The Cost of Soil Lost Caused by Sugar Beet Harvest: A case study for Turkey

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Abstract: Studies related with soil loss due to crop harvesting have been recently included in soil erosion investigations. Harvest of root crops like sugar beet causes significant soil loss. This study was conducted to determine soil loss and to estimate the economic value of related losses of plant nutrients during 2005. Soil losses were compiled from the reports of the General Directorate of the Turkish Sugar Industry. According to these reports, 47 866 t soil per year was transported from sugar beet fields in Ankara province, for which economic value of plant nutrients was estimated to be US$ 204 158. The estimated values for Turkey are approximately 951 000 t and 4 056 203 US$ for soil loss and the economic value of lost N, P, and K.

Key Words: Soil loss, soil erosion, sugar beet, soil tare, Turkey

Introduction

The impacts of agricultural activities on soil degradation processes have received considerable attention. Significant soil losses occur also during the harvest of crops such as sugar beet (Beta vulgaris L.), potato (Solanum tuberosum L.), carrot (Daucus carota L.), onion (Allium cepa L.), radish (Raphanus sativus L.), and leek (Allium porrum L.). Fine earth adhering to the crop and loose soil and rock fragments are harvested and removed from the field together with the crop (Auerswald et al. 2006, Li et al. 2006, Poesen et al. 2001, Ruysschaert et al. 2004, 2005, 2006).

Although soil loss due to crop harvesting (SLCH) may be the same order of magnitude as water and tillage erosion values, few studies have incorporated SLCH as a soil erosion process. Mean SLCH values for sugar beet calculated from soil tare data measured in sugar factories were 6 t ha⁻¹ harvest for the Netherlands, 14 t ha⁻¹ harvest for France, 9 t ha⁻¹ harvest for Belgium and 5 t ha⁻¹ harvest for Germany for the period 1978-2000 (Ruysschaert et al. 2005), and 3.8 t ha⁻¹ harvest for Turkey (Oruç and Güngör 2000, Öztas et al. 2002).

Sugar beet harvest is done mechanically in European countries. Harvest is also being mechanized in Turkey, but small producers are still harvesting by hand.

The on- and off-site environment and economic consequences of SLCH are considerable. On-site, valuable top soil is lost from the field. Added to soil loss caused by other soil erosion processes, the critical soil loss tolerance level may be exceeded, resulting in...
a lowering of the soil profile and related consequences, such as decline of crop productivity. Moreover, plant nutrients and soil organic matter are removed together with the exported soil, which ultimately will have to be replenished by the farmer, resulting in an additional cost (Oruç and Güngör 2000, Öztas et al. 2002). SLCH also has negative off-site consequences for the environment. Ruysschaert et al. (2004) attributed these consequences to 1) transport of soil, causing energy loss and air pollution, 2) cleaning of the soil from the beet, resulting in energy and water loss, 3) storage of soil in sediment ponds, which causes loss of space and odor nuisance and finally 4) disposal of the soil, which may spread diseases and pollution.

Five hundred million tons of soil rich in plant nutrients are carried away by water erosion every year in Turkey (Cangir et al. 2000). Sugar beet production in Turkey is 9 331 850 t in 2005 (Anonymous 2006). An average soil tare for sugar beet in Turkey was 10.19 % of the gross weight of the sugar beet harvested in 2005 (Anonymous 2006). This indicates that about 951 000 t of soil rich in organic matter and plant nutrients are lost annually in Turkey (Anonymous 2006). This represents 0.19 % of the soil lost by water erosion in Turkey.

The objectives of our study were to estimate the cost of soil and plant nutrients lost due to sugar beet harvesting in Ankara province and in Turkey.

**Materials and Methods**

Ankara province is located at 39° 57’ N latitudes and 32° 53’ E longitudes in Central Turkey. There is about 9170 ha of sugar beet growing area in Ankara and the total production is approximately 455 000 t in 2005 (Anonymous 2006). Sugar beet production of Turkey in 2005 was 9 331 850 t and planting area was 221 950 ha (Anonymous 2006). Long term means of monthly precipitation and temperature of the research area are 399.2 mm and 11.8 °C, respectively (Anonymous 2005). Sugar beet is harvested within October and November in Ankara. The amount of rainfall during the harvesting period of 2005 was 28 and 48.1 mm, respectively.

The amounts of soil tare for 2005 were calculated from the data of the General Directorate of Turkish Sugar Industry (Anonymous 2006). Soil tare was calculated as;

\[
\text{Soil tare} = \text{total mass delivered by the growers} - 5\% \text{ top tare (percentage of the gross delivery)} - \text{mass of beet processed by the sugar factories (Oruç and Güngör 2000)}. 
\]

The amounts of plant nutrients in soil lost by harvest were estimated by analyzing soil samples taken from the delivery sites. Twenty one adhering soil samples were collected from seven different sugar beet delivery sites in Ankara province in November 2005.

The soil samples were air-dried, sieved to remove soil particles > 2mm, and stored in air-tight plastic boxes until analysis. Organic matter was determined by oxidation with potassium dichromate (Nelson and Sommers 1982). Total nitrogen was determined by Kjeldahl automatic analyzer using the Bremner method (Bremner 1962). Total phosphorus was determined calorimetrically according to the method of Olsen and Sommers (Olsen and Sommers 1982). Exchangeable potassium was carried out following the procedures described by Thomas (1982).

**Results and Discussion**

Sugar beet production in Ankara province, Turkey was 455 000 tons from 9170 ha land, in 2005 (Anonymous 2006). Soil tare was estimated 10.52%, which equals to 47 866 t (5.22 t ha\(^{-1}\)) soil that has been lost in a year. Using the same method the soil tare for the whole of Turkey was estimated as 10.19%. The annual sugar beet production of Turkey is 9 331 850 t which translates to about 951 000 t (4.28 t ha\(^{-1}\)) of soil removed annually (Anonymous 2006).

Organic matter, total nitrogen, total phosphorus and exchangeable potassium results of the soil samples are given in Table 1.
Table 1. Some chemical properties of soil samples collected in Ankara (n=21).

<table>
<thead>
<tr>
<th>Soil chemical property</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Coefficient of variation (%)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter (%)</td>
<td>3.44</td>
<td>1.95</td>
<td>56.68</td>
<td>1.38</td>
<td>7.87</td>
</tr>
<tr>
<td>Total N (mg kg⁻¹)</td>
<td>1719</td>
<td>975</td>
<td>56.72</td>
<td>690</td>
<td>3940</td>
</tr>
<tr>
<td>Total P (mg P₂O₅ kg⁻¹)</td>
<td>1469.2</td>
<td>349</td>
<td>23.75</td>
<td>870</td>
<td>2322</td>
</tr>
<tr>
<td>Exchangeable K (mg K₂O kg⁻¹)</td>
<td>1707</td>
<td>717</td>
<td>42</td>
<td>542</td>
<td>3157</td>
</tr>
</tbody>
</table>

Table 2. The cost of N, P, and K losses associated with soil loss due to sugar beet harvesting for Ankara province

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Losses (kg)</th>
<th>Fertility equivalents</th>
<th>Unit price* (US$ t⁻¹)</th>
<th>Total cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nitrogen</td>
<td>82.281</td>
<td>178.87 t urea (46%)</td>
<td>413</td>
<td>73873</td>
</tr>
<tr>
<td>Total P₂O₅</td>
<td>70.324</td>
<td>163.54 t triple superphosphate (43%)</td>
<td>370</td>
<td>60509</td>
</tr>
<tr>
<td>Exchangeable K₂O</td>
<td>81.707</td>
<td>163.41 t K₂SO₄ (50%)</td>
<td>427</td>
<td>69776</td>
</tr>
</tbody>
</table>

Total 204.158

* Unit price of fertilizer was calculated according to commercial sale value.

Texture of sugar beet cultivated area soils of Ankara Sugar Factory are generally clay, clay loam, and silty clay loam (Munsuz et al. 1996).

Table 2 shows annual soil and plant nutrient losses by sugar beet harvest in Ankara. Estimated annual costs of these losses are US$ 204 158 in terms of fertilizer. 951 000 t of soil has been removed in Turkey due to the sugar beet production and it is estimated that it resulted in US$ 4 056 203 loss (Annual soil loss in sugar beet production in Turkey) x US$ 204 158 (The cost of annual soil loss in sugar beet production in Ankara province) / 47 866 t (Annual soil loss in sugar beet production in Ankara province) in terms of N, P and K nutrients.

Öztas et al. (2002) calculated the annual fertilizer cost in Erzurum due to the plant nutrient loss as US$ 7500. Because of both increasing fertilizer costs in Turkey and controlling factors of SLCH (soil, plant, agronomic practices and harvest technique), cost figures are different from ones of Öztas et al. (2002). Commercial fertilizer-produce cost relation has to be considered in fertilizer use. Cost of commercial fertilizer was 6.6 times more in 2003 than in 1999, but cost of 6 different produce was only 3.8 times expensive (Kacar 2004). As long as agricultural produces do not have their real value, it is unreasonable to expect growers to allocate more money to fertilizers and increase their use.

**Conclusion**

The farmers should be informed about the significance of minimizing soil tare on sugar beet fields by training them on improved sugar beet growing methods and mechanization.

Sugar beet has been produced for over 80 years in Turkey. Undoubted SLCH has reduced the thickness of soil profile. This fact has to be taken into account in soil loss estimates.

**References**


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