International Soil and Water Conservation Research 4 (2016) 121–125

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Contents lists available at ScienceDirect

International Soil and Water Conservation Research

journal homepage: www.elsevier.com/locate/iswcr

Original Research Article

Effects of soil physical properties on soil loss due to manual yam harvesting under a sandy loam environment

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ARTICLE INFO

Article history:
Received 5 August 2015
Received in revised form
24 February 2016
Accepted 29 February 2016
Available online 31 March 2016

Keywords:
Heap bulk density
Manual yam harvesting
Soil degradation
Soil loss
Soil physical properties

ABSTRACT

Soil degradation is a growing problem worldwide because it reduces the fertile top layer of the soil available for food production and one such degradative action is soil erosion due to the harvesting of crops. Soil loss due to crop harvesting with particular reference to yam tubers has not been quantified globally despite the fact that yam is a major staple food consumed worldwide and it is prevalent in many parts of Nigeria. Harvesting yams in our environment is usually done with the soil attached to the yams due to the fact that farmers do not want additional work of removing soil attached to the yams. This study investigates the soil physical properties that influence soil loss due to yam harvesting in Abeokuta, South-Western Nigeria and to assess the quantity of soil loss due to yam harvesting. Based on representative sampling area per location, yam tubers were harvested manually within the entire yam farmland from October to December 2012. Gross weight, net weight and the amount of soil adhering to the yams were measured. Effects of soil physical properties such as soil moisture content, heap bulk density, inter-heap bulk density and soil texture were investigated with respect to soil losses. The results showed that moisture content ranged from 4% to 15%, heap bulk density ranged from 0.93 to 1.29 g cm^{-3} and inter-heap bulk density ranged from 1.03 to 1.50 g cm^{-3}. They all had a positive correlation with soil loss. Soil particle size analysis for Federal University of Agricultural, Abeokuta (FUNAAB) and Alabata revealed that sand content was (86.78% and 88.32%), clay content (10.69% and 7.6%) and silt content, (2.53% and 4.08%) respectively. Study also revealed that clay content of the soil positively influenced the total soil loss during the yam harvesting. The mean soil losses in Federal University of Agriculture, Abeokuta (FUNAAB) and Alabata village yam farms were 4303 and 2125 kg/ha/harvest respectively. The study also revealed that soil moisture content at harvesting time and clay content are the key factors affecting soil loss due to yam harvesting. Consequently, soil loss due to crop harvesting should be considered in soil erosion control strategies, sediment budget and for better post harvest procedures.

1. Introduction

Soil erosion is the removal of topsoil and in severe cases the subsoil by water, tillage, or wind. It is often the concern of farmers to maintain the topsoil since the quality of the topsoil is one of the factors affecting the growth of crops. Soil erosion is a growing problem worldwide because it reduces the fertile top layer of many agricultural lands available for food production and studies have shown that more than 99% of the world's food comes from agricultural lands (FAO, 2012).

A major area of soil erosion research which has received little attention is soil lost from farm land during the harvesting of root crops such as sugar beet, potato, carrot, onions, cassava and chicory (Mwango et al., 2015). During the harvesting of some of these crops, soil adhering to the crop, loose soil or clods and stones are exported from the field together with the harvested crop (Ruysschaert, Poesen, Verstraeten, & Govers, 2004, 2005, 2006). This process of detaching soil from the field where the crops are grown to locations such as markets, farmsteads and crop processing factories is known as Soil Loss During Crop Harvesting (SLCH). Yam

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Peer review under responsibility of International Research and Training Center on Erosion and Sedimentation and China Water and Power Press.

http://dx.doi.org/10.1016/j.iswcr.2016.02.007

is a tropical crop that has not been fully mechanised in most parts of Africa despite the fact that most of the world production of yam is from Africa (about 96%) with Nigeria alone accounting for nearly 71% (about 37 million tonnes) of the total world yam production (IITA, 2007) and yam production is rapidly declining due to loss of soil fertility.

Soil factors that influence soil loss during harvesting are attributed to texture, moisture content, structure and organic matter level. The shape and roughness of the crop could also influence the soil loss during harvesting operations. There is the possibility that soil loss during harvesting will increase with the size and shape of the tuber crops. Agronomic factors such as plant density and crop yield also have effects on the soil lost. Although SLCH is mostly overlooked in soil erosion and sediment budget studies, Poesen, Verstraeten, Soenens, and Seynaeve (2001) reported that SLCH for sugar beet and chicory roots can vary between a few to tens of mg ha^{-1} per harvesting event and that soil losses induced by crop harvesting could be of the same magnitude as soil loss by water or tillage erosion and this should not be disregarded in soil erosion control strategies. Soil losses during sugar beet harvesting ranges between 1.2 to 1.9 t ha^{-1} yr^{-1}, and 0.2 to 0.39 t ha^{-1} yr^{-1} for potato harvesting (Li, Ruysschaert, Poesen, & Zhang, 2006). In a study carried out in Tanzania, soil loses due to harvesting of carrot, onion and potato, were 7100, 3800 and 700 kg/ha/harvest (Mwango et al., 2015) and it was concluded that soil water content during onion harvesting played a major impact on soil loss but for carrot and potato, the effect of moisture content was not significant which can be as a result of time of harvesting or the moisture condition of the soil. A study in Uganda also revealed a soil loss from cassava harvesting with an average of 3400 kg/ha/harvest (Isabirye et al., 2007) representing a huge amount of soil degradation. Despite the assessment of soil losses in tuber and root crops in many parts of the world, there is very little information on soil losses during manual yam harvesting, the need then arises to embark on this study to evaluate losses of soil from harvested yam fields and investigate the soil physical properties influencing it.

2. Materials and method

2.1. Site description

The experimental sites for this project were situated within the Federal University of Agriculture at Abeokuta (Latitude 7°14′ North and Longitude 3°25′ East) and Alabata, both in Odeda local Government Area Abeokuta, Ogun State, Nigeria (Fig. 1). Land slope of the locations varied between 2% and 3%. The vegetation is mainly secondary forest. The annual rainfall is 1200 mm. Particle size distribution investigated revealed that the soil texture at both locations was sandy loam. The dominant soil in the study locations is classified as an *Alfisol.*

2.2. Sample protocol

Soil samples from the yam fields were taken in the mornings during the harvesting of the yams from the heaps. Twenty different spots at each location were used for sample collection. Yam tubers were carefully dug out of the heaps using small cutlasses and hands after cutting off the yam stems. The tubers are weighed with the soil attached and thereafter the soil adhering to the tubers is scraped off with a light stick and weight of soil and yam tuber measured with a spring balance. The soil samples collected are then packed into polythene bags and sealed for transportation to the laboratory for further investigation.

2.3. Determination of gravimetric moisture content from the yam heaps (GMC)

$$\text{GMC}(\%) = \frac{\text{mass of water}}{\text{mass of oven dried soil}} \times 100. \quad (1)$$

2.4. Heap bulk density and interheap bulk density

Bulk density samples from yam heaps and in between heaps were taken from yam fields at depths of 0–10 and 10–20 cm using cylindrical cores 7 cm diameter × 10 cm height (Blake & Hartge, 1986). Each of the samples were transferred into a moisture can, weighed and oven dried at 105 °C to constant weight. Thereafter the samples were reweighed to determine the mass of dry soil. Mathematically, bulk density was calculated using the relation below

$$\text{Bulk density } (g/cm^3) = \frac{\text{mass of dry soil}}{\text{volume of core}} \quad (2)$$

where volume of the soil core sampler $(cm^3) = \pi r^2 h$, where r is radius of soil core and h is the height (cm).

2.5. Particle size distribution

Particle size distribution was determined by Hydrometer method of Gee and Or (2002) to determine the soil textural class of the soil in the yam fields.

2.6. Measurement of plant density (PD) ha^{-1}

The plant density (PD) ha^{-1} was computed by multiplying the number of yam plants by 10,000 m^2 divided by the Experimental Plot Area (EPA).

$$\text{PD}\left(ha^{-1}\right) = \frac{\text{number of yam plants}}{\text{EPA}} \times 10,000. \quad (3)$$

2.7. Determination of average tuber yield (ATY)

This was computed as

$$\text{Average tuber yield (ATY)} = \frac{\text{netweight of yams}}{\text{number of yam tubers}} \quad (4)$$

2.8. Determination of mass tuber yield (MTY) kg ha^{-1} $harvest^{-1}$

This was computed by multiplying the plant density (PD) ha^{-1} with the Average Tuber Yield (ATY) kg.

Therefore,

$$\text{Mass of tuber yield (MTY)} = \text{PD}(ha)^{-1} \times \text{ATY}((kg). \quad (5)$$

2.9. Determination of total soil loss due to yam harvesting specific

Total soil loss due to yam harvesting specific $TSLYH_{Spec}$ is dimensionless (Ruysschaert et al., 2004).

$$\text{Total } SLYH_{Spec}\left(kg kg^{-1}\right) = \frac{M_{ds}}{M_{crop}}. \quad (6)$$

where M_{ds} = total mass of over-dried soil loss (kg) and M_{crop} = net mass of yam tubers (kg).