USE OF CEREAL AND MAIZE STRAW FOR BIO-ENERGY – AN ECOLOGICAL CONTRADICTION

Bavec F., Turinek M., Jakop M., Grobelnik Mlakar S., Bavec S., Bavec M.
University of Maribor, Faculty of Agriculture and Life Sciences, Pivola 10, 2312 Hoče/Maribor, Slovenia. Tel.: +386 2 23209030, franci.bavec@uni-mb.si

1 INTRODUCTION

Crop residues, like cereal and maize straw, are a potential source of bio-energy. Their use for real bio-energy is on one hand a good idea because of their very high energy potential, which were discussed (Bavec et al., 2007) at the workshop 'Cereal straw and agricultural residues for bio-energy in new member states and candidate countries' organized by EU Commission's Joint Research Centre in Novi Sad 2007. For example, if Japanese technologies enable the effective use of agricultural rice residues abroad as a result of Japanese effort from the years after 2010, the resulting reduction of greenhouse gas emission can be counted under the framework of the Kyoto Protocol (Matsumura et al., 2005). The same importance was attributed for all organic wastes in Canada (Champagne, 2007).

But on the other hand, in the longer term, their indiscriminate removal has adverse impacts on soil, the environment, and crop production. Therefore agronomists do not support removal of crop residues from the fields (Kastori and Tesic, 2005).

Straw removal from the fields can decrease humus content, provoke degradation of soil structure with additional negative influences on erosion of soil and plant nutrients, and reduce the natural pathways of plant nutrients, especially nitrogen mineralization. As a consequence, a great reduction in natural soil fertility occurs. In all types of soils, except chernozem, lack of organic matter in the soil (straw is the main input in specialised field crop production) significantly decreases earthworm population and in consequence available nitrogen and other nutrients from organic budget (pools). However, the lack of organic matter in the soil also has a lot of interactions with soil water and temperature regimes associated with physical (e.g. water infiltration, saturated/unsaturated hydraulic conductivity, and air permeability, thereby increasing runoff/soil erosion and transport of non-point source pollutants such as sediment and chemicals (Blanco-Canqui and Lal, 2009), chemical and biological properties of soils and has direct effects on the environment and growth of plants.

2 METHODS

We made a simple data analysis (data for arable land from Slovenian Yearbook,) of cereal straw residues and their potential use for bio-energy. On this basis we analyzed potential use of straw and made a critical review, especially if we take into account the ecological and agronomical weaknesses, which influence the soil, environments and yields in the long term period.

3 RESULTS AND DISCUSSION

In the case of Slovenia we have 323.000 t of straw from which 61.000 t are used as litter for livestock bedding and for production of mushrooms. It means that this straw can be returned as organic manures to approx. 19% of the fields. The residual 262.000 t might be used for bio-energy, but there remains a question on how much and which kind of organic matter is available to apply for adequate protection of soil fertility in the other 81% of the fields. For now, due to the Slovenian Guidelines for Integrated Field Crop Production, removal of straw from the fields is not allowed in the case where there is no other supply of organic matter, especially if the content of humus is very low. For those we need additional information. Strategy and guidelines are due to follow reviews and discussion.

A simulation of the effect of removing 50% and 95% of the above-ground residues over a 50-year period showed that removing 50% of the straw would likely have a detectable effect on the soil C, while removing 95% of the straw certainly would. Measurements and model simulations suggest that adoption of no-tillage without proper fertilization will not increase soil C. Although it appears that a modest amount of residue may be safely removed from black chernozem without a measurable effect on soil C, this would only be feasible if accompanied by appropriate fertility management (Lemke et al., 2010). Also a short term 10y experiment shows that residue removal may not always degrade soil physical properties and decrease crop yields in the short term depending on the soil type, topography, and fluctuations in annual weather conditions. It was reported that sloping terrains are not only highly susceptible to water and wind erosion but also to tillage erosion in comparison to flat terrains (Blanco-Canqui and Lal, 2009). The same authors (Blanco-Canqui and Lal, 2008) reported that removal of stover at 50% rates reduced sub critical water repellence by 2 to 10 times in all soils in case of chernzem, but in case of sandy soil characteristic sub critical water repellence can be poorly, because of earlier intensive conventional use and faster mineralization of organic matter. Overall, stover removal altered micro-scale soil properties, and complete stover removal had the most detrimental effects.

In spite of these experiences and conclusions the main target in agronomy is improving the soil quality over the longer term, and not to compare the actual bad soil characteristics, which have become more and more poor over the last decades due to their intensive use, especially under monocroping systems. When we remove organic residues without any additional organic fertilisers (stable manure, green manure, etc.) we will also lose some undefined soil properties like sustainable influences of natural growth regulators, micronutrients, natural disinfection compounds and many more compounds on beneficial's of soil biodiversity and growth of crops than we analyse as a standard characteristics.

The removal of residues for bio-energy production would have risky consequences for the sustainability of agricultural productivity, particularly on soil conservation and stability of production systems. There is a further exploration of alternative sources such as bio-energy crop plantations or shrub or tree species, rather than the use of crop residues (Montico, 2009). Also conservation tillage (which includes straw residues) should be also addressed for farming system sustainability in terms of energy conservation and nutrient management (Carter 1994).

In case of future scenarios (Saffih-Hdadi and Mary, 2008) the selected simple AMG model was used to simulate the impact of a straw export scenario in nine experiments considering a systematic straw removal one year out of two. With this scenario, straw removal vs. incorporation would reduce humification described as carbon stocks by 2.5–10.9% of the initial SOC after 50 yr, depending primarily on the experiment (soil, climate, productivity) and secondarily on the size of the stable C pool (varying from 10% to 65%), but from long term agronomic experiences it is nothing new. It is just a confirmation that in activities of removing cereal residues from the fields we need very careful consideration.

4 CONCLUSIONS

The fact is that uncontrolled removal of straw from the fields for bio-energy will deteriorate environment, soil properties and reduce the yields of crops at large scale. We suggest that the influence of cereal straw removal from the fields (if it will not return to the fields in the form of manure) should be carefully investigated before a long term EU green light is given for these activities. After that the standard guidelines should be laid down. The quantity of straw removal from the fields needs to be defined and controlled for each environment and soil type – it means that the removal amount should not have negative influences on the soil and ecology. However, to avoid the next big damage to sustainability, best cultivation practices need to be involved into plant production systems including obligatory fertilization with organic manures (which have an apropriate C:N ratio), and inclusion of cover crops for a better crop rotation to minimize impacts of straw removal.

REFERENCES

Bavec F, Bavec M 2008. Potential use of straw and agricultural residues for bioenergy in Slovenia. In: Scarlat N, JF Dallemand and M Martinov. *Proceedings of the workshop "Cereals straw and agricultural residues for bioenergy in European Union new member states and candidate countries", 2-3 October 2007, Novi Sad, Serbia*, (EUR - Scientific and technical research series). Luxembourg: European communities, 71-75.

Champagne P 2007. Feasibility of producing bio-ethanol from waste residues: A Canadian perspective: Feasibility of producing bio-ethanol from waste residues in Canada Resources Conservation and Recycling 50: 211-230

Carter MR 1994. A review of conservation tillage strategies for humid temperate regions Soil & Tillage Research 31: 289-301

Blanco-Canqui H, Lal R 2009. Crop Residue Removal Impacts on Soil Productivity and Environmental Quality Critical Reviews in Plant Sciences, 28: 139-163

Blanco-Canqui H, Lal R 2008 Corn stover removal impacts on micro-scale soil physical properties, Geoderma, 145: 335-346

Kastori R, Tesic M 2005 Use of harvest residues as alternative fuel – advantages and disadvantages. Agr. Engng. – Reports for Southeastern Europe,11: 21-26.

Lemke RL, VandenBygaart AJ, Campbell CA, Lafond GP, Grant B 2010. Crop residue removal and fertilizer N: Effects on soil organic carbon in a long-term crop rotation experiment on a Udic Boroll. Agriculture ecosystems and environment, 135, 42-51

Matsumura Y, Minowa T, Yamomoto H 2005. Amount, availability, and potential use of rice straw (agricultural residue) biomass as an energy resource in Japan. Biomass and Bioenergy, 29, 347-354.

Montico S 2009. Bioenergy production capacity in the province of Santa Fe, Argentina. Ciencia Investigacion Agrarira, 36: 465-474.

Saffih-Hdadi, Mary B 2008. Modeling consequences of straw residues export on soil organic carbon, *Soil* Biology and Biochemistry, 40: 594-607