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Soil losses due to carrot harvesting in south central Turkey

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ABSTRACT

Harvest of root crops such as carrots (*Daucus carota* L.), sugar beets (*Beta vulgaris* L.), potatoes (*Solanum tuberosum* L.), and turnips (*Brassica rapa*) may cause significant losses of soil from croplands. The soil loss due to crop harvesting (SLCH) may be as severe as that by water, wind, and tillage erosion, but experimental data on SLCH, particularly due to carrot harvesting, are limited. Thus, we quantified soil losses due to carrot harvesting in the Konya Basin, south central Turkey, and discussed its implications for the sustainable management and conservation of croplands in the region. About 60% of carrot in Turkey is produced in the Konya Basin. During the harvest season in November 2013, carrot was harvested manually and mechanically at four representative locations and soil removed with the carrot roots was determined. Results showed that the mean annual soil loss was 22.4 Mg^{-1} ha^{-1} for manual and 14.0 Mg^{-1} ha^{-1} for machine harvesting. It is important to note that these large losses of soil due to carrot harvest occur every four years because carrot is grown in a four year rotation with other crops in the study region. Under manual harvesting, clay and soil organic matter content explained 76% of the variability in SLCH. Under machine harvesting, crop yield and the liquid limit of the soil explained 50% of the variability of SLCH. Overall, manual and machine harvests of carrot roots cause significant losses of soil, and can be an important contributor to the total soil erosion in the study region.

1. Introduction

Soil erosion leads to major changes in physical, hydrological, chemical, and biological processes, adversely affecting long-term soil productivity. Intensive agriculture is one of the leading anthropogenic activities that cause soil erosion (Blanco and Lal, 2008). One of the sources of soil erosion in agricultural systems can be the soil loss associated with the harvesting of root crops and tuber crops including carrot (*Daucus carota* L.), potato (*Solanum tuberosum* L.), sugar beet (*Beta vulgaris* L.), witloof chicory (*Cichorium intybus* L.), cassava (*Manihot* spp.), sweet potatoes (*Ipomoea batatas* (L.) Lam), yam (*Dioscorea* spp.), radish (*Raphanus sativus* L.), and black salsify (*Scarzonera intybus* L.). Harvesting of root crops may not only cause soil erosion by exporting soil with roots but also by increasing the susceptibility of the soil to water and wind erosion by loosening the soil.

The intensity of SLCH can vary strongly from one crop to the other, and from region to region. For instance, mean SLCH for sugar beet equals 14 Mg ha^{-1} $year^{-1}$ in France and 1 Mg ha^{-1} $year^{-1}$ in China, 2.5 Mg ha^{-1} $year^{-1}$ for potatoes in Russia, 11.9 Mg ha^{-1} $year^{-1}$ for witloof chicory in Belgium, and 3.4 Mg ha^{-1} $year^{-1}$ for cassava in Uganda (Ruysschaert et al., 2007a). The SLCH can also differ with harvesting techniques and soil type. Ruysschaert et al. (2007a) reported that SLCH values for manually harvested sugar beet, potato, cassava and sweet potato in China and Uganda were generally smaller than SLCH values for mechanically harvested sugar beet, potato and witloof chicory roots reported in Belgium and France. The SLCH value was 5.94 Mg^{-1} ha^{-1} $harvest^{-1}$ for onions in Haplic and Gleyic Fluvisols in Tanzania (Mwango et al., 2015) and 1.81 Mg^{-1} ha^{-1} $harvest^{-1}$ for potato in Calcaric Fluvisols in Turkey (Parlak and Blanco-Canqui, 2015). The large variation in SLCH warrants further studies for different crops, soil types, management practices, cultural operations, and climatic conditions.

Carrot is an important vegetable in Turkey. The total area under carrot and turnip cultivation in this country is about 30,000 ha, which is 2.5% of the world carrot and turnip cultivated land (FAO, 2012). About 60% of the total production of carrot in Turkey is from the Konya Basin in south central Turkey (TUIK, 2013). Although some studies report on soil losses due to sugar beet harvesting in Turkey (Oruc and Gungor, 2000; Oztas et al., 2002; Zengin et al., 2003; Parlak et al., 2008; Oruc, 2012), no study has assessed soil losses due to carrot harvesting.

It is also important to better understand the factors that affect soil loss due to carrot harvesting. Identifying specific soil properties or agronomic parameters that affect SLCH can be useful to predict SLCH such that appropriate management strategies can be developed for the region. Ruysschaert et al. (2004) classified the factors controlling SLCH for sugar beet into four main categories: 1) soil (e.g. soil texture, soil moisture content at harvest, organic matter content, $CaCO_3$ content),

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2) crop characteristics (e.g. root shape), 3) agronomic practices (e.g. plant density, crop yield), and 4) harvest technique (e.g. type and size of harvester, harvesting speed). Similar predictive factors may influence soil loss from carrot harvesting. Yet, experimental data on the factors or soil properties affecting soil loss under carrot harvest are limited.

The objectives of this study were: 1) to quantify the amount of the soil lost due to manual and machinery harvesting of carrot in south central Turkey, 2) to determine the factors affecting carrot harvest soil loss, and 3) to discuss the SLCH implications for carrot growers in the region.

2. Materials and methods.

2.1. Description of the study area

This study was conducted in Kasınhanı, Cumra, Carıklar and Boruktolu regions of the Konya Basin in south central Turkey (Fig. 1). The Konya Basin (37°38'N, 33°35'E) is on the southern side of the Central Anatolian Plateau at an altitude of around 1000 m above sea level. Mean annual precipitation is 315.9 mm, total evaporation is 981.2 mm, mean annual temperature is 12.3 °C, and mean annual soil temperature at 50 cm depth is 13.2 °C (DMI, 2014). Soil moisture and temperature regimes are xeric and mesic, respectively (USDA, 1999).

The study area consists of volcanic and sedimentary rocks (de Meester, 1970). The soil physicochemical and mineralogical properties in the Konya Basin were extensively studied (Driessen, 1970; de Meester, 1971; Inoue et al., 1998; Ozaytekin et al., 2012). Soils have originated from lacustrine and marine deposits and volcanic rocks, and have restrictive characteristics such as shallow depth, high clay content, poor drainage, and increased susceptibility to water erosion and salinization (Topraksu, 1978). Soil profiles in the study area mainly consist of A and C horizons and are classified as Entisols (USDA, 1999). The most common crops grown in the Konya Basin are wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), sugar beet (*B. vulgaris* L.), chickpea (*Cicer arietinum* L.), carrot (*D. carota* L.), potatoes (*S. tuberosum* L.), and turnip (*Brassica rapa* L.).

2.2. Sampling protocol and measurements

Soil and carrot samples for this study were collected in November 2013 (Fig. 1). Carrot fields were irrigated with sprinklers two days

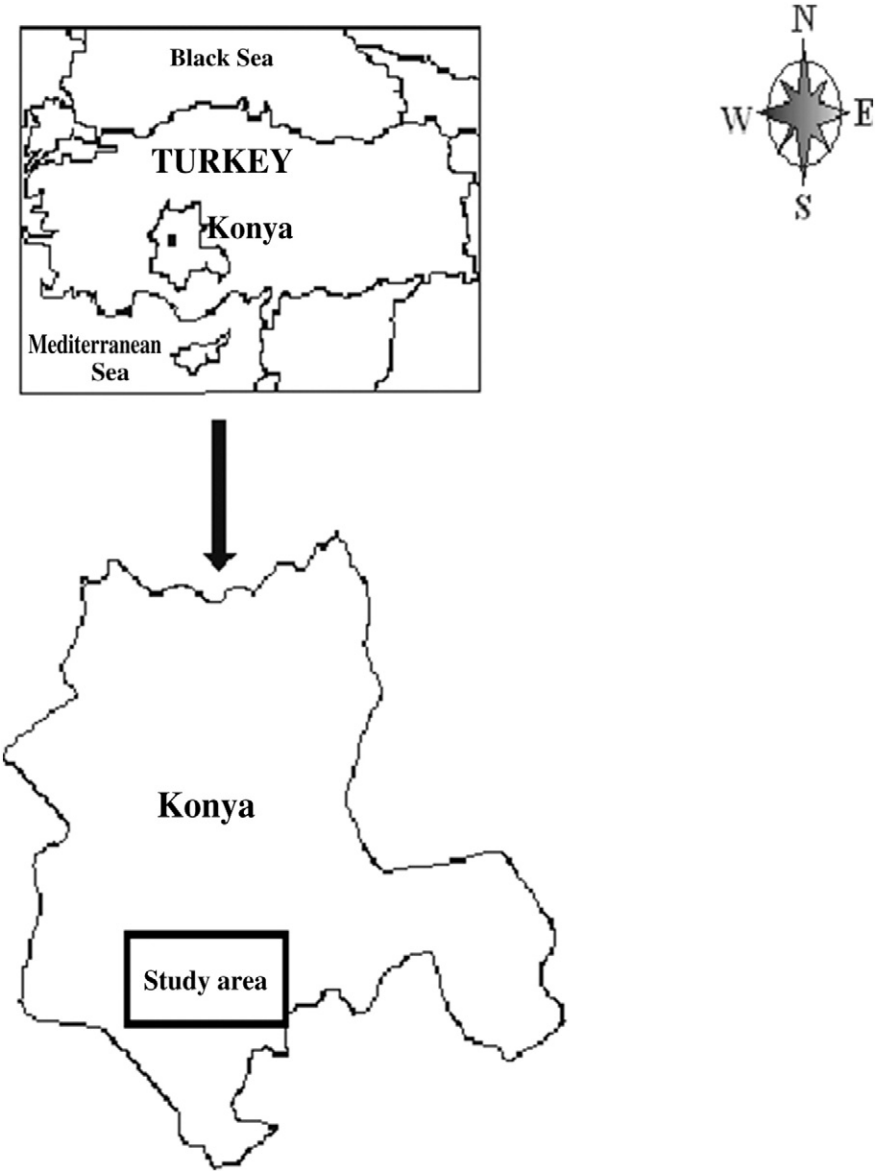

Fig. 1. Location of the carrot sampling sites within the Konya Basin in Central Anatolia, Turkey.