1.Introduction

Estimation of Carbon Footprint Equivalent of Soil Nitrogen Loss Due to the Sugar Beet Harvest in Turkey: A Review

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Abstract:
This paper is aimed to create awareness on the amount of soil lost due to the sugar beet harvest and fertilizer value of harvested soil nitrogen in terms of carbon footprint equivalent as well. Soil erosion studies on cropland usually only consider water, wind and tillage erosion However, significant amounts of soil are also lost from the field during the harvest of root crops such as sugar beet *(Beta vulgaris L.).* There are total of 33 sugar beet enterprise in Turkey, 25 of them run by the state (Türkşeker), eight of them belong to the private sector. According to the data of Türkşeker. It was given that average soil loss rate as 3.41 Mg ha-1 y-1, total loss of soil as≈716983 Mg y-1 and notably total amount of soil nitrogen loss as ≈2151 Mg y-1 from sugar beet growing areas of Türkşeker from 1996 to 2016. Global warming due to greenhouse gas emissions (GHG) has become very important concern of worldwide in 21th century. Production of nitrogenous fertilizer requires high energy consumption, emitting large amounts of CO_2 (carbon footprint equivalent) to atmosphere. The carbon footprint of the average N- fertilizer production in different regions of world varies from 3.42 Mg to 8.43 Mg while the world average given as 5.66 Mg CO_2 eq/Mg Nitrogen. In this study total amount of soil nitrogen loss≈2151 Mg y-1 and world average of carbon footprint 5.66 Mg CO2-eq./Mg of mix nitrogen fertilizer production were used to estimate annual carbon footprint equivalent. Hence, the annual carbon footprint equivalent is calculated as 12045 Mg CO_2 eq. /Mg Nitrogen fertilizer. Loss of fertile layer of soil due to the root crops harvest should also be considered as an important reason of land degradation. To minimize the soil loss from the most fertile layer in terms of organic matter, microbiological activities and plant nutrients, growers have to be enlighten that soil moisture should be taken into account in sugar beet harvesting, harvested piles should be covered to ensure good drying and soils separated by cleaning machines at delivery points should be conveyed back to their agricultural lands.These precautions would mitigate not only land degradation but also environmental impacts of climate change due to global warming.

Key Words: Sugar Beet Harvest, Soil-N Losses, Carbon Footprint, Turkey

Soil erosion studies on cropland usually only consider water, wind and tillage erosion However, significant amounts of soil are also lost from the field during the harvest of root crops such as sugar beet *(Beta vulgaris L.),* potato *(Solanum tuberosum L.)*, carrot *(Caucus caroto L.)* chicory roots *(Cichorium intybus L.)*, cassava *(Manihot spp.),* celery *(Apium graveolens L.)* Radish *(Raphanus sativus L.)* and sweet potato *(Ipomoea batatas (L.)*. Soil losses from the top and most fertile layer by harvesting sugar beet *(Beta vulgaris L.)* cause agricultural and environmental problems as well. During the harvest soil adhering to the crop, loose soil or soil clods and rock fragments are transported from the field (Figure 1). Main objective of this study is to assess (1) soil losses due to sugar beet harvest in Turkey, (2) fertilizer value of removed soil nitrogen in

terms of carbon footprint equivalent of soil nitrogen lost due to the sugar beet harvest in Turkey and to create the public awareness of global warming and climate change in this contex as well.

Figure 1. Soil adhering to sugar beet at harvest. Sugar Beet Factory Eskişehir,Turkey,Oct.2010.(Photo by N.Oruç)

2. Material and Method

Both, sugar beet and sugar industry have very significant place in Turkey's agriculture and agro-industry in terms of the technological, economic and social-economic development of rural areas. The sugar beet growing area is approximately 300.000 ha and about 15 million Mg of sugar beet processed annually in Turkey. The soil textures of sugar beet growing areas are generally clay and clay loam. Soils have pH values mostly medium alkaline, high lime content and low organic matter (Tuğrul et al. 2012). This study is fundamentally based on two reference (Saygın 2018), (Kool et al. 2012). Average value of soil loss as 3.41 Mg ha-1 y-1, total loss of soil as≈716983Mg y-1 and total amount of soil nitrogen loss≈2151 Mg y-1 was estimated due to sugar beet harvest between 1999 and 2016 from sugar beet growing areas of Türkşeker Enterprise (Saygın 2018). In the production of ammonia, which forms the basis of nitrogenous fertilizers, nitrogen is obtained from air and hydrogen from natural gas, both processes requires high amounts of energy. In the production of one Mg of nitrogen, the carbon footprint equivalent varies from 3.42Mg CO_2 to 8.43Mg CO_2 while the world average is 5.6 Mg CO_2(Kool et al. 2012). Total amount of soil nitrogen loss ≈ 2151 Mg y-1 and the world average ≈ 5.6 Mg CO_2 were used to calculate carbon footprint eq. of mix nitrogen fertilizers (such as urea, ammonium nitrate, ammonium sulfate etc..)

3. Results and Conclusion

3.1. Studies on soil losses due to sugar beet harvest in Turkey

Oruc and Gungor(2000) studied the soil loss due to the sugar beet harvest(SLCH) in Turkey about 20 years ago. It was estimated the soil tare values for the gross weight of harvested sugar beet as 10.24% and 11.20% for the period of 1989-1999 in Turkey and in Eskişehir Province, respectively. It meant that approximately

4.16 Mg ha-1 y-1 soil in Turkey and 4.8 Mg ha-1 y-1 soil in Eskisehir were transported from sugar beet fields annually. Oztas et.al.(2002) calculated that 3.48 Mg ha-1 of soil is removed due sugar beet harvest annually in Erzurum. Parlak et al.(2008) estimated that 5.22 Mg ha-1 y-1 soil exported from sugar beet fields in Ankara. Zengin et.al. (2001) assessed average soil tare as 3.42 Mg ha-1 y-1 in Konya and indicated that lower level of SLCH in Konya, than the SLCH values of Eskişehir and of Ankara that was related to less rainy months in beet harvesting period at Konya. Koc et al. (2012) carried a detailed research on the total soil amounts transported from the field for years from 2001 to 2008 that based on the 33 sugar factory data in Turkey. It was reported that the amount of soil transported from the field was calculated to be 3.86 Mg ha-1y-1from approximately 300,000 ha of sugar beet growing area in Turkey. Oruc (2012) assessed soil loss due to sugar beet harvest that based on annual reports of 33 sugar factories in Turkey for the years between 2000 and 2011. The study indicated that an average soil loss was as 4.65 Mg ha-1 with a Std= ±0.7. Since production of mineral fertilizers contributes to the global GHG emissions, Oruc (2013) estimated the fertilizer value of transported soil nitrogen in terms of carbon footprint equivalent due to the sugar beet harvest based on the data of 25 public and 8 private sugar factories in Turkey. Total soil N lost and total carbon footprint equivalent of ammonium nitrate (35%) were estimated as 20,157 Mg and 141,392 Mg, respectively. Saygın(2018) assessed soil loss due to sugar beet harvest and economic cost of the transported of plant nutrients based on the data of 25 state owned sugar beet factories for the period of from 1999 to 2016 in Turkey. Average value of soil loss as 3.41 Mg ha-1 y-1, total loss of soil as ≈ 716983Mg y-1 and total amount of soil nitrogen loss ≈ 2151Mg y-1(Median:0.3% Std±0.11) were calculated in the study. This result indicated that harvest erosion represents only 0.9% of soil lost by water erosion in Turkey. However, the average 3.41 Mg ha-1y-1 soil loss value was considered to be higher than the tolerable soil loss value of 1 Mg ha-1 y-1 for each of the studied sugar beet factories. The amount of suspended soil carried away by the rivers was measured by the General Directorate of State Hydraulic Works (DSİ). According to these measurements 154 million Mg of soil is transported by the streams in Turkey annually. This means that approximately 2 Mg of soil per hectare would be carried by rivers (Anonymous,2018).

Saygın(2018) also indicated that average soil loss rate was 3.41 Mg ha-1y-1 and US $419,433 investment which must be made annually to recover N-P_2O_5-K_2O losses. Parlak (2019) assessed the carbon footprint eq. value of fertilizers to replace nutrients lost with soil due to potato, carrot, and celery harvesting areas in Turkey. It was indicated that about $40x10^3$ Mg y -1of soil was lost annually through potato, carrot and celery harvest from the studied regions, which resulted in 32.93 Mg of N, 3.21 Mg of P_2O_5, and 7.69 Mg of K_2O losses per year. Fertilizer value of transported plant nutrients in terms of carbon footprint equivalent was estimated as about 270 Mg CO_2 per year. It was pointed out that due the large nutrient losses and GHG emissions deserve consideration of soil management practices to reduce SLCH. An over view of some SLCH values related to sugar beet harvest in Turkey and some of the European Countries is given in Table 1.

Table 1.Soil losses due to sugar beet harvesting (SLCH) in Turkey and EU countries.

Country/Region	SLCH Mg ha^{-1} (Min - max)	Measurement	Reference
Belgium	8.7 (4.4 - 9.5)	1968 - 1996	Poesen et al., (2001)
Belgium	9.3 (4.7 - 19.5)	1978 - 2000	Ruysschaert et al., (2005)
Belgium	8.5 (3.0 - 24.5)	1993 - 1995	Ruysschaert et al., (2007)
France	14.0 (2.0 - 44.3)	1984 - 1986	Ruysschaert et al., (2005)
Germany	5.2 (2.2 - 10.7)	1978 - 2000	Ruysschaert et al., (2005)

The Netherlands	6.2 (3.4 - 13.4)	1972 - 2001	Ruysschaert et al., (2005)
Croatia	1.3 - 2.3	2008	Jurisic et al., (2011)
Turkey (Eskisehir)	4.8	1999 - 2000	Oruc and Gungor (2000)
Turkey (Erzurum)	2.6	1990 - 2000	Oztas et al., (2002)
Turkey (Konya)	3.42	2000	Zengin et al., (2003)
Turkey (Ankara)	5.22	2006	Parlak et al., (2008)
Turkey (Ankara)	3.66	2004	Tugrul et al., (2012)
Turkey (Average)	4.54	2000 - 2008	Tugrul et al., (2012)
Turkey (Average)	4.65 (3.1 - 5.45)	2000 - 2001	Oruc (2012)
Turkey (Average)	3.41	1999 - 2016	Saygın (2018)

Note: SLCH values (except measurement for 2004 and 2008) based on factory data.

3.2. Studies on soil losses due to sugar beet harvest in European Countries

Several researchers have drawn attention to an often neglected, but apparently significantly soil erosion process, i.e., soil loss due to root crop harvests in last decades in European countries.. Poesen et al.(2001) reported the average SLCH value as 8.7 Mg ha^{-1} for Belgium between 1986 and 1996. Mean SLCH values for sugar beet that estimated from sugar factories data were 9.3 Mg ha^{-1} for Belgium, 14.0 Mg ha^{-1} for France, 6.2 Mg ha^{-1} for the Netherlands and 5.2 Mg ha^{-1} for Germany (Ruysschaert et al.2005, 2007). It was indicated that average SLCH values were in the range from 1.3 Mg ha^{-1} to 2.3 Mg ha^{-1} in Croatia (Jurisic et al. 2011). It was concluded that soil moisture content at harvesting time was one of the most important factor explaining SLCH variability, besides soil texture and harvesting technique. Panagos et al.(2019) indicated that SLCH for sugar beet has decreased significantly in the EU-28 from 15 Mg y−1 in the period of 1986–1999 to 9.6 Mg y−1 in the period of 2000–2016 (−36%) due to a sharp decrease in sugar beet production driven by changes in diets and sugar policy after 2006.

3.3. Carbon footprint equivalant of soil N lost

Global warming and climate change has become the most important challenge of the humanity in this century. Global climate change induced by global warming, triggers desertification, environmental degradation and migration.

Besides methane and nitrous oxides CO_2 is the most important greenhouse gas causing global warming. Among the factors that cause global warming and climate changes the amount of CO_2 released (carbon footprint equivalent) to the atmosphere during the production of nitrogenous chemical fertilizers is of great importance. Production of nitrogenous fertilizer requires high energy consumption, emitting large amounts of CO_2 to atmosphere. Annual carbon footprint equivalent calculated as CO_2 12174 Mg /Mg y-1 mix nitrogen fertilizer regarding to the total soil nitrogen loss≈2151 Mg y-1 and world average as 5.66 Mg CO_2 eq./Mg nitrogen production. This result seems rather small but it should not be ignored that many small make a great.

3.4.Conclusion

Loss of fertile layer of soil due to the root crops harvest should also be considered as an important reason of land degradation. To minimize the soil loss from the most fertile layer in terms of organic matter, microbiological activities and plant nutrients, growers have to be enlighten that soil moisture should be taken into account in timing of sugar beet harvesting, harvested piles should be covered to ensure good drying and soils separated by cleaning machines at delivery points should be conveyed back to their agricultural lands. These precautions would mitigate not only the land degradation but also socio-economic and environmental impacts in terms of global climate change as well.

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