THE IMPACT OF WEED CONTROL METHODS ON SUGAR BEET CROP

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Abstract
The effect of non-chemical weed control on organically grown sugar beet crop productivity and quality was tested at the Experimental Station of the Aleksandras Stulginskis University in 2015-2016. The aim of the experiment was to ascertain the influence of living mulch, mechanical (mellowing, cutting, mulching) and physical (steaming) weed control methods on sugar beet productivity and quality parameters. There were tested 6 weed control methods: inter-row mellowing (control treatment), cutting and mulching with weeds, Persian clover, white mustard and spring barley, inter-row steaming.
Different alternative weed control methods usually had negative significant impact on the sugar beet crop yield except inter-row steaming treatment. In these plots, decrease of root yield was insignificantly less compared with control treatment. The effect of weed control methods on sugar beet root quality parameters was weak.

Key words: *sugar beet; non-chemical weed control; organic farming; productivity; quality.*

INTRODUCTION

Today's traditional agriculture uses growing technologies based on a chemical pest control system. Sugar beet is one of the most sensitive crop for weeds suppression, as they grow slowly in their early stages of development and cannot compete with the weeds that germinate at that time. Weeds can reduce sugar beet yield by 26–100% *(Vasinauskienė & Brazienė, 2017)*. Usually, in sugar beet crop, herbicides containing the active ingredients as phenmedipham, desmedipham, etofumezate, metamitron, trisulfuronmethyl, clopyralid and chloridazone *(Bennett, et al., 2004; Deveikytė, 2005; Domaradzki, 2007)*. High yields of root crop are obtained, but the extensive use of chemicals causes ecological pollution. Avoiding damage the balance of nature and the risk of contamination of agricultural production with residues of chemicals that are harmful to humans, encourages the transition to organic farming. Weeds are one of the most important agronomic problems in all farming systems, but the most important in organic as the non-chemical methods of weed control are less effective than the use of herbicides in intensive farming systems *(Liebman, et al., 2003; Pilipavičius, et al., 2011)*.
Mechanical inter-row weed control is practiced in organic farms and can significantly reduce crop weediness. The effectiveness of a mechanical weed control depends on the time and intensity of its application. Methods of thermal engineering are also used to kill weeds. The heat source used around the plant creates a high-temperature environment which, when heated, destroys them *(Sirvydas & Kerpauskas, 2012)*.
Cover crops (like as mulch) might suppress weeds and improve the fertility of soil at the same time *(Kader, et al., 2017; Pannacci, et al., 2017)*. Some of inter-cropped catch crops continue vegetation and known as a "living mulch" *(Robačer, et al., 2016)*. The use of the living mulch is a sufficient alternative to the mechanical weed control. As living mulch can be grown clover, black medic, white mustard or cereal grasses *(Den Hollander, et al., 2007a; Kunz, et al., 2016; Masilionyte, et al., 2017)*. However, living mulch crops can compete with the main crop *(Liedgens, et al., 2004)*.
To summarize, sugar beet growing with living mulch crops is not widely investigated. In most cases, the inter-cropping of legumes in cereals *(Duchene, et al., 2017)* or maize *(Adamavičienė, et al., 2012; Verret, et al., 2017)* are investigated. So, the aim of the experiment was to establish the impact of non-chemical weed control methods on the productivity and quality of organically grown sugar beet crop.

MATERIALS AND METHODS

A stationary field experiment was performed in 2015–2016 at the Experimental Station (54º52′ N, 23º49′ E) of the Aleksandras Stulginskis University (ASU), Lithuania. The main objective of experiment was to ascertain the influence of different non-chemical weed control methods on sugar beet crop productivity and quality in the conditions of organic farming. Six weed control methods were established: inter-row mellowing (CT, control treatment), cutting and mulching with weeds (MW), Persian clover (MC), white mustard (MM) and spring barley (MB) living mulches, and inter-row steaming (ST). According to the *Yagioka (2015)*, MW treatment imitates "natural farming" system. By the way, *Lumbanraja et al. (2004)* established, that weeds as a cover plants were a sufficient control method in coffee fields. The soil of experimental site was a silty loam (on average 46% sand, 42% silt, 12% clay) Planosol (*Endohypogleyic-Eutric – Ple-gln-w*) (WRB, 2014), climate – boreal (subarctic) with an average annual temperature by the 6.7°C and precipitation rate – 625 mm. Length of vegetation season with active temperatures (≥ 10 °C) is about 6 months. Meteorological conditions during the investigations are presented in Table 1. Length of vegetation means the period from sugar beet sprouting to harvesting. 2015 and 2016 vegetative seasons were quite different in precipitation rates and temperatures.

Tab. 1 Meteorological conditions during investigations, Kaunas Meteorological Station, 2015–2016

Year	Length of vegetation days	Average temperature of 24 hours ° C	Sum of active temperatures ° C	Precipitation rate mm
2015	159	15.2	2273.9	171.5
2016	137	16.4	2161.7	384.6

The agrotechnical operations and timing are presented in Table 2. Pesticides and mineral fertilizes were not used in the experiment.

Tab. 2 Agrotechnical operations and timing

Agrotechnical operation	Timing
Straw loosening, manure distribution (30 t ha^{-1}), ploughing	2014 October only
Pre-sowing tillage	End of April
Sowing	After pre-sowing tillage
Inter-row mellowing before living mulch plants sowing	End of May, after the emergence of sugar beet sprouts
Sowing of living mulch	After inter-row loosening
Inter-row steaming	The beginning of June, after weed sprouts emergence
Inter-row loosening, cutting and mulching	3 times up to the beginning of July
Harvesting	The beginning of October

Four replication of an experiment were performed, distribution of plots – randomized. In 2014, the pre-crop of sugar beet was spring barley. Since 2015, continuous sugar beet crop was cultivated.
The distance between sugar beet rows was 45 cm, between seeds – about 16 cm. Sugar beet variety – „Firenze". The sowing rate of white mustard and Persian clover as living mulch was 10 kg ha^{-1}, spring barley – 200 kg ha^{-1}. The living mulch plants were cut and distributed on the soil surface 3 times by a hand-operated brush cutter 'Stihl' FS–550. Inter-row steaming was performed with mobile steaming machine, which had been projected and manufactured in ASU (patents LT5620B and LT55332B) (Fig. 1).

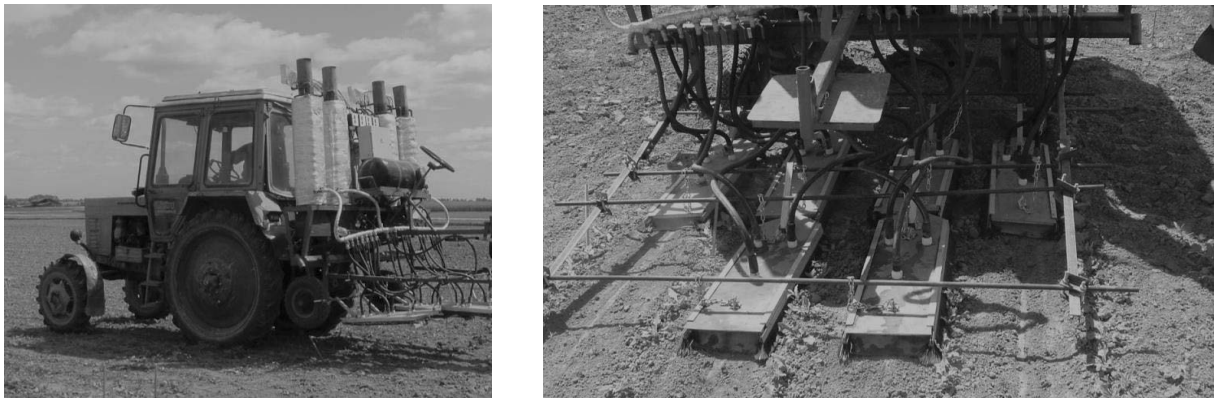

Fig. 1 Inter-row steaming machine

The experimental data were statistically evaluated using the ANOVA software.

RESULTS AND DISCUSSION

Results of investigations show, that alternative weed control methods mainly decreased yield of sugar beet root compared with mechanical inter-row mellowing (CT) (Table 3). Inter-row steaming treatment (ST) was effective against weeds. The yield of root crops was about 15 t ha^{-1} less than in control, but difference was insignificant. Due to the concurrence with main crop, mulching methods significantly decreased yields of roots. The most negative effect was observed in MC and MM plots. In our earlier investigations, white mustard living much effectively controlled weeds in sugar beet crop *(Romaneckas, et al., 2009)*, but competed with main crop and decreased yields of root crop *(Adamavičienė, et. al., 2009)*. Similarly, *Kunz et al. (2016)* found, that the most effective was herbicide application (control) compared with living mulch application. Despite that, *Trifolium subterraneum* initiated the highest yield of white sugar.

Tab. 3 Sugar beet root yield and quality, average of 2015–2016

Weed control treatment	Yield t ha^{-1}	Sucrose content g kg^{-1}	Potassium content mmol kg^{-1}	Sodium content mmol kg^{-1}
CT	55.82a	173.9a	31.0a	2.5a
MW	31.86b	167.0a	31.6a	3.0a
MC	28.06b	166.9a	32.0a	3.2a
MM	27.20b	166.4a	32.0a	3.1a
MB	31.48b	168.4a	30.8a	2.6a
ST	40.74ab	174.2a	30.6a	2.4a

Note: CT – inter-row mellowing (control treatment); MW – inter-row cutting and mulching with weeds; MC – inter-row cutting and mulching with the Persian clover; MM – inter-row cutting and mulching with white mustard; MB – inter-row cutting and mulching with spring barley; ST – inter-row steaming. Values with different letters mean significant differences between treatments at 95 % probability level.

In our experiment, different weed control methods included living mulch application, did not have significant effect on sugar beet root crop quality (Table 3). In the case of quality, ST treatment was the most effective. In steamed plots, roots of sugar beet had the higher amount of sucrose and the lowest concentration of impurities (potassium and sodium). In *Afshar et al. (2018)* experiment, living mulch increased sucrose concentration and decreased sodium, potassium and amino-N concentration in the beet roots.

CONCLUSIONS

Different alternative weed control methods usually had negative significant impact on the sugar beet crop yield, except inter-row steaming treatment. In these plots, decrease of root yield was insignificantly less compared with control treatment. The effect of weed control methods on sugar beet root quality parameters was weak. To summarize, inter-row steaming is an effective weed control method, which might be widely used in conditions of organic farming.

REFERENCES

1. Adamavičienė, A., Romaneckas, K., Šarauskis, E., & Pilipavičius, V. (2009). Non-chemical weed control in sugar beet crop under an intensive and conservation soil tillage pattern: II. Crop productivity. *Agronomy Research, 7* (special issue 1), 143-148.
2. Adamavičienė, A., Romaneckas, K., Pilipavičius, V., Avižienytė, D., Šarauskis, E., & Sakalauskas, A. (2012). Interaction of maize and living mulch: Soil chemical properties and bioactivity. *Journal of Food, Agriculture & Environment, 10*(3-4), 1219-1223.
3. Afshar, R. K., Chen, C., Eckhoff, J., & Flynn C. (2018). Impact of a living mulch cover crop on sugarbeet establishment, root yield and sucrose purity. *Field Crops Research, 223*, 150-154.
4. Bennett, R., Phipps, R., Strange, A., & Grei P. (2004). Environmental and human health impacts of growing genetically modified herbicide-tolerant sugar beet: a life-cycle assessment. *Plant Biotechnology Journal, 2*, 273-278.
5. Deveikytė, I. (2005). Comparison of weed control systems in sugar beet. *Žemdirbystė/ Agriculture*. *92*(4), 93-105 (in Lithuanian with English summary).
6. IUSS working group WRB. (2014). *World reference base for soil resources*. 3th edition. World Soil Resources Reports No. 106. Rome: FAO. Retrieved from http://www.fao.org/3/a-i3794e.pdf.
7. Domaradzki, K. (2007). Optimization of herbicide application in the sugar beet protection system. *Prog. Plant Prot.\Post. Ochr. Roślin, 47*(3), 64-73.
8. Duchene, O., Vian, J. F., & Celette, F. (2017). Intercropping with legume for agroecological cropping systems: Complementarity and facilitation processes and the importance of soil microorganisms. A review. *Agriculture, Ecosystems & Environment, 240*, 148-161.
9. Den Hollander, N. G., Bastiaans, L., & Kropff, M. J. (2007). Clover as a cover crop for weed suppression in an intercropping design. II. Competitive ability of several clover species. *European Journal of Agronomy, 26*, 104-112.
10. Kader, M. A., Senge, M., Mojid, M. A., & Ito, K. (2017). Recent advances in mulching materials and methods for modifying soil environment. *Soil & Tillage Research, 168*, 155-166.
11. Kunz, C. H., Sturm, D. J., Peteinatos, G. G., & Gerhards, R. (2016). Weed Suppression of Living Mulch in Sugar Beets. *Gesunde Pflanzen, 68*(2), 1-10.
12. Liebman, M., Bastiaans, L., & Baumann, D. T. (2003). Weed management in low-external-input and organic farming systems. In *Weed Biology and Management* (pp. 285-315). Kluwer Academic Publishers.
13. Liedgens, M., Frossard, E., & Richner, W. (2004). Interactions of maize and Italian ryegrass in a living mulch system: (2) Nitrogen and water dynamics. *Plant and Soil, 259* (1-2), 243-258.
14. Lumbanraja, J., Adachi, T., Oki, Y., Senge, M., & Watanabe, A. (2004). Effect of weed management in coffee plantation on soil chemical properties. *Nutrient Cycling in Agroecosystems, 69*, 1-4.
15. Masilionyte, L., Maiksteniene, S., Kriauciuniene, Z., Jablonskyte-Rasce, D., Zou, L., & Sarauskis, E. (2017). Effect of cover crops in smothering weeds and volunteer plants in alternative farming systems. *Crop Protection, 91*, 74-81.
16. Pannacci, E., Lattanzi, B., & Tei, F. (2017). Non-chemical weed management strategies in minor crops: A review. *Crop Protection, 96*, 44-58.
17. Robačer, M., Canali, S., Lakkenborg Kristensen, H., Bavec, F., Grobelnik Mlakar, S., Jakopa, M., & Bavec, M. (2016). Cover crops in organic field vegetable production. *Scientia Horticulturae, 208*, 104-110.

18. Romaneckas, K., Romaneckienė, R. & Pilipavičius, V. (2009). Non-chemical weed control in sugar beet crop under intensive and conservation soil tillage: I. Crop weediness. Agronomy Research, *7* (Special issue 1), 457-464.
19. Sirvydas, P. A. & Kerpauskas, P. (2012). *Thermal weed control: monography*. Akademija-Kaunas: Aleksandras Stulginskis University Press (in Lithuanian with English summary).
20. Vasinauskienė, R. & Brazienė, Z. (2017). Control of pests in the sugar beet crop using the damp water steam. *Optimization of ornamental and garden plant assortment, technologies and environment*. *8*(13), 89-96 (in Lithuanian with English summary).
21. Verret, V., Gardarin, A., Pelzer, E., Médiène, S., Makowski, D., & Valantin-Morison, M. (2017). Can legume companion plants control weeds without decreasing crop yield? A meta-analysis. *Field Crops Research*, *204*, 158-168.
22. Yagioka, A., Komatsuzaki, M., Kaneko, N., & Ueno, H. (2015). Effect of no-tillage with weed cover mulching versus conventional tillage on global warming potential and nitrate leaching. *Agriculture, Ecosystems & Environment*, *200*, 42-53.

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