SOIL LOSSES AND SOIL DEGRADATION PROCESSES CAUSED BY HARVEST OF SUGAR BEET

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Abstract: Soil loss due to crop harvesting (SLCH) leads to the reduction of substrate fertile layer. SLCH study started recently in soil erosion research. The goals of this investigation were to assess SLCH for sugar beet grown at three locations in eastern part of Croatia and to determined possible differences in nutrients decay for soil and soil tare samples. Average SLCH values were in the range from 1.3 t ha^{-1} to 2.3 t ha^{-1}. Significantly higher contents of organic matter, total nitrogen, plant available phosphorus and potassium were determined in soil tare samples than in soil samples where sugar beet grown.

Keywords: nutrient content, SLCH, soil loss, soil tare, sugar beet

Introduction

Most soil erosion investigations are focused on soil loss caused by water, wind or tillage. Also, significant amounts of soil could be lost from arable land during the harvesting of sugar beet, potatoes and chicory roots. The studies of soil loss due to crop harvesting (SLCH) were conducted in Europe (Auerswald et al., 2006; Ruysschaert et al., 2007) and Asia (Li et al., 2006). The soil tare (*i.e.* the relative amount of soil adhering to sugar beet after harvest), based on clean beet mass, is usually the highest for beet grown on heavy soils (Vermeulen et al., 2003). SLCH leads to the reduction of substrate fertile layer and that can eventually lead to the relief depression, or to complete loss of soil. Parlak et al. (2008) estimated the cost of soil and plant nutrients lost due to sugar beet harvesting in Turkey. They noted that SLCH has reduced the thickness of soil profile and that farmers should be informed about the significance of minimizing soil tare on sugar beet fields by training them to improved sugar beet growing methods and mechanization. The objectives of this research were: to assess SLCH for sugar beet grown in eastern Croatia and to determine possible differences in nutrients (total nitrogen, organic matter, plant available phosphorus and potassium) decay for soil and soil tare samples.

Materials and methods

This study was carried on three locations near Vukovar in eastern part of Croatia. Investigations were done on the following soil types: Eutric cambisol typical on loess (Nijemci location – N: 45°08´ E: 19°01´), Chernozem calcaric (Miklusevci – N: 45°15´ E: 19°04´) and Eutric cambisol (Ovcara location – N: 45°16´ E: 19°04´). Soil sampling was conducted after sugar beet (*Beta vulgaris* L.) harvest in November 2008. At each location composite soil samples were taken from one depth (0-30 cm) in four replications. For 50 roots, randomly chosen, soil tare was measured in the field immediately after harvesting by weighing gross crop mass (mass of root plus mass of moist soil), washing the roots and weighing the individual root again. The soil moisture content (SMC) was measured eight times by penetrologger (Eijkelkamp, 2007). Soil

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samples and soil tare samples for physical and chemical analysis were air dried, milled, sieved and homogenized (ISO 11464). Texture was determined by sieving and sedimentation method according to ISO 11277 (modified). Total nitrogen (TN) content was determined by dry combustion method (ISO 13878). Plant available phosphorus and potassium were extracted by ammonium lactate (AL) solution (Egner et al., 1960) and detected by spectrophotometric and flame photometric, respectively. Organic matter (OM) was determined by wet oxidation method with potassium dichromate (ISO 14325 modified). Observed data were subjected to analysis of variance (ANOVA) using SAS Institute 9.1.3 and mean values were separated by Fisher's LSD test at $P \leq 0.05$.

Results and discussion

The results of soil loss due to crop harvesting (SLCH) and soil moisture content (SMC) are shown in *Table 1.* Average SLCH varied from 1.3 t ha^{-1} at Ovcara location to 2.3 t ha^{-1} at Miklusevci location. Soil loss depends mainly on soil type, soil moisture content, characteristic of the beet and the skill of machine-operator to properly adjust the machine to the prevailing harvesting conditions. Average SLCH values in Belgium (Poesen et al., 2001), Nederland (Ruysschaert et al., 2005) and Turkey (Oztas et al., 2002) were respectively 8.7, 5.9 and 3.8 t ha^{-1}. Compared to Europe results, manual harvesting for sugar beet in northeast (NE) China leads to average soil losses of 1.0 tha^{-1} (Li et al., 2006). They concluded that differences in soil loses between Europe and China can be attributed not only to differences in harvesting technique but also to agronomic practices such as the growth of sugar beet on ridges in NE China as opposed to flat seedbeds in Europe. The highest SMC content (35.0%) was recorded at Miklusevci location where the highest SLCH value was also recorded. Li et al. (2006) reported positive correlation between SLCH and moisture content (R^2= 0.5).

Table 1. Soil loss due to crop harvesting (SLCH) and values of soil moisture content per locations

	SLCH (t ha^{-1})			SMC (%)		
	Nijemci	Miklusevci	Ovcara	Nijemci	Miklusevci	Ovcara
Average	1.5	2.3	1.3	30.3	35.0	31.3
Median	1.3	0.0	0.0	30.5	35.0	31,5
Min	0.0	0.0	0.0	28.0	34.0	30.0
Max	11.0	23.0	9.0	32.0	36.0	33.0
SD	2.806	3.852	2.123	1.488	0.756	1.165
n	50	50	50	8	8	8

n = number of observations; SMC = soil moisture content.

Soil texture for Miklusevci and Ovcara locations was silty clay (*Table 2.*), while for Nijemci location was clay loam texture. For all three investigated locations significantly higher content of coarse send was recorded in soil tare samples than in soil samples where sugar beet grown. Li et al. (2006) found out positive correlation between SLCH and sand percentage, and also negative correlation between SLCH and clay percentage. These results are in contrast with findings that were reported by Poesen et al., (2001).

Table 2. Texture and particle size distribution for soil and soil tare samples per locations

	Texture class	Particle size distribution (%)			
		Coarse sand (2-0.2 mm)	Fine sand (0.2-0.02 mm)	Silt (0.02-0.002 mm)	Clay (< 0.002 mm)
	Nijemci				
Soil	Clay loam	0.155 b*	41.7 a	32.7 a	25.8 a
Soil tare	Clay loam	0.870 a	42.5 a	32.9 a	24.0 a
	Miklusevci				
Soil	Silty clay	0.093 b	38.7 a	33.5 a	27.6 a
Soil tare	Silty clay	0.258 a	36.5 a	33.8 a	26.9 a
	Ovcara				
Soil	Silty clay	0.145 b	40.8 a	31.8 a	27.2 a
Soil tare	Silty clay	0.386 a	43.1 a	30.0 a	26.6 a

*Values are means of 4 replicates. Values in the same column for each parameter and each location followed by an identical letter are not significantly different according to Fisher's LSD test ($P \leq 0.05$).

Content of total nitrogen, organic matter, plant available phosphorus and potassium of soil and soil tare samples are shown in *Table 3.* For all three investigated locations significantly higher content of plant available potassium, organic matter and total nitrogen were recorded in soil tare samples than in soil samples where sugar beet grown. The reason is probably contribution of organic rhizodeposition. A large proportion of the photo synthetically fixed carbon can be translocated to the root system. Out of this carbon fraction, substantial proportion can be release into the root environment (Liljeroth et al., 1994). Organic rhizodeposition comprises lysates of sloughed-off cells and dead tissues as well as exudates, released from intact root cells either passively as diffusates or actively as root secretions or excretions.

Table 3. Chemical properties of soil and soil tare samples per locations

	P_2O_5 (mg kg^{-1})	K_2O (mg kg^{-1})	OM (%)	TN (%)
Nijemci				
Soil	71.2 b*	209.0 b	1.62 b	0.125 b
Soil tare	120.7 a	602.7 a	3.53 a	0.220 a
Miklusevci				
Soil	70.6 a	225.3 b	2.05 b	0.149 b
Soil tare	72.8 a	463.4 a	2.30 a	0.162 a
Ovcara				
Soil	175.3 b	257.3 b	2.00 b	0.148 b
Soil tare	323.3 a	592.0 a	2.45 a	0.177 a

*Values are means of 4 replicates. Values in the same column for each parameter and each location followed by an identical letter are not significantly different according to Fisher's LSD test ($P \leq 0.05$).

Significantly higher content of plant available phosphorus was recorded at Nijemci and Ovcara locations in soil tare samples than in soil samples where sugar beet grown. The reason is probably mucilage, which can to same extent promote phosphorus desorption from clay minerals (Matar et al., 1967). Parlak et al. (2008) also determined content of TN, OM, phosphorus and potassium in soil tare samples and calculated annual cost of these losses (US$ 204 158) in terms of fertilizer.

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Conclusions

- Soil loss due to crop harvesting (SLCH) varied from 1.3 t ha^{-1} at Ovcara location to 2.3 t ha^{-1} at Miklusevci location.
- The highest soil moisture content (35.0%) was recorded at Miklusevci location were the highest SLCH value was also recorded.
- Nutrient content in soil tare samples was influenced by root rhizosphere. Significantly higher contents of organic matter, total nitrogen and plant available potassium were determined at all three investigated locations in soil tare samples than in soil samples where sugar beet grown. Significantly higher content of plant available phosphorus was determined in soil tare samples than in soil samples where sugar beet grown for two locations (Nijemci and Ovcara).
- Nutrient decay by soil tare samples was noted and significant cost saving can be achieve by using adequate agriculture management system.

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