season crop. Some authors point out that increase in grain yield by mulching is attributed primarily to decrease in soil temperature and improved soil moisture regime (Lal, 1974). However, some mulches (straw, peat, sawdust) may negatively affect crops by drying up soil nitrogen due to a wide C:N ratio (Johnson et al., 2004; Sønsteby et al., 2004). According to the data of Gruber et al. (2008), there was no effect of mulching with wood chips on crop yield. The experiments of Kar & Kumar (2007) showed that higher potato yield and better crop growth were observed in plots with straw mulch. Potato yields were similar in mulched and unmulched plots, but the watermelon yield was higher in plots with straw mulch (Johnson et al., 2004). Döring et al. (2005) established no positive effect of straw mulch on potato yield. But the fact that yield was not significantly affected by straw mulch is mainly attributed to the relatively low amounts of straw applied.

The aim of this investigation was to evaluate the effect of different mulches on soil properties and crop yield.

MATERIALS AND METHODS

The two–factor microplot field experiment was carried out in an organic certified field in the Pomological Garden of the Lithuanian University of Agriculture (54°53'N, 23°50'E) in 2005–2008. The soil type – *Calc(ar)i-Endohypogleyic Luvisol*. Soil texture: medium clay loams on heavy clay loams and clays.

Treatments: 1) without mulching; 2) straw (chopped wheat straw); 3) peat (medium decomposed fen peat); 4) sawdust (from different tree species); 5) grass (regularly cut, from grass-plots). The individual plot size was 2x6 m, with each plot replicated 4 times. In 2005 in each plot were grown *Allium cepa* L. variety *Stuttgarter Riesen,* 2006 – *Beta vulgaris* L.variety *Cylindra* , 2007 – *Brassica oleracea* L. variety *Kamennaja golovka* in raws with interlinears 0.5 m, 2008 – *Solanum tuberosum* L. variety *Anabela* in raws with interlinears 0.7 m. Mulch was spread manually in a 5-cm and 10-cm thick layer shortly after sowing. Mulch remains were inserted into the soil by ploughing after harvesting in autumn.

Botanical surveys were carried out on four 0.2 x 0.5 m squares in each plot every 10 days from 10 June until 10 November. Weed sprouts were countered and removed. Summarized data (weed number during spring-autumn period) are used in this paper. Soil temperature was measured with an electronic thermometer every 10 days from 10 June until 10 November in the soil layer 0–10-cm, measuring units – °C. Soil moisture was measured at the same time by taking soil samples with a soil drill from soil layer 0–25 cm and drying them at temperature 105°C in a thermostat until they held at a steady temperature.

Available potassium and available phosphorus in the soil were determined by the Egner-Riem-Domingo (A–L) method.

The means were compared using the least significant difference test at $P < 0.05$ with SYSTAT 10 (SPSS Inc., 2000).

RESULTS AND DISCUSSION

All examined organic mulches significantly decreased soil temperature. The biggest temperature differences – 0.7–1.6°C – were observed between plots without mulch and those mulched with straw (Fig. 1). Reduction of soil temperature is of great importance in countries with hot climate conditions, but now, as the climate is warming, conditions for temperate crops are becoming unfavourable. For example, potato growth and yield are highly affected by high temperature, especially mean temperature above 17°C (Caldiz et al., 2001).

Mulched plots also had higher soil moisture content during the experimental period in 2005–2008 (Fig. 2). In Lithuania the average amount of precipitation (more than 600 mm per year) is sufficient for the majority of agricultural crops. A lack of moisture in some growing periods often accounts for yield decrease. Soil moisture in mulched plots is not only higher, but is also more stable during the entire vegetation period, an important factor for crops.

The highest soil moisture content was in plots mulched with peat (2.6–7.3% units) and with sawdust (3.8–6.1% units) compared with soil moisture in plots without mulch. The soil moisture in plots mulched with grass was narrowly (0.3–1.1% units) higher compared with soil moisture content in plots without mulch. The positive effect of grass mulch was manifest at the beginning of the investigations – in spring and during the first part of summer. Later, after decomposition of grass has started, this mulch has no important influence on soil moisture and soil temperature, so the average soil temperature is higher and average soil moisture is lower in plots mulched with grass.

The favourable effect of organic mulches on increasing the available plant nutrient content in the soil is well documented. By the data of Saroa & Lal (2004), mulching increased total phosphorus concentration in the soil after 4 years of mulching from 601–658 mg kg^{-1} and from 491–694 mg kg^{-1}after 11 years of mulching.

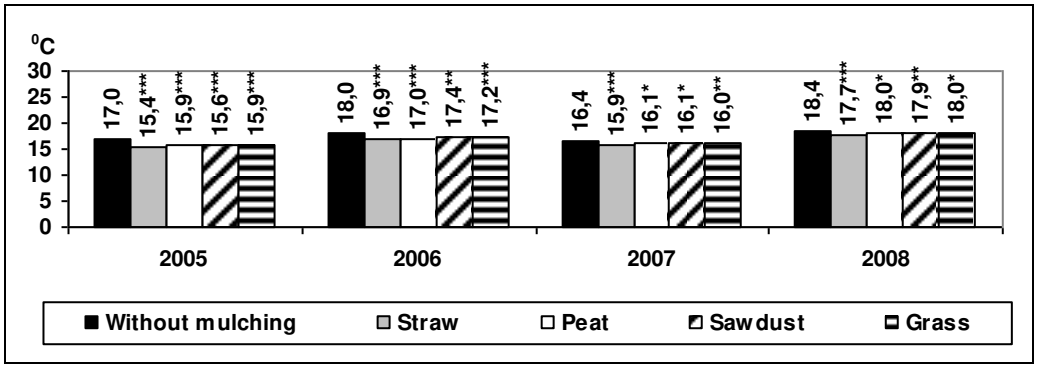

Fig. 1. The influence of organic mulches on soil temperature, 2005–2008 years; * - 95% probability level, ** - 99% probability level, *** - 99,9% probability level.

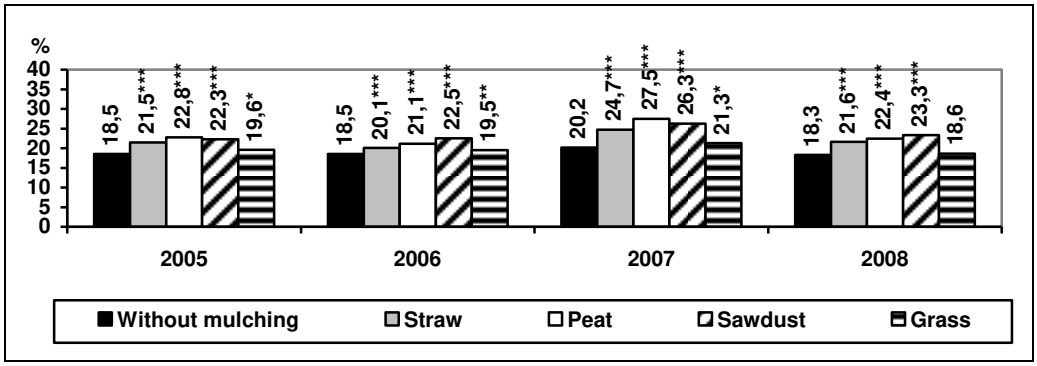

Fig. 2. The influence of organic mulches on soil moisture, 2005–2008 years; * - 95% probability level, ** - 99% probability level, *** - 99,9% probability level.

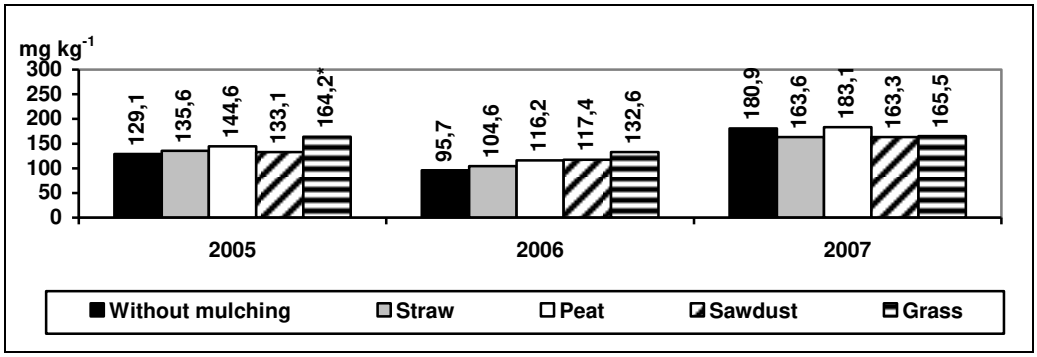

Fig. 3. The influence of organic mulches on available phosphorus, 2005–2007 years; * - 95% probability level, ** - 99% probability level, *** - 99,9% probability level.

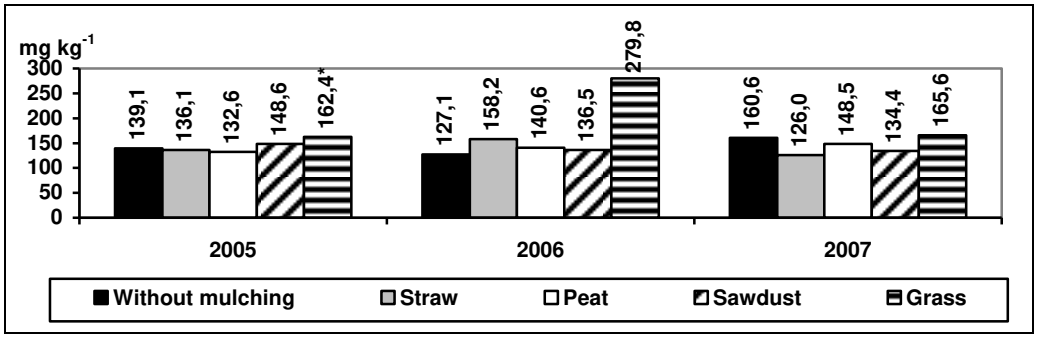

Fig. 4. The influence of organic mulches on available potassium, 2005–2007 years; * - 95% probability level, ** - 99% probability level, *** - 99,9% probability level.

We established the tendency towards a higher amount of available phosphorus in the soil in mulched plots in 2005–2006 (Fig. 3).Grass mulch on available phosphorus had the most influence. In 2007 the content of available phosphorus in the soil in un-mulched plots was higher than in plots mulched with straw, sawdust and grass. The

content of available plant nutrients was estimated in autumn after harvesting. Crop (cabbage) yield in 2007 in mulched plots (except with sawdust mulched plots) was 1.2–4.3 times higher compared with un-mulched plots. Nutrient output with crop yield could be one reason for the lower phosphorus content in the soil.

The positive effect of grass mulch on available potassium in the soil was estimated (Fig. 4). Other examined mulches, straw, peat and sawdust, had no significant influence on available potassium in the soil.

Mulching decreased the number of weeds (Fig. 5.). According to the data of our experiments, straw mulch is best for weed control. In plots with straw mulch weed density was established at 2.8–6.4 times lower compared with weed density in plots without mulch. Significant differences between weed density in plots mulched with peat and sawdust compared to that in plots without mulch were estimated.

The influence of grass mulch on weed emergence is not equal. In 2005–2007 grass mulch significantly decreased the weed number – by 3.4–5.4 times compared with that in un-mulched plots. In 2008 weed density in plots mulched with grass was established higher than in plots mulched with straw, peat and sawdust due to rapid emergence of *Poa annua* in the second part of summer, when grass mulch has been infected with seeds of *Poa annua*. In 2008 the number of *Poa annua* formed a big part – 79.5% of total weed number, as in 2005 – 11.3%, 2006 – 4.9%, and 2007 – 5.1%.

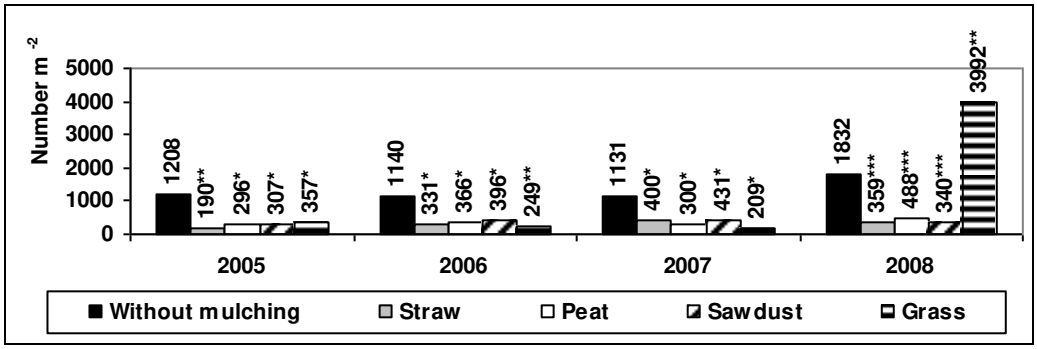

Fig. 5. The influence of organic mulches on weed density, 2005–2008 years; * - 95% probability level, ** - 99% probability level, *** - 99,9% probability level.

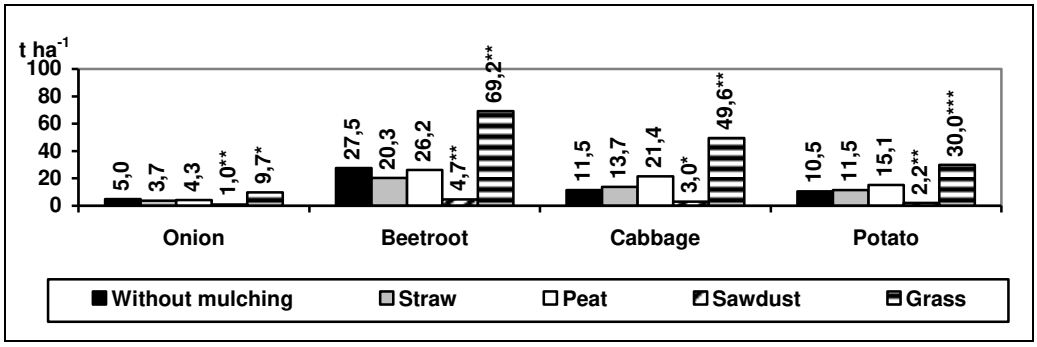

Fig. 6. The influence of organic mulches on crop yield, 2005–2008 years; * - 95% probability level, ** - 99% probability level, *** - 99,9% probability level.

The influence of different organic mulches on weed density was not the same as the influence of these mulches on crop yield. Throughout the experiment significantly higher crop yields were obtained in grass-mulched plots. The biggest nutrient inputs to the soil occurred when grass mulch was used. Grass mulch readily decomposes compared with other examined mulches, and it is a constant and quick supplier of available nutrients for plants.

CONCLUSIONS

1. All examined organic mulches significantly decreased soil temperature.
2. Mulched plots also had higher soil moisture content during the entire experimental period. The highest soil moisture content was in plots mulched with peat and in plots mulched with sawdust.
3. The tendency of a higher amount of available phosphorus in the soil in mulched plots in 2005–2006 was established. The positive effect of grass mulch on available potassium in the soil was estimated.
4. Mulching decreased weed density.
5. During all years of the experiment significantly higher crop yields were obtained in grass-mulched plots. Sawdust mulch significantly decreased weed number though it has a significant negative effect on crop yield.

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