CONDITIONS OF SUSTAINABLE SOIL QUALITY VS. ENERGETIC USE OF FIELD-LAND BY-PRODUCTS

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Summary

Hungary extremely depends on external energy supplies – it is an obvious fact and the reduction of this dependence is a common task. The energetic use of stubble residues is a real alternative if all harmful aftermaths are known and there are also feasible solutions applied for the mitigation of damages. The attribute "sustainable" holds true of the energy but, as to the soil by which the biomass is produced, it is unfortunately false because this means an organic-matter and nutrient-element removal and, on top of that, the supplementation is doubtful. If the biological life of the habitat and its resistance against the harmful climate effects is in danger, the energy derived from the mass cannot be "bio".

Keywords

soil quality, removal of straw and stalk, water content

Introduction

The quality of the soil is determined by the processes taking place in it and its properties. Beside the natural soil properties, the human activities modify (make better or worse) the outcome of the processes in the soil. The soil cultivation does not change the clay content, the physical kind or the pH value. The longer-time soil use influences the soil cohesiveness (it might worsen or ease) and the soil moisture content range of cultivability (it gets wider or narrower). The physical properties changing with the soil cultivation (tillage) are the mechanical resistance, the looseness, the water, air and heat budget of the soil, and the surface profile. The living beings (useful or damaging) and their activity, the organic-matter content, the dynamics of the organic-matter decomposition and the crumb forming aptness indicate the biological value of the soil. The risk of plant growing, theoretically depending on soil quality as good, medium or low, is high, medium or low. The quality of soil may change in the good or bad direction conditionally on that whether the operations carried out on the soil improve, protect or worsen its natural properties and physical or biological state.

The permanent rise in price of fossil energy carriers and the limited reserves necessarily focus attention on the increasing utilization of renewable energy resources. At the beginning the first so-called plans of alternative energy production and use still met the regulations of environment protection, and were in harmony with the requirements of the sustainable development. In the newer plans, the sustainability is only a slogan and the energetic-purpose use of stubble residues gains more and more ground. The feedstock of "renewable" energy is annually yielded on the lands – on the soils which must be renewed year by year as well (Birkás, 2007, 2010). The rational supplement of organic matter for assisting the soil renewal is missing in the actual plans. (The ash mixed with vehicle medium for fertilizer application can be used but its value is much less than that of the incinerated material.) The question is whether the sustainable development, the stable husbandry and the effective climate damage mitigation with soils endangered in their physical, nutrient and biological state can be feasible or cannot in the agriculture.

Material and method

The present study is a summarizing paper. The data gained during the Soil quality vs. climate experiment in 2002 at Hatvan-Józsefmajor (Birkás, 2011, Birkás and Kisic et al., 2012, Birkás and Kalmár et al., 2012, Csorba et al., 2011) and the Stubble vs. climate experiments carried out in each summer since 2004 provide the background of the suggestions.

Results

Facts

According to the EU commitment, the factors endangering the soils are 1) Erosion, 2) Decrease in organic matter content, 3) Pollution, 4) Capping (overbuilding) of land, 5) Soil compaction, Decrease of biodiversity, 7) Alkalization and 8) Flood and earth-slide. So the decrease of organic matter content takes the second place in the order of importance. The resources of organic matter supplement in the importance order in Hungary are 1) stubble and root residues, 2) green manure, 3) farm or litter manure, 4) compost and 5) slurry.

In an average season, an amount of 20 to 21 million metric tons of stalk residue is formed on the arable land of 4.45 million ha (Gyuricza et al., 2012). The most is maize stalk (12 to 13 million t), the quantity of cereal straw is less (7 to 8 t) and that of sunflower stalk is about 1.4 to 1.9 tons. Considering it any point of view, the significance of this mass is great. The area where farm manure is applied is maximum 130,000 ha in a year. The application of green manure greatly depends on the summer weather; the actual area was 28,000 ha in 2011, and even less than this in 2012 and the application proved ineffective. Due to the decreasing livestock, the animal husbandry is not capable of covering the farmyard manure demand of the plant production therefore the stubble residue remains a necessary organic-matter resource for a long time in the future as well. The energy demand (1000 PJ/year) is real and resources must be found for this as well. The energetic utilization of stubble residues is a possible alternative as Gyuricza et al. (2012) indicated. However, they emphasize that the best solution would be to operate decentralized power plants with lower capacity (1 to 5 MW) since the running of power stations with the demand of large amount of feedstock in certain regions already now causes the quality worsening of the earlier eroded forest soils. The macro and micro-elements removed with the straw and stalk matter from the land can be supplied by rational application of artificial fertilizer but there is no good solution for the carbon supplementation. According to data provided by AKI AT (22 September), 2.73 million tons of straw was gathered from cereal producing lands, with a carbon content of 1,090,800 t, and amount of humus (due to the different husbandry practices) is 272,700 to 818,100 tons. It is a troublesome fact if the rape, pea or soy-bean stalk also removed from the land but not with animal feeding purpose.

Denomination

The meaning of the biomass – perhaps originally – is the definition "energetically utilizable plants, crops, by-products, vegetable and animal wastes". By ones who are interested in that, "the importance of the biomass materials is that they can be substituted for fossil energy carriers and, in this way, the sustainable energy use (sustainable development) is feasible" (see publications on internet). The attribute "sustainable" holds true of the energy but, as to the soil by which the biomass is produced, it is unfortunately false because this means an organic-matter and nutrient-element removal and the supplementation is doubtful. If

the biological life of the habitat and its resistance against the harmful climate effects is in danger, the energy derived from the mass by incineration cannot be "bio". The case of necessity evolved from of the energy shortage has to be treated but the euphemism is a self-delusion. The exact denomination is 'energy derived from straw' or 'energy derived from stove (corn stalk)' etc.

The gain of the industrial-purpose removal of straw and stalk

Beside the experiments carried out, we have been collecting the below listed facts since 2007 in 14 counties in Hungary. The soils endangered most of all are in counties Baranya, Tolna, Bács-Kiskun (south region), Békés, Somogy, Vas, Győr-Moson-Sopron, and lately Fejér.

The use of straw for bedding is advantageous since the organic material returns into the soil in the form of farmyard manure (perhaps not to the same land where gathered). However, the industrial utilization results in a quite another situation. In an actual farm management, some advantages may attend this decision. 1) A less amount of straw or stalk residue theoretically eases the soil cultivation but the water loss of soil due to cultivation delays and the treading damage in summer and early autumn will increase the energy requirement of tillage. In a season of low rainfall, in the case of the tillage of 10 to 12-cm working depth, the extra diesel oil consumption is minimum 1.5 to 2.5 l/ha. 2) The number of plant-protection problems may be reduced in the case of succession of plants with similar pathogens; it is a help where the level of plant protection is low. 3) It is an income in the harvest season; however, some farmers give the land residue over to a user for nothing as they just want to dispose of the materials making the tillage more difficult. It may be asked whether the income from the sell of stubble residues compensates the disadvantageous effects of the organic-matter imbalance and the costs of the extra tillage energy. Also a problem is the supplement of P and K removed in the straw and stalk mass.

The risk of the industrial-purpose removal of straw and stalk

The negative aftermaths of the industrial-purpose removal of the stubble residues in the soils of an actual farm land are as follows: 1) Losing the supplement resource of organic matter is a high risk if there is no possibility of application of farmyard or green manure and, in addition, it is a carbon loosing cultivation practice. It is a pitiable experience that the producers selling straw in bulk – in any county – usually carry on a carbon loosing cultivation, including the delayed and bad stubble ploughing. 2) The stubble cultivation is delayed due to the longer baling and transport (often 3 to 8 weeks) and this is why the quality of stubble cultivation falls. Because of the increased water loss of the top layer, farmers till – irrationally – even deeper the stubble. 3) In a hot day a deep layer of the uncultivated cracked soil without the covering matter warms up (to 15 or 20 cm averagely 28 °C). Due to the undesirable warming-up, the water loss and the drying of soil increases. The water loss is not or hardly recovered in a dry season (experience in 2011 and 2012, Figure 1).

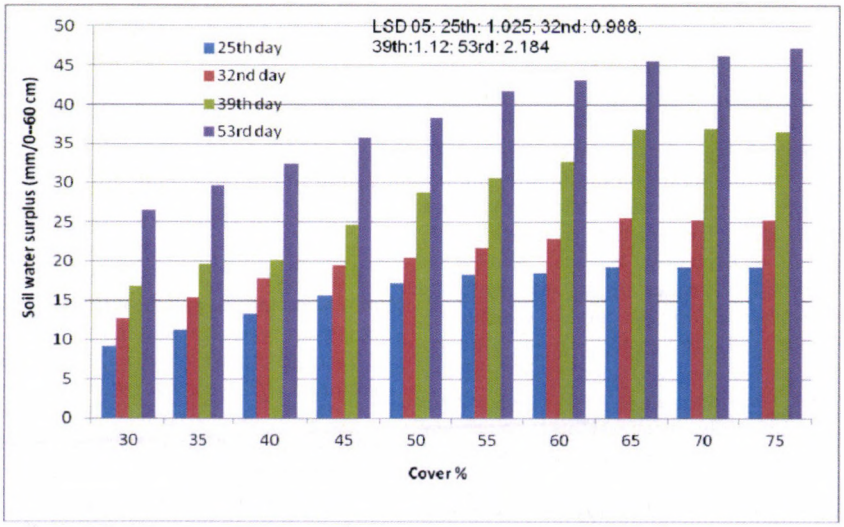

Figure 1. Soil water content surplus (mm) in an undisturbed soil covered differently during 53 days in rainless period (Hatvan, 1 Aug.-13 Sept, 2012) Water content at harvest: 270 mm/0-60 cm soil layer; Water content in the clean soil on the 53rd day: 207 mm/0-60 cm

In dog-days the temperature of the ploughed stubble layer between 0 and 8 cm is 28 to 30 °C but below this layer – only 22 to 24 °C. There was more water by 17 to 24 mm during 2 weeks in July 2012 in the covered soil than that in the uncovered one. 4) On soils got biologically passive due to the water loss and the crusted surface, the summer-end and autumn tillage requires more energy by 12 to 14 % (experiences of years 2007 to 2009 as well as 2011 and 2012). 5) Without covering, the soil is directly exposed to the drying, drop-impact and silting effects of the hotness and the summer showers and, because of this, the crumb formation fails or decreases. After the repeated cultivation pass, in the seed bed, the fractions of nut-like clods (25 to 42 %) and dust (19 to 33 %) are dominant. 6) There are more treading damages in the soil; beside the wheel-tracks of harvester, tracks of the balers and the transporting vehicles appear on the surface. The reach of treading damage in depth is 25 to 45 to 55 cm. 7) In the soil that lost its moisture, the shoot of weeds and volunteer plants extends and the chance for surveying the weed potential and the weed killing decreases. 8) The other extreme is common as well; on the stubble that has not been ploughed for weeks, the allergenic weeds shoots and develops the most quickly. 9) The stubble residue is a nutrient resource of plants; for example there is a nutrient-element (N, P, K and Ca) amount of 20 to 60 kg (see also data of Gyuricza et al., 2012). Over the world, 118 million t

NPK amount is forms in stubble residues which is 83.5 % of the consumption of artificial fertilizers in the world. The wheat straw, the straw of legumes as well as the maze stalk is a good potassium resource. If the supplement recovers the demand of the following plant rather than the shortage on the grass-land soil, a reasonable K-cycle can be achieved and the K-fertilizer demand – reduced. However, the interruption of the cycle arrests this saving. 10) There are many so-called half-way measures; a higher cereal stubble left behind is only theoretically is a good. Now the stubble cultivation is more difficult and only a deeper tillage can achieve a better mixing. In addition, they use conventional disc harrows after which the soil remains more cloddish and better dries. (To reduce the damage, rollers can be attached behind which has to be transported to the land separately.) The moisture saving effect of the high stubble is 1 to 2.2 mm/day in 2 to 3 weeks (data in 2011) but after deep stubble tillage the loss is 2.32 to 3.35 mm/day.

The loss list claims particular attention.

1. In the first year, due to soil drying, crusted surface and treading, a temporary quality worsening arises and it hits back in the increased R+M and fuel costs (Figure 2).
2. During a longer time the problem worsens; the nutrients removed in the straw and stalk should be supplemented but the income of residue selling does not cover the cost of chemical fertilizer. From the 2nd or 3rd year the lack of organic-matter recycling causes a serious worsening in soil quality; its obvious indicator is the lower water retention and the climate sensibility of the soil. Of course, in an extreme season, the decrease in yield cannot be avoided but the loss on the soils with decreasing organic-matter balance is multiplied in comparison with the well cultivated ones.
3. The harm caused by graniferous weeds (incl. many allergenic) growing between the straw windrows and bales has not been surveyed as yet.
4. During the transport of straw the roads are exposed to a damaging load and the roadside areas – to weed-seed and pathogen pollution.
5. A bad addition is the carbon losing cultivation; the combination of the lack of organic-matter supplement and the carbon losing cultivation is especially dangerous on (aslope, eroded, sandy and loamy) soils poor in humus.

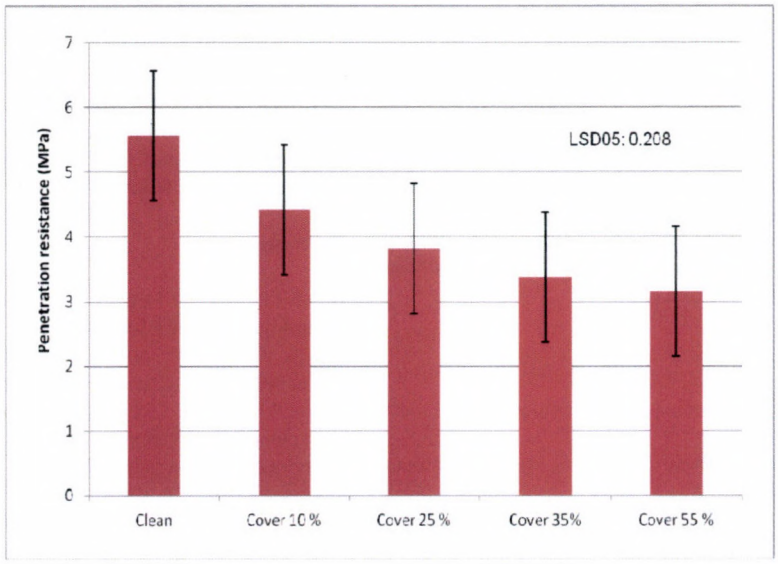

Figure 2. Typical penetration resistance (MPa) values in average of 0-65 cm soil layer in a dry season at different surface cover ratio (Hatvan, 16 July-30 August, 2012)

The reaction of cohesive soils should be considered as well; with worsening organic-matter balance, the negative effects of cohesiveness are more intensive – the cultivability moisture range narrows, the soil resistance and the energy requirement of tillage increases.

Organic-matter loss and climate damage

If new organic materials (stubble residues, farmyard manure) are not added into the soil, the by-product of the microbial respiration at first develops from the easy-to-degrade humus, and then – from the humus of difficult degradation. The loss is 20 to 50 % of the reserve in 2 to 5 years. When all organic matters get back into the soil but the cultivation is carbon losing, a slow carbon intake can be expected – annually about 0.6 %. The "unexpected" aftermaths of the carbon losing farming:

1. Decrease in water retention capacity (increased drought damage).
2. Decreased crumb formation (cloddish structure after basic tillage and dusty decay with any tillage; (Figure 3).
3. Worsening of cultivability; the optimum moisture range of tillage narrows and the tillage at unsuitable moisture content causes a hardly correctable fault (thicker plough sole).
4. Too quick re-consolidation of soil after ploughing or loosing: the 4 to 5-year loosening period cannot be held – often 2-year or more frequent period required.
5. Unexpected excess-water damage in the following year after loosening (due to the soil re-consolidation).
6. Worsening of the viability of land – deeper treading damage.
7. Worse effect of manures due to the worse structure and the duller soil life.
8. Increase in the energy demand of tillage (increased cultivation input on settled soil) – for deeper tillage, minimum 55 l/ha diesel oil on chernozem soil and 62 l/ha on meadow soil; in addition, the increase of passes required for the after-plough top-soil tillage.

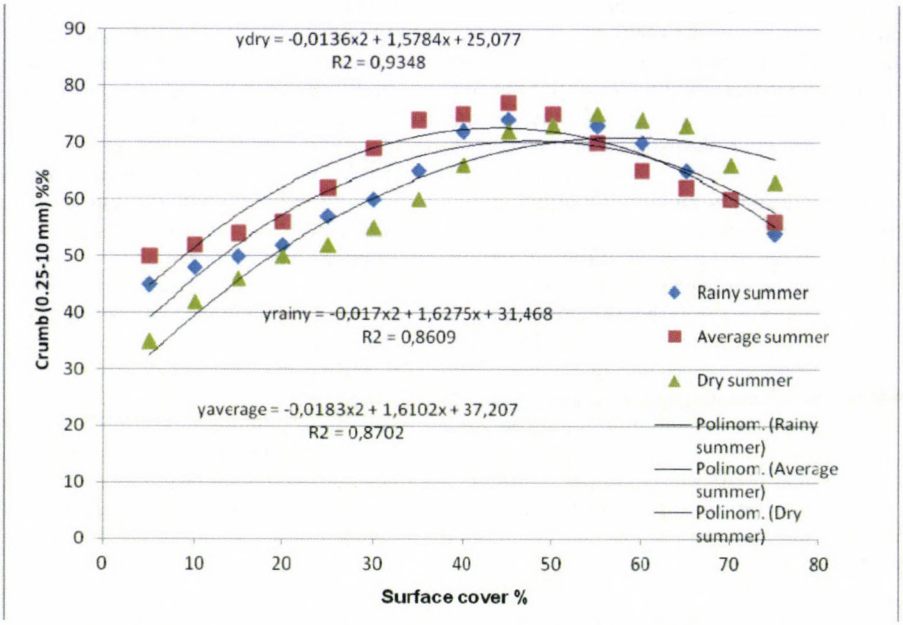

Figure 3. Surface cover ratio impact on soil crumbliness in different summer periods (Hatvan, 2004-2012)

The latest advertisements aim at the maize stalk. It is dangerous to store stalk close to the growing land up to the following summer because of the corn-borer risk. It was established in 2012 that the corn stalk (with the knowledge of its values) is necessary as roughage as well. In a dry autumn the soil-surface protection must not be neglected on the maize stubble either. It is a precondition that – to assist the moistening-up – the soil shall rest under the shred layer for several days.

Conclusions

1. The sustainable plant growing can be achieved only with positive soil-carbon balance.
2. If x t carbon is removed from the system, the same amount must be given back there.
3. Energy dependency of Hungary is a fact and rational solutions must be found, without endangering the foodstuff production of the country and the connected incomes.
4. If the stubble residues are planned to use for a long-term energetic purpose as well, its conditions have to be regulated (once from a land by 5 years).
5. If the gathering of the landscape-destructive biomass or the plants blocking the canals etc. were considered by the interested ones as well, Hungary would be competitive with the well-kept landscape against any other country.
6. From the willow and poplar experiments in Gödöllő, it can be seen that the protection as well as the improvement of soil quality can be achieved.
7. The energy grass and reed, the tree species of short cutting age in unsuitable areas for foodstuff production are cultivated biotopes and, in addition, they improve the micro-climate and the landscape.

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