A MARKET SURVEY OF SOIL TRANSPORTED WITH TUBER CROPS: SWEET POTATO AND COCOYAM AS A CASE STUDY

BY

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Abstract

Farmers typically transport harvested tubers with soil adhering to them to the market for sale. As a result, a market survey of soil transported with sweet potato and cocoyam tubers was conducted in Ibadan, Oyo State, Nigeria, to estimate the amount of soil loss during transportation to the market. Bodija and Moniya markets, where sweet potato and cocoyam tubers are marketed, were selected for the study.

Sweet potato and cocoyam were grown and harvested majorly in Niger, Taraba, and Plateau states (sweet potato) and Oyo, Osun, and Ogun states (cocoyam) and transported to the Ibadan metropolis for sales. Soils from the vehicle that transported the tubers, as well as soil from sacks, were packed and weighed separately at each location. Also, several tubers were counted per sack. Soils collected were analysed for physical and chemical properties. Data were subjected to statistical analysis.

The particle size distribution of cocoyam tuber differed significantly between soils transported from Oyo, Ogun, and Osun to Moniya market, but there was no significant difference between soils transported from Niger, Plateau, and Taraba to Bodija market.

The harvest of sweet potatoes and cocoyam that was transported from the farms to the market resulted in a considerable loss of soil and nutrients. Farmers are advised to handrub harvested produce before transporting it to the market to avoid soil and nutrient loss on the farm, as this can lead to low crop production, which is a precursor to food insecurity. Keywords: Food security, soil health, sustainable agriculture, food systems,

Introduction

The inefficient and haphazard use of soils is one of the main issues affecting agricultural productivity in developing nations like Nigeria nowadays. Soil loss due to crop harvesting (SLCH) is a phenomenon that occurs during the harvesting of some crops such as potato (*Ipomoea batatas* L. Lam), cocoyam (*Colocasia esculenta*), carrot (*Daucus carota* L.), groundnut (*Hypogaea arachis),* and yam (*Dioscorea spp.*) (Frost and Speirs, 1996; Poesen *et al.*, 2001). Though soil loss from wind or water erosion has been the most common degrading process of soil, very few studies have attempted to estimate the SLCH value for sweet potatoes and cocoyam. Soil erosion is widely recognised as a major land degradation process (Oldeman and van Lynden, 1998). Although there is another significant soil erosion process occurring on farmers' fields, namely soil losses due to crop harvesting (SLCH), water, tillage, and wind erosion are the processes that are most frequently studied as causing soil losses from farmlands (Eichler, 1994; Frost and Speirs, 1996; Poesen *et al.*, 2001).

Reduced soil quality results from soil holding onto harvested crops, particularly tuber crops, which are transported from the field with these crops. However, the decline in soil quality is caused by SLCH. Soil degradation is a global process that causes the depletion of nutrients and soil organic matter (Ora, 1968).

The physical characteristics of the soil, including its texture, greatly influence the yields of tubers as well as their shapes and overall aesthetic appeal (Kehr *et al.*, 1968). Some of the best soils for sweet potatoes are well-drained and well-supplied with organic matter and available nutrients (Ora, 1968). Despite its potential, as evidenced by its growth in production, sweet potatoes (Ipomoea batatas) are a minor root crop in tropical Africa. Among the root and tuber crops, it is the only one that had a positive per capita annual rate of increase in production in Sub-Saharan Africa (Tewe *et al.*, 2003). SLCH values of sweet potato processing range between 0.4 and 16.0 mg/ha harvest in Belgium, with an average of 2.0 mg/ha harvest. Biesmans (2002), who measured an average of 2.1 Mg/ha/harvest from 1999 to 2001, confirmed this. However, Biesmans (2002) reported that SLCH values of individual deliveries may rise to 32.9 Mg/ha/harvest. In Russia, the average soil loss caused by the potato harvest appeared to be 2.5 Mg/ha/harvest based on some field measurements in 1985 and 0.6 Mg/ha/harvest based on factory measurements in 1985 and

1986.

In the humid zone of Nigeria, at the National Root Crops Research Institute (NRCRI) and the International Institute of Tropical Agriculture (IITA), its high agronomic potential has been proven. During the past 25 years, Nigeria's production, marketing, and use of sweet potatoes (Ipomoea batatas) have spread beyond the country's traditional riverine and central zones to include humid, sub-humid, and semi-arid regions (Tewe *et al.,* 2003). The national production figures reported by FAO showed a rapid increase in production and area harvested in the 1990s, surpassing two million metric tonnes harvested from more than 300,000 hectares annually by the end of the decade (FAOSTAT, 2000).

The cocoyam (Colocasia esculenta), also called "taro" (Dutta), is an herbaceous root crop that is a member of the Araceae family. It grows to a height of 0.5 to 2 meters. It has underground round starchy corn, which produces at its apex a whorl of large leaves with long, robust petioles. The leaves are heart-shaped, and the corms, which vary greatly in size, are surrounded by several secondary corms (cormels). The root system is superficial. It is thought that India and other Southeast Asian countries are the origins of cocoyam (FAO, 1988). Nigeria is the world’s largest producer of cocoyam (FAO, 2000). The annual cocoyam production in Nigeria is about 4.5–5 million metric tonnes, and this accounts for about 37% of the world's output of cocoyam (FAO, 2007). Cocoyam is cultivated mainly for edible corms, while the leaves, petioles, and flowers are used in soup preparation (Eze and Maduewesi, 1990). According to the Food and Agriculture Organisation (2007), cocoyams have the smallest starch grains of any root or tuber, which makes them ideal for use in a variety of food products, particularly those intended for infants who may be allergic to gluten.

Limited research has assessed the quantity and quality of soils that have been transported to the market**.** Therefore, there is a need to conduct a market survey to determine the amount or quantity of soil nutrient loss when transported.

Materials and Methods

Description of the study areas

This research was carried out at the Department of Agronomy, University of Ibadan. Bodija and Moniya markets were used for the study. Tubers made of cocoyam and sweet potatoes were supplied to and sold at Bodija and Moniya, respectively. Sweet potato tubers were supplied from Niger, Taraba, and Plateau states, while cocoyam tubers were supplied from Oyo, Osun, and Ogun states.

Data collection

By offloading, the quantity of cocoyam and sweet potato tubers was estimated, and the tubers that were bagged in the sacks were weighed using a weighing scale. Sweet potatoes and cocoyam tubers were weighed at random, and the weight was used to estimate the total weight of tubers inside each sack, respectively. To calculate the total number of tubers in the sacks, the number of sweet potato and cocoyam tubers was counted during the offloading process. After unloading and packing the tubers from the sacks, the soils were weighed on a weighing scale, bagged, and labelled appropriately.
The bagged soils were then brought to the laboratory for a physical and chemical analysis. This process allowed for the determination of the soil loss.

Soil physical properties Particle size distribution

For each soil sample, the relative amounts of sand, silt, and clay were ascertained by particle size analysis using Bouyouco's hydrometer method (Day, 1965).

The procedure is as follows:

Samples of soil were run through a 2 mm sieve. Fifty grammes of air-dried soil samples were weighed into the decantation core.

i. Twenty millilitres of Calgon were added as a dispersing agent.

ii. Three hundred and fifty millilitres of water were added. iii. It

was stirred for 10 minutes with the aid of a mechanical stirrer.

iv. It was stirred and then poured through a funnel and sieve into a measuring cylinder. The soil particles that were collected on the sieve were transferred into a moisture can and placed in an oven. This was oven-dried at 105°C for 24 hours.

v. The mixture inside the sedimentation cylinder was made up to the 100-ml mark by the addition of water.

vi. The sedimentation cylinder was oscillated 60 times before allowing it to stand on a table.

Wet-bulb hydrometers were inserted at one-minute and two-hour intervals to obtain hydrometer readings, respectively. A thermometer was also used to record the temperature at each of the two intervals.

Determination of chemical properties Soil pH

Using a glass electrode pH meter, the pH of the soil was measured in a 1:1 soil and water mixture (Udo and Ogunwale, 1986). Ten grammes of air-dried soil passed through a 2 mm sieve were weighed into sample bottles. Ten millilitres (10 ml) of distilled water were added to the soil and placed on a mechanical shaker for 10 minutes before allowing it to stand for 15 minutes. To determine the pH of the soil, the partially settled suspension was filled with the glass electrode of a pH meter.

Organic carbon

Using the Walkley Black wet oxidisation method, the soil's organic carbon content was ascertained (Udo and Ogunwale, 1986). A half-gramme (0.5 g) of sieved soil was weighed into a conical flask. Ten millilitres of $K_2Cr_2O_7$ solution were measured into the flask and swirled gently to disperse the soil. After adding twenty millilitres (20 ml) of concentrated sulphuric acid, the flask was gently agitated to combine the soil and reagents. The sample was left to cool for 20 minutes before adding distilled water up to the 100-ml mark of the conical flask. Three drops of phenol indicator were added to the mixture before titrating the samples with a 0.5 N ferrous ammonium sulphate solution. As the endpoint was approaching, the solution gave a greenish colouration and then changed to dark green. At this stage, the ferrous ammonium sulphate was added in drops until the colour changed to maroon red. To standardise the dichromate, CrO, an identical blank titration was also performed without soil.

The organic matter content of the soils was obtained from organic carbon by multiplying the organic carbon value with the conventional Van Beminelar factor of 1.724.

Total nitrogen

Half a gramme (0.5 g) of 0.5 mm sieved soil samples was weighed into test tubes, respectively, and one tablet of selenium was added. The samples were cooked on the digestion stand for five hours (5 hours) until the digestion process was finished, and ten millilitres of concentrated sulphuric acid was also added. Chemical decomposition of the sample was indicated when the initially very dark-coloured medium became colourless. The samples were removed from the digestion stand and left to cool. The digests were made up to 50 ml and then transferred into sample cups. The next step involved distillation, utilising five millilitres of boric acid that had been weighed into Erlenmeyer flasks and set beneath the apparatus's condenser. Five millilitres (5 ml) of the digested solution were then distilled with 5 ml of sodium hydroxide (NaOH). Fifty milligrammes of the solution were then titrated with 0.01 M HCl. The colour changed at the end point from green to pink. A blank sample was also prepared using the same procedure but without a soil sample.

Available phosphorus (P)

Available phosphorus was determined with the aid of a spectrophotometer using Mehlich III as the extractant. Mehlich III (20 ml) was added to extractant cups containing two grammes (2 g) of 2 mm sieved soil samples. The samples were shaken with a mechanical shaker for 15 minutes. The mixture was then filtered using filter paper. Five millilitres of colour reagent were added to it. The samples were made up to 50 ml by adding 40 ml of distilled water. The samples were read with the spectrophotometer.

Exchangeable bases (K, Ca, Mg, and Na)

Five grammes of 2 mm sieved soil were weighed into an extraction cup, and 20 ml of Mehlich III solution was added. The mechanical shaker was used to shake the sample for ten minutes. Afterwards, filter paper was used to filter the combination. Sodium was determined by flame photometer while Mg, K, and Ca were determined with the aid of an atomic absorption spectrometer.

Exchangeable acidity

Ten grammes (10 g) of 2 mm sieved soil was weighed into an extraction cup, and 10 ml of KCl was added. The solution was filtered through filter paper after being shaken for ten minutes using a mechanical shaker. Ten millilitres of the filtrate were measured into an extraction cup, and three drops of phenolphthalein indicator were added. The solution was then titrated with 0.01N NaOH. At the endpoint of the titration, the colour of the solution changed to light pink. Multiplying the volume of NaOH used to titrate each sample by 0.5 will yield the total exchangeable acidity of the soil samples.

Micronutrient determination (Fe, Mn, Cu, and Zn)

Two grammes (2 g) of 2 mm sieved soil was weighed into an extraction cup, and 10 ml of Mehlich III solution was added. The mechanical shaker was used to shake the samples for ten minutes. The mixture was then filtered through a filter paper. Fe, Mn, Cu, and Zn were determined with the aid of an atomic absorption spectrometer.

Statistical Analysis

The obtained data were analysed using the Genstat statistical package (8th Edition) for variance (ANOVA), and the least significant differences (LSD) at the 5% probability level were used to distinguish significantly different means.

Result and Discussion

Weight losses

The quantity of cocoyam tubers that were shipped to the Moniya market from the three separate locations is displayed in Table 4.1. The result shows that there are significant (p = 0.05) differences among the number of tubers from the three locations. The highest number of cocoyam tubers (732) was transported from Ogun. This was followed by 459 and 202 tubers transported from Osun and Oyo, respectively.

Table 4.2 shows the number of sweet potato tubers transported from the three different locations to the Bodija market. The result shows that there were no significant differences (p = 0.05). Variations between the three locations' weight of soil loss, sweet potato tuber weight, and tuber count.

Nutrient losses

The results of the chemical analysis of the soils carried in with the cocoyam tubers are displayed in Table 4.3. The soils were slightly acidic with a pH value of 6.5 for soils transported from Ogun, while soils from Osun and Oyo had a pH value of 6.5, respectively. The transported soils' pH values did not differ from one another statistically (p = 0.05). The pH values obtained are optimum for most agricultural soils. Ezeaku (2013) stated that the optimum pH for most crops falls between 6.0 and 7.0 and nutrients are more available at a pH of about 6.5 (Lai, 1994).

The organic carbon content of soils transported with cocoyam tubers to the Moniya market did not differ significantly (p = 0.05). However, soils transported from Osun had the highest organic carbon value of 61.4 g/kg, while Ogun had 52.5 g/kg and Oyo had the lowest value of 47.8 g/kg. Given that all of the values were higher than the previously established critical limit of 30 g/kg, the results indicate that the soils transported from the various locations were rich in organic carbon (Akinrinde and Obigbesan, 2007).

Table 1: Weight of transported soil loss with cocoyam tubers to the market

Results and Discussion

Location	Numner of tubers	Weight of tubers	Weight of soil loss
		Kg	
Ogun	732	162	2.83
Osun	459	150	1.44
Oyo	202	102	1.30
LSD (p=0.05)	0.04*	Ns	Ns

*: Significant at p=0.05, ns: Not significant

Weight losses

Table 1 shows the number of cocoyam tubers transported from the three different locations to Moniya market. The result shows that there are significant (p= 0.05) differences among the number of tubers from the three locations. The highest number of cocoyam tubers (732) was transported from Ogun. This was followed by 459 and 202 tubers transported from Osun and Oyo, respectively.

Table 2: Weight of transported soil loss with sweet potato tubers to the maket

Location	Number of tubers	Weight of tubers	Weight of soil loss
		Kg	
Niger	267	98	2.00
Plateau	324	192	2.45
Taraba	820	310	4.20

LSD (p=0.05)	Ns	Ns	Ns

*: Significant at p=0.05, ns: Not significant

Table 2 shows the number of sweet potato tubers transported from the three different locations to Bodija market. The result shows that there was no significant (p= 0.05) differences among the number of sweet potato tubers, weight of tubers and the weight of soil loss from the three locations.

Total nitrogen was highest in soils transported with cocoyam from Oyo, with value of 10.6 g/kg. This was not significantly (p= 0.05) higher than soils transported from Osun (6.0 g/kg) and Ogun (5.1 g/kg). These values are above 1.5 g/kg, the value for tropical soils (Enwezor *et al.*, 1989).

Values of available phosphorus were in the range of 20.8 and 55.6 mg kg^{-1} with the least observed in soils transported from Ogun and the highest in soils from Oyo. These values were higher than the critical range of 8 to 12 mg kg^{-1} phosphorus reported for tropical soils by Enwezor *et al*., (1989), indicating that the soils transported are not phosphorus deficient.

Potassium was highest (2.71 cmol kg^{-1}) in soils transported from Osun while Ogun had the lowest value of 0.69 cmol kg^{-1}. In comparison, K values obtained from the transported soils were higher than the reported critical values of 0.16 cmol kg^{-1} (Obigbesan *et al*., 1974) and

0.20 cmol kg^{-1} (Adeoye and Agboola, 1984; Isisimah *et al.*,2003.

Table 3: Nutrient composition of soils transported with cocoyam tubers to the market

Location	pH	O.C	N	A. P.	K	Ca	Mg	Na	E.A	Mn	Fe	Cu	Zn
		g/kg		mg/kg	cmol/kg					mg/kg			
Ogun	6.6	52.5	5.1	20.8	0.93	12.9	6.82	0.71	0.70	99	326	2.6	2.
Osun	6.5	61.4	6.0	54.2	2.71	16.6	4.38	0.84	2.58	106	459	3.4	3.
Oyo	6.5	47.8	10.6	55.6	0.69	10.8	6.16	0.81	1.70	90	303	7.2	5.
LSD	ns	ns	ns	0.04*	ns	Ns	ns	ns	ns	ns	ns	ns	ns

O.C: Organic carbon. A.P: Available phosphorus. ns: Not significant. *: Significant at p=0.05

Nutrient losses

Table 3 shows the result of the chemical analysis of the soils transported with cocoyam tubers. The soils were slightly acidic with pH value of 6.5 for soils transported from Ogun, while soils from Osun and Oyo had pH value of 6.5 respectively. The soil pH value among the soils transported were not significantly (p = 0.05) different from each other. The pH values obtained are optimum for most agricultural soils as Ezeaku (2013) stated that the optimum pH for most agricultural crops falls between 6.0 and 7.0 and nutrient are more available at pH of about 6.5 (Lai, 1994).

There was no significant (p = 0.05) difference in the organic carbon content of soils transported with cocoyam tubers to Moniya market. However, soils transported from Osun had the highest organic carbon value of 61.4 g/kg, while

Ogun had 52.5 g/kg and Oyo had the lowest value of 47.8 g/kg. The result shows that the soils transported from the various locations were rich in organic carbon as they all had values that exceeded the reported critical limit of 30 g/kg (Akinrinde and Obigbesan, 2007).

Table 4: Nutrient composition of soils transported with sweet potato tubers to the market

Location	pH	O.C	T N	A. P.	K	Ca	Mg	Na	E. A.	Mn	Fe	Cu	Zn
		g/kg		mg/kg	ıol/kg					mg/k			
Niger	7.04	4.71	0.36	62.8	0.88	40.5	5.37	1.32	0.29	99	193.5	2.93	6.4
Plateau	6.66	3.06	0.17	45.9	0.66	31.4	5.80	1.34	0.25	122	224.5	0.69	3.0
Taraba	7.28	2.31	0.12	66.1	1.66	35.2	4.58	1.35	0.33	108	208.0	2.72	6.8
LSD (p=0.05)	ns	ns	Ns	ns	Ns	Ns	ns	ns	ns	ns	Ns	ns	ns

O.C: Organic carbon. A.P: Available phosphorus. ns: Not significant. *: Significant at p=0.05

Table 4 shows the result of the chemical analysis of the soils transported with sweet potato tubers. The soils transported from Niger and Taraba are slightly acidic with pH value of 7.0 and 7.2 respectively while the pH value of soils transported from Plateau were slightly basic with pH value of 6.6.

There was no significant (p = 0.05) difference in the organic carbon content of soils transported with sweet potato tubers to Bodija market. However, soils transported from Niger had the highest organic carbon value of 4.71 g/kg, while Plateau had 3.06 g/kg and Taraba had the lowest value of 2.31 g/kg.

Total nitrogen was highest in soils transported with sweet potato from Niger, with value of 0.36 g/kg. This was not significantly (p= 0.05) higher than soils transported from Plateau (0.17 g/kg) and Taraba (0.12 g/kg).

Potassium was highest (1.66 cmol kg^{-1}) in soils transported from Taraba while Plateau had the lowest value of 0.66 cmol kg^{-1}. In comparison, K values obtained from the transported soils were higher than the reported critical values of 0.16 cmol kg^{-1} (Obigbesan *et al*., 1974) and 0.20 cmol kg^{-1} (Adeoye and Agboola, 1984; Isisimah *et al*.,2003).

Values of available phosphorus were in the range of 45.9 and 66.1 mg kg^{-1} with the least observed in soils transported from Plateau and the highest in soils from Taraba. These values were higher than the critical range of 8 to 12 mg kg^{-1} phosphorus reported for tropical soils by Enwezor *et al*., (1989), indicating that the soils transported are not phosphorus deficient.

Table 5: Particle size distribution of soils transported with cocoyam tubers

Location	Sand	Silt	Clay	Textural class
		g kg^{-1}		
Ogun	708.5	124	167.5	Sandy loam
Osun	782.5	79.5	138	Loamy sand
Oyo	821.3	50.7	128	Loamy sand
LSD (p=0.05)	0.02*	0.02*	0.01*	N/A

N/A: Not applicable, *: Significant at p=0.05

Particle size distribution analysis

Table 5 shows the particle distribution of the soils transported with cocoyam tubers to Moniya market are presented in Table 5. There was significant (p=0.05) differences in the sand, silt and clay fractions of soils from the various locations. Sand fraction of soils transported was in the range of 708.5 and 821.3 g kg^{-1} with soils from Oyo recording the highest value of sand, and this was followed by soils from Osun, while soils from Ogun had the lowest sand value. Furthermore, the silt fraction had a range of 50.7 g kg^{-1} and 124 g kg^{-1} with soils from Oyo having the lowest value, while the highest value for silt was obtained in soils from Ogun. Significant (p=0.05) differences were observed in the clay content among the various soils. Soils from Ogun had the highest clay content of 167.5 g kg^{-1}, while the lowest content (128 g kg^{-1}) was observed in soils transported from Oyo.

Table 6: Particle size distribution of soils transported with sweet potato tubers

Location	Sand	Silt	Clay	Textural class
		g kg^{-1}		
Niger	722	114	164	Sandy loam
Plateau	382	324	294	Clay loam
Taraba	662	194	144	Sandy loam
LSD (p=0.05)	ns	Ns	ns	N/A

N/A: not applicable, ns: not significant

Furthermore, Table 6 shows the particle distribution of the soils transported with sweet potato to Bodija market are presented in Table 6. There was no significant (p= 0.05) difference in the sand, silt and clay fractions of the transported soils, respectively. However, Niger state had the highest amount of sand particles with the value of 72.2 g kg^{-1}, followed by Taraba, which had 66.2g kg^{-1} and Jos had the lowest sand content of 38.2g kg^{-1} thus, Jos had the highest silt content of 32.4g kg^{-1}, followed by Taraba with the silt content of 19.4 g kg^{-1} while the lowest was observed in Niger with the content value of 11.4g kg^{-1} and the highest content of clay was observed in Jos with the value of 29.4g kg^{-1}, followed by Niger with the value of 16.4g kg^{-1} and Taraba had the lowest value of 14.4g kg^{-1}.

The higher values of sand content reported in soils transported with cocoyam and sweet potato from the various locations are typical of soils in south-western Nigeria (Babalola *et al*., 2000).

Conclusion

After sweet potato and cocoyam tubers were harvested, farmers or middlemen carried the soils that contained a considerable amount of nutrients to the market. Moreover, more sweet potatoes and cocoyams are harvested, which results in a greater loss of soil; the greater the yield of these crops, and vice versa, the more soil loss occurs.

Ogun State experienced the most soil loss of the three cocoyam-producing states. Of the three states, Taraba State experienced the greatest soil loss due to sweet potatoes.

Recommendation

Reducing the amount of soil transported to the market or storage can be achieved by encouraging farmers to always hand rub harvested sweet potato and cocoyam tubers before transporting them to the market.

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