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Alternative method of reducing soil loss due to harvesting of sweet potato: A case study of low input agriculture in Nigeria

S.O. Oshunsanya

Department of Agronomy, University of Ibadan, Nigeria

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ABSTRACT

Soil loss due to crop harvesting (SLCH) has been established as an important soil erosion process that has contributed to soil degradation in many countries of the world. Consequently, researchers have recommended washing of harvested tubers before transporting to market place. Unfortunately, many low resource farmers could not adopt washing method due to scarcity of water during harvesting period (dry season), cost of additional labor and possible tuber spoilage when not dried on time. This has stimulated the need for alternative method of removing soil adhering to tubers. A field experiment was conducted between 2011 and 2012 on an Alfisol derived from basement complex parent rock to (i) compare effectiveness and efficacy of hand rubbing process with washing process of harvested potato tubers and (ii) examine sweet potato cultivar effects on soil loss during harvesting. Ten commonly grown cultivars of sweet potato in Africa were planted in an experiment laid out in a randomised complete block design with four replications. Total harvested tubers from each replication were weighed and shared into two equal weights of tubers for hand rubbing and washing respectively to remove soil sticking to tubers. Soil collected was analysed to estimate plant nutrients contained in it. All data collected on soil loss and cost of removing soil from tubers were analysed using ANOVA. Contribution of hand rubbed soil loss to total soil loss ranged from 93.2% (Ex-igbaraian) to 98.2% (Shaba) in 2011 and ranged from 95.4% (Benue) to 97.0% (TIS87/0087) in 2012. Total SLCH was significantly ($P \leq 0.05$) different among the cultivars and largely determined by the size of the tubers as significant ($P \leq 0.05$) correlation coefficient between yield and soil loss was obtained. Average soil nutrient losses for two growing seasons were 32.8 g org. C ha^{-1} $harvest^{-1}$, 10.0 g N ha^{-1} $harvest^{-1}$, 16.4 g P ha^{-1} $harvest^{-1}$, 6.3 g K ha^{-1} $harvest^{-1}$, 6.9 g Ca ha^{-1} $harvest^{-1}$, and 10.4 g Mg ha^{-1} $harvest^{-1}$. The average potato yield ranged from 2.0 t ha^{-1} (TIS 8441) to ≈0.2 t ha^{-1} (Akwide). Averagely, cost analysis of soil removal revealed that farmers would have saved ₦42, 600 ha^{-1} $season^{-1}$ and ₦36, 400 ha^{-1} $season^{-1}$ in 2011 and 2012 respectively by adopting hand rubbing technology instead of washing. Thorough hand rubbing of harvested tubers on the farm is suggested as an alternative to washing because the method removed about 96% of soil adhering to tubers. Developing potato harvesters that could mimic the hand rubbing process is suggested on large scale potato farms.

1. Introduction

Sweet potato spreads and covers soil surface and consequently reduces soil erosion by preventing direct impact of rain drops. Recently, tillage erosion has been studied extensively as a process of soil removal leading to land degradation with various adverse agricultural and economic effects (Ruysschaert et al., 2002; Auerswald et al., 2006; Mwango et al., 2014,2015a). In Nigeria, soil degradation has been reported to be a major problem facing the country (FDALR, 1999) with major focus on water erosion. Field observations by Poesen et al. (2001) in Belgium indicated a neglected but nevertheless important soil loss process: soil exported from the field sticking to harvested root and tuber crops such as potatoes (*Solanum tuberosum L.*), sugar beets (*Beta vulgaris*), chicory roots (*Cichorium intybus L.*), carrots (*Daucus carota*), sweet potato (*Ipomea batatas*), yam (*Discorea spp*) andcocoyam (*Colocasia esculenta*) which causes land degradation. Recently, researchers have estimated soil loss due to harvesting from farmlands to be 6 t ha^{-1} yr^{-1} (Bakker et al., 2007). Such losses could not be neglected, because large amounts of nutrients could be exported from the field during harvesting. For example, central Belgium has soil losses of between 8.1 and 11.8 t ha^{-1} per harvest representing 19.2% of all soil losses that have been reported

E-mail address: soshunsanya@yahoo.com (S.O. Oshunsanya).

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(Poesen et al., 2001). Many authors have made efforts to assess the soil losses caused by potato harvesting (Campbell, 1982; Belotserkovsky and Larionov, 1988; Biesmans, 2002). In addition, several studies have indicated that soil loss due to harvesting is of the same order of magnitude as water and tillage erosion under highly mechanised agriculture in Europe. For example, Auerswald and Schmidt (1986) reported an average soil loss of 6 Mg ha^{-1} harvest^{-1} caused by sugar beet harvest in Bavaria (Germany). Similarly, value of 8.7 Mg ha^{-1} harvest^{-1} for Belgium (Poesen et al., 2001) and 3.8 Mg ha^{-1} harvest^{-1} for Turkey (Oruc and Gungor, 2000; Oztas et al., 2002). Average soil loss due to crop harvesting (SLCH) values for collected data in Belgium are 8.1 Mg ha^{-1} harvest^{-1} for inuhne chicory, 11.9 Mg ha^{-1} harvest^{-1} for wit loof chicory (Poesen et al., 2001), 6.8 Mg ha^{-1} harvest^{-1} for black salsity (Soenens, 1997) and 15.8 Mg ha^{-1} harvest^{-1} for carrot (Soenens, 1997; Van Esch, 2003). Maximum observed SLCH values can exceed several tens of Mg ha^{-1} harvest^{-1}, indicating that SLCH may supersede water erosion if not arrested. Although, less soil loss due to crop harvesting was reported under low input agriculture as compared to mechanised agriculture (Ruysschaert et al., 2004, 2005, 2006; Isabirye et al., 2007; Mwango et al., 2015b).

Like other annual crops, cultivation of sweet potato is associated with soil degradation in the form of nutrient mining and soil loss due to water erosion (Stoorvogel and Smaling, 1991; Srivastava et al., 1996; Nkedi-Kizza et al., 2003; Ebanyat et al., 2003). Nutrient losses estimated due to sweet potato removal were 46 kg ha^{-1} year $^{-1}$ (N), 8 kg ha^{-1} year^{-1} (P) and 55 kg ha^{-1} year^{-1} (K) in Uganda (Wortmann and Kaizzi, 1998). Parlak et al. (2008) and Jurisic et al. (2011) estimated the cost of soil and plant nutrients lost due to sugar beet harvesting in Turkey. They noted that soil loss due to crop harvesting (SLCH) has reduced the depth of top soil and that farmers should be educated on how to minimise soil tare on sugar beet fields. Recently, Mwango et al. (2015b) reported that SLCH values were significantly highest in carrot (7.1 Mg/ha/harvest) followed by onion (3.8 Mg/ha/harvest) and least by potatoes (0.7 Mg/ha/harvest) in Tanzania. They concluded that SLCH could be reduced by avoiding harvesting of crops when soils are wet and sticky.

In Africa, there is a dearth of information on soil loss due to harvesting of sweet potato. FDALR (1999) argued that deep rooted tuber crops such as sweet potato are less sensitive to soil erosion, thus making them the preferred crops for eroded land. However, harvesting of sweet potato may lead to more soil degradation as a result of soil loss due to crop harvesting if caution is not taken. Recommended method of soil removal is washing of harvested potato right on the field before packing to the market place (Poesen et al., 2001; Li et al., 2006; Ruysschaert et al., 2006). However, this method of reducing soil loss can be hampered by scarcity of water during the dry season, cost of washing tubers and cost of drying especially during the wet season. Inability of farmers to spread and dry washed harvested potato tubers could lead to building up of moulds, which might encourage diseases that would finally reduce farmer's income if not properly handled. Therefore, it is pertinent to look for another method which is simple, cheap and sustainable for low input farmers who cannot afford the cost of washing tubers on the field. Hence, a thorough hand rubbing of harvested tubers is investigated as an alternative method of reducing soil loss due to harvesting of commonly grown cultivars of sweet potato in Africa.

2. Materials and methods

2.1. Description of the study area

The field experiment was conducted at the University of Ibadan campus in Nigeria between 2011 and 2012. Ibadan lies between latitude 7^0 25^1–7^0 31^1 N and longitude 3^0 51^1–3^0 56^1 E. The site has an altitude of 200 m above sea level. The rainfall pattern is bimodal and averages 1230 mm per annum. Rainfall peaks occur in June and September. There are two growing seasons; an early season runs from March/April to August and late season, from mid-August to October/November. Annual temperatures range from 31.2 to 21.3 °C. Ibadan has a percentage sunshine that ranges between16% in August to 59% in February and December with an average of 44%. The soil of the area was Iwo series derived from highly deformed igneous and metamorphic materials, typically referred to as basement complex rocks. The soil was classified as an Alfisol under subgroup Oxic Paleustalf according to the USDA classification (Soil Survey Staff, 2006). Rainfall monitoring was achieved by installing rain gauge directly on the field to record daily rainfall for 2011 and 2012 period of study (Fig. 1).

2.2. The experimental design and treatments

The field was laid out in a randomised complete block design (RCBD) with ten treatments (ten sweet potato cultivars) replicated four times. Each replicate occupied 5 m × 3 m plot size, resulting to 0.775 ha farmland. Each plot had 15 mounds at 1 m × 1 m spacing, resulting to 600 mounds for the ten cultivars investigated. The cultivars planted include Ex-igbaraiam, Benue, Akinima, TIS 87/0087, Eruwa, Arrow tip, Shaba, Ishiayi, TIS 844 and Akwide.

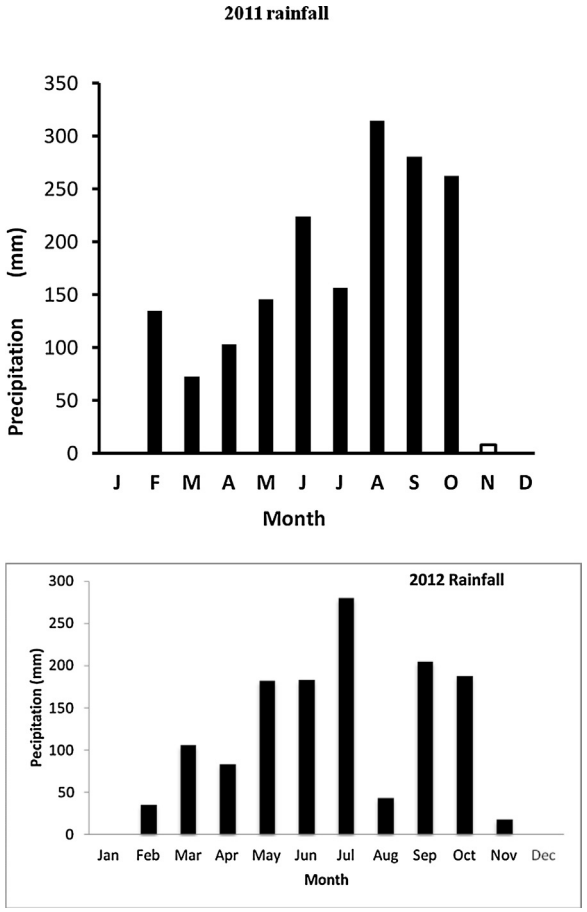

Fig 1. Precipitation depth (mm) recorded during sweet potato life cycle in University of Ibadan and indication of the measurement dates in 2011 and 2012.