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# Assessment of soil loss and nutrient depletion due to cassava harvesting: A case study from low input traditional agriculture

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**Abstract**

Cassava is a major food crop for farmers and especially small holder farmers and cultivated under low input other than the irrigation. It is cultivated as mono crop or intercrop at early stage and cultivating throughout the year. It is harvested carefully because of cyanogenic glucosides and consumed with in day. Easy and undamageable uprooting of the tuber mainly depends on soil moisture, texture and agronomic practices. The study was focused with the objectives of the assessment of soil loss due to the harvesting of cassava roots tubers under low input agriculture, and to estimate the amount of plant nutrients loss due to crop harvest for cassava. Also the observation was made the correlation between the soil loss and physical characters of the tuber, soil texture and agronomic practices. Average plant specific soil loss due to crop harvesting was 80.7 g $root^{-1}$ and crop specific soil loss due to crop harvesting was 7.64 kg $ha^{-1}$ $harvest^{-1}$ loss in Valliagmam area in Jaffna, Sri Lanka. Soil moisture content at harvesting time was a significant factor that explained the variations in the soil lost at cassava harvesting. Soil moisture has linear positive relationship with average plant specific soil loss due to crop harvesting. Soil nutrient loss during cassava harvesting by removal of adhering soil with root tuber was 1.15 kg of N, 1.99 kg of P and 2.91 kg of K $ha^{-1}$ $harvest^{-1}$. Application of fertilizer is important since considerable amount nutrient loss was observed due to soil loss due to crop harvest.

**Key Words**: Soil erosion, Soil loss, Cassava, Root crop, SLCH (soil loss due to crop harvesting)

## 1 Introduction

Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks. Glenn et al. (1993) stated that with the advent of modern civilization, the pressure on land increased, which lead to it's over exploitation, and subsequently, its degradation. Soil erosion is one of the major processes leading to soil degradation. Poesen et al. (1999) stated that land use changes typically affect the water, wind and tillage erosion. Soil loss due to crop harvesting also have significant attention in soil loss. Montgomery (2007) reported that, soil fertility generally declines with accelerated erosion. Ruysschaert et al. (2004) said that the soil losses due to crop harvesting may be of the same order of magnitude as soil losses caused by other soil erosion processes.

When harvesting crop likes Beetroot (*Beta ulgaris* L.), Potato (*Solanum tuberosum* L.), Carrot (*Daucus carota* L.), Cassava (*Manihot* spp.), Sweet potato (*Ipomoea batatas*) and Jams (*Dioscorea spp*) have significant soil loss. Soil sticking with harvested crop and soil clods are exported from the field and rarely returned. Hence, this soil volume represents a true soil loss and it referred to as true soil losses due to crop harvesting (SLCH). The on-site impacts of SLCH are obvious. The removal of soil by this soil erosion process causes loss of valuable topsoil and nutrients. Research conducted by Isabirye et al. (2007) in highly mechanised agriculture has shown that mean SLCH was similar to those of other soil erosion processes and justified the need to incorporate SLCH into future as-

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sessment of soil degradation and sediment budgets. Li et al. (2006) stated that SLCH was responsible for the export of substantial quantities of soil material, contributing to soil degradation in a range of intensively cultivated environments.

Norman et al. (1986) stated that cassava could become a source of income and employment for both men and women where communities having access to markets. Suyamto and Howeler, (1997) stated that cassava cultivation might lead to both nutrient depletion and soil erosion; these are more serious than other food crops under similar condition. Cassava is often blamed focusing sever soil erosion when grown on sloping land, as the crop is planted at a wide spacing and has a slow initial development; thus, it takes a long time for the canopy to protect the soil from raindrop impact. Odemerho and Avwunudiogba, (1993) showed that monoculture planting of cassava gave severe soil erosion compare with polyculture.

Ruysschaert et al. (2004) stated that cassava was associated with soil degradation in the form of nutrient depletion or mining and soil loss due to water erosion as like other annual crops production. Among tropical food crops, cassava does not extract large amounts of N and P, but removes relatively high amounts of K from the soil and has there for a high K:N ratio in the harvested cassava roots (Suyamto and Howler, 1997). Cassava is extremely tolerant to low pH and high levels of aluminium. When cassava was grown continuously without fertilizer application for more than 25 years, yield was decreased (Putthacharoen et al., 1998).

Investigation into SLCH as another possibly important source of soil and nutrient loss under tropical low input traditional agriculture are non-existent. This study attempts to fill this knowledge gap and aims to get an insight on quantities of soil and nutrient losses where harvesting of cassava roots by hand. The objective of the study was aimed to estimate the soil loss due to cassava harvesting, to check the effect of harvesting time after irrigation on soil loss, to check the effect of root characteristics on soil loss and to estimate soil nutrient loss due to cassava harvesting.

## 2 Materials and method

### 2.1 *Location and soil characters of the study area*

The experiment was carried out in calcic red latosols in Valigamam area in Jaffna district, Sri Lanka (longitude of 80° 017′E and the latitude of 09°065′N) and with the land slope of 0 – 3%. All the selected fields were located in soil type of calcic red yellow latosol.

### 2.2 *Crop characters*

Cassava (*Manihot exulenta*) is an important food crop in Jaffna district with the extent of 237 ha in *Maha*, 140 ha in *Yala* in 2010 and 259 ha in *Maha*, 159 ha in *Yala* in 2011. According to Jaffna agricultural department statistics, the average yield of cassava, in paddy land was 20 t $ha^{-1}$, in high land was 25 t $ha^{-1}$ and maximum yield was 30 t $ha^{-1}$ (Department of Agriculture, 2012). Cassava has been growing as sole crop with the spacing of 1 m × 1 m. As a sole crop intercropping with onion, carrot, amaranths, radish, green-gram and beetroot occurs at early stage. Harvesting occurs normally 12 month after planting, but early maturing varieties can be harvested 6 month after planting. Cassava is harvested by using hand hoe and/or simply uprooted by hand. After harvesting, the roots are broken from the stems and placed in baskets for home transportation. Cleaning of roots before transportation is not common practice.

### 2.3 *Baseline questionnaire survey*

Valigamam area in Jaffna district and cassava was purposively chosen due to very intensive agricultural area, most of the farmers cultivate cassava continuously in large extent and it is one of the low input agricultural crop. Base line questionnaire survey was conducted about cassava cultivation in Jaffna district and the detailed study was conducted in five selected fields. Questionnaire was structured with open and close end questions focused on personal data, history of cassava cultivation, detail of soil and water, pre-harvest operations, operations during harvesting and post-harvest operations more related directly or indirectly to soil loss during crop harvesting. Randomly 100 farmers were selected for this survey which was used to understand the local farmers' pre-harvest, harvest and post-harvest operations in low input agriculture by personal interviews and through the structured questionnaires.

### 2.4 *Soil physical properties analysis*

Representative composite soil sample was taken from the experimental soil for the determination of important physical properties; soil moisture, bulk density, particle density, porosity and soil particle analysis. All these parameters were determined by adopting standard techniques. Moisture content and bulk density of soil samples were measured by gravimetric method and Tube core method respectively. Soil particle analysis was done based on Bear (1988) by sieving method, and uniformity coefficient and coefficient of variance were estimated. Soil texture was performed by Hydrometer method.

## 2.5 *Harvesting*

Five representative cassava fields, with the same soil type and the same age group trees were selected. Cassava fields were irrigated only one time, one day before the first harvesting. After the particular irrigation, tubers were harvested at next day morning ($1^{st}$ day morning) at 7am (14 hrs), evening 5 pm ($1^{st}$ day evening) (24 hrs), day after morning ($2^{nd}$ day morning) (38 hrs), evening ($2^{nd}$ day evening) (48 hrs) and two days after morning ($3^{rd}$ day morning) (62 hrs). Five time harvestings were done by hand or hand hoe, in every morning and evening to estimate the soil loss due to every harvesting time with moisture content.

## 2.6 *Removal and drying of soil*

After the removal of tubers from stalk, soil sticking to the harvested tubers was separated by knife then those were carefully washed-out without the damage of the skin. Wash water was allowed to sun drying for removal of water through quick evaporation. Those soil samples were let in oven at 105℃ for 24 h after.

## 2.7 *Physical properties of cassava*

After washing of tubers, water was removed from the tuber surface and the following measurement was taken such as tuber length (cm), maximum diameter (cm), weight (g), number of tubers and surface area. Baugerod's method recommended by Furness et al. (2002) was used to estimate the cassava root surface area. Surface area ($A$) was calculated as;

$$A = \frac{4C\pi rh}{1 + C}$$

$$C = \frac{W}{\pi r^2 h}$$

where $A$ = root surface area ($cm^2$); $C$ = indicator of shape factor (unity for cylinder); $W$ = weight (g); $r$ = maximum radius (cm) and $h$ = length (cm). The derived root surface area was checked with original surface area for certain selected roots.

## 2.8 *Prediction of soil loss*

The soil losses were calculated per unit of net crop mass, per root/tuber and per unit of area according to the SLCH definitions proposed by Ruysschaert et al. (2004) and Vermeulen (2001). In addition, long-term SLCH values (expressed in Mg $ha^{-1}$ $yr^{-1}$) were calculated to compare SLCH with other soil erosion processes in the region.

## 2.9 *Mass-specific SLCH*

Mass-specific SLCH (in g $g^{-1}$) expresses the soil loss value per unit of net crop mass as follows,

$$\mathrm{SLCH}_{\mathrm{spec}} = \frac{M_{\mathrm{ds}} + M_{\mathrm{rf}}}{M_{\mathrm{crop}}}$$

where $M_{ds}$ = total mass of oven dry soil; $M_{rf}$ = mass of rock fragments (as the crop is harvested by hand $M_{rf}$ will be zero); $M_{crop}$ = net crop mass of the sample (equal to mass of the washed Cassava).

## 2.10 *Plant specific SLCH*

$$\mathrm{SLCH}_{\mathrm{spec/p}} = \frac{M_{\mathrm{ds}} + M_{\mathrm{rf}}}{\mathrm{NPl}}$$

where NPl = number of roots in the sample.

## 2.11 *Crop-specific SLCH*

Crop-specific SLCH (in Mg $ha^{-1}$ $harvest^{-1}$) expresses the total soil loss per harvest for a given crop on an area unit basis

$$\mathrm{SLCH}_{\mathrm{crop}} = \mathrm{SLCH}_{\mathrm{spec}} \times M_{\mathrm{cy}}$$

where $M_{cy}$ = net crop yield (Mg $ha^{-1}$ $harvest^{-1}$). $SLCH_{crop}$ of cassava was determined in this study based on average gross crop yields calculated from baseline survey.

## 2.12 *Soil nutrient loss*

Nutrient loss expressed on elemental basis through crop harvesting was estimated based on the study by Isabirye et al. (2007) by using the following equation:

$$\text{Nutrientloss}(g/ha/harvest) = \left[\frac{\text{nutrient}(g)}{\text{soil}(100g)}\right] \times 10 \times SLCH_{crop}(kg/ha/harvest)$$

The chemical properties of soil such as available N, P and K were determined using standard procedure with spectro photo meter and flame photo meter. It is necessary to estimate the amount of nutrients losses through crop product in small holding faming or low input agriculture to have an insight on the relative importance of nutrients lost by SLCH.

### 2.13 *Statistical analysis*

All data were analyzed by 'R' statistical online software version 1.1.23-r7 (Wessa, 2002). Pearson product moment correlation coefficient was used measure of the strength of the linear relationship of two variables since the data were ungrouped and independent yield. And also partial or tri-variate and part correlation was used to measure relationship between three variables such as root characteristics, soil moisture and SLCH parameters where soil moisture ($x$) and root characteristics ($y$) were considered as independent variable and correlate with SLCH parameters ($z$) as dependent variable.

## 3 Results and discussion

### 3.1 *Soil physical properties*

Soil physical properties are the major component influence soil loss due crop harvesting. Table 1 shows physical properties of soils such as bulk density, textural analysis and soil particle distributions; mean bulk density as 1.5 g $cm^{-3}$, percentage of clay 22.5%, percentage of silt 6.1%, percentage of fine sand 39.4%, percentage of coarse sand 32%.

**Table 1 Summery of soil physical properties**

| Field | Bulk Density | Textural Analysis | | | | Sieve Analysis | |
|---|---|---|---|---|---|---|---|
| | | Clay (%) | Silt (%) | Fine Sand (%) | Coarse Sand (%) | Uniformity Coefficient (Cu) | Coefficient of Variance (Cc) |
| Kondavil [F1] | 1.48 | 22.4 | 6.5 | 38.6 | 32.5 | 3.94 | 1.38 |
| Inuvil [F2] | 1.50 | 21.0 | 5.7 | 37.5 | 35.8 | 4.19 | 1.49 |
| Kopay [F3] | 1.51 | 24.6 | 6.3 | 40.3 | 28.8 | 4.06 | 1.17 |
| Urumpirai [F4] | 1.44 | 20.7 | 6.2 | 39.7 | 33.4 | 4.69 | 1.46 |
| Suthumail [F5] | 1.57 | 23.7 | 5.8 | 41.1 | 29.4 | 4.40 | 1.38 |
| Average (Stdev) | 1.50 ±0.05 | 22.5 ±1.7 | 6.1 ±0.3 | 39.4 ±1.4 | 32.0 ±2.9 | 4.3 ±0.3 | 1.4 ±0.1 |

### 3.2 *Baseline survey*

The crop was planted at 1 m × 1 m spacing, cultivating though out the year, growing period depend on variety and season but averagely eight months and intercropping with green amaranth, onion, leek, beet root, cabbage, radish, carrot and green gram. That is because cassava has quite a long initial stage (50 – 60 days) and it takes more than two months to cover the land. Average yield was (3.5 ± 1.2) kg per plant and number of root tubers in plants varies between 3 – 5 roots per plant, which depended on variety, soil and agronomic practices. Almost every plant was planted in rich & furrow for easy harvesting and root tuber development in loose soil. All the farmers add manure as basal fertilizer and mostly avoid using inorganic fertilizers. Irrigation interval was 4 – 6 days depending on weather and growth stage of cassava. The day before harvesting irrigation was done by 50% of farmers for easy uprooting the plant and rest practicing two days before harvesting. Top soil also was removed by 75% of farmers depending on hardness of top soil and soil moisture level. Harvesting was done at early morning or late evening which depends on labour availability and distances from the market. If too much soil sticks with tuber, 33% of the farmers removed the soil by using knife back side without damaging the skin and never washed the tuber after harvesting.

### 3.3 *Soil loss*

The estimated soil loss, including mass-specific ($SLCH_{spec}$), plant-specific ($SLCH_{spec/p}$) and crop specific ($SLCH_{crop}$) in five fields is listed in Table 2. The average yield is obtained from base line questionnaire survey. Average mass-specific ($SLCH_{spec}$) was 0.22 g $g^{-1}$, mean plant-specific was (80.65±43.37) g $root^{-1}$ and crop-specific ($SLCH_{crop}$) was (7.64±4.35) kg $ha^{-1}$ $harvest^{-1}$. Median values of $SLCH_{spec}$ and $SLCH_{crop}$ also have smaller values. Isabirye et al. (2007) determined $SLCH_{spec}$ value was 0.021 kg $kg^{-1}$ and $SLCH_{crop}$ 3.44 t $ha^{-1}$ $harvest^{-1}$ for cassava. Those values depend on agro-climatic conditions, soil characteristics, agronomic practices and cassava yield.

**Table 2 Estimated soil loss by cassava harvesting in different fields**

| Location | $SLCH_{spec}$ (g $g^{-1}$) | $SLCH_{spec/p}$ (g $root^{-1}$) | $SLCH_{crop}$ (kg $ha^{-1}$ $harvest^{-1}$) | Location | $SLCH_{spec}$ (g $g^{-1}$) | $SLCH_{spec/p}$ (g $root^{-1}$) | $SLCH_{crop}$ (kg $ha^{-1}$ $harvest^{-1}$) |
|---|---|---|---|---|---|---|---|
| Kondavil [F1] | 0.29 | 103.88 | 10.00 | Suthumail [F5] | 0.16 | 44.99 | 5.46 |
| Inuvil [F2] | 0.22 | 123.00 | 7.72 | Average | 0.22 | 80.65 | 7.64 |
| Kopay [F3] | 0.38 | 107.37 | 13.23 | Median | 0.22 | 103.8 | 7.72 |
| Urumpirai [F4] | 0.05 | 24.03 | 1.8 | Standard deviation | ±0.13 | ±43.37 | ±4.35 |

## 3.4 *Effect of soil properties on SLCH*

Several studies have shown soil physical properties play a significant role in soil loss by crop harvesting. Soil moisture, soil organic matter, soil texture and soil structure are major factors determining soil loss. Soil moisture, soil texture, bulk density and particle size analysis of uniformity coefficient and coefficient of variance are correlated with SLCH and shown in Table 3. Isabirye et al. (2007) observed that correlations of SLCH with soil texture were not significant in their cassava study. With low strength of correlations other factors would have likely had an influence on SLCH. An example could be root morphology such as the extent of rough, kinked branched roots.

The Pearson product moment correlation coefficient is a measure of the strength of the linear relationship between ungrouped two variables. Correlation between the determined soil physical properties and calculated SLCH parameters were analyzed by Pearson product moment. Percentage of clay was positive correlation with $SLCH_{crop}$ like other research work mentioned in Li et al. (2006), but they obtained negative correlation. The percentage of fine sand and that of coarse sand have negative correlation with SLCH parameters but not strong. Particle size sieve analysis, uniformity coefficient (Cc) and coefficient of variance (Cv) have strong negative correlation with SLCH parameters. Possible explanation for this soil physical properties result was the strong correlation between the independent variable between sieve analyses Cc with SLCH crop. Li et al. (2006) indicated that harvesting operation also interacted with soil texture and other variables and these interactions were also the reason why no significant multiple regression equation was found.

## 3.5 *Effect of harvesting time after irrigation on SLCH*

Previous studies have shown soil moisture has exponential and linear relationship with SLCH parameter (Isabirye et al., 2007; Li et al., 2006; Ruysschaert et al., 2006; Ruysschaert et al., 2005). Isabirye et al. (2007) obtained exponential correlation of $R^2=0.14$ for their cassava study in Africa. Fig. 1 shows soil moisture has positive liner relationship with the value of $R^2=0.65$ and exponential relationship $R^2=0.63$ with $SLCH_{spec/p}$. Table 4 shows Pearson product movement correlation coefficient between mean soil moisture level and mean $SLCH_{spec/p}$ was

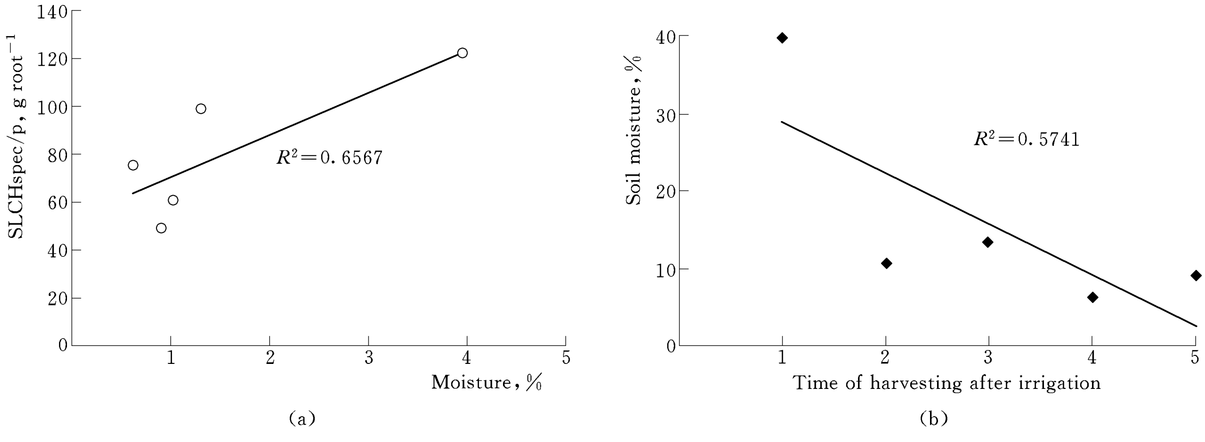


**Fig. 1 Correlation between soil moisture level and plant specific ($SLCH_{spec/p}$) (a) and time of harvesting after irrigation and soil moisture (b)**

$r = 0.81$ and P-value was 0.05.

Fig. 1 shows moisture level has negative correlation ($R^2 = 0.57$) with time of harvesting after irrigation. Crop specific $SLCH_{crop}$ is decreasing with decreasing soil moisture level. Time of harvesting after irrigation negatively correlated with $SLCH_{crop}$. The correlation between $SLCH_{spec}$ and soil moisture was explained by the tendency of moist soil to stick on roots more than dry soil. Since farmers rarely clean roots in the field, most of this soil is carried away with the roots from the fields to farmer's compound.

**Table 3 Pearson correlation coefficient between SLCH variables of $SLCH_{spec/p}$, $SLCH_{crop}$, bulk density, soil texture, sieve analysis uniformity coefficient (Cu) and coefficient of variance (Cc)**

| Pearson correlation | Textural analysis | | | | Sieve analysis | | Soil Loss due to Crop Harvest | |
|---|---|---|---|---|---|---|---|---|
| | Clay (%) | Silt (%) | Fine sand (%) | Coarse sand (%) | Cu | Cc | $SLCH_{spec/p}$ (g $root^{-1}$) | $SLCH_{crop}$ (kg $ha^{-1}$ $harvest^{-1}$) |
| Bulk density | 0.67 | −0.51 | 0.47 | −0.56 | −0.21 | −0.29 | 0.08 | 0.25 |
| Clay (%) | | 0.19 | 0.66 | −0.93* | −0.89* | −0.89* | 0.17 | 0.66 |
| Silt (%) | | | 0.07 | −0.26 | −0.34 | −0.46 | 0.05 | 0.36 |
| Fine sand (%) | | | | −0.88* | 0.34 | −0.52 | −0.62 | −0.1 |
| Coarse sand (%) | | | | | 0.13 | 0.82* | 0.2 | −0.37 |
| Cu | | | | | | 0.46 | −0.88* | −0.91* |
| Cc | | | | | | | −0.25 | −0.75* |
| $SLCH_{spec/p}$ (g $root^{-1}$) | | | | | | | | 0.81* |

* Significant at α level 0.05.

**Table 4 Estimated SLCH on time of harvesting after irrigation and Pearson correlation between soil moisture and plant specific ($SLCH_{spec/p}$) and crop specific ($SLCH_{crop}$)**

| Harvesting time | Mean | | | Pearson product movement correlation (P-value one sided) | |
|---|---|---|---|---|---|
| | Moisture (%) | $SLCH_{spec/p}$ (g $root^{-1}$) | $SLCH_{crop}$ (kg $ha^{-1}$ $harvest^{-1}$) | $SLCH_{spec/p}$ (g $root^{-1}$) | $SLCH_{crop}$ (kg $ha^{-1}$ $harvest^{-1}$) |
| 1st day morning | 39.7 | 121.3 | 8.66 | 0.70 (0.09) | 0.95 (0.005)* |
| 1st day evening | 10.4 | 60.0 | 8.83 | −0.10 (0.24) | −0.63 (0.13) |
| 2nd day morning | 13.1 | 98.8 | 7.40 | −0.48 (0.21) | −0.68 (0.10) |
| 2nd day evening | 6.3 | 75.0 | 8.42 | −0.55 (0.17) | −0.47 (0.21) |
| 3rd day morning | 9.1 | 48.2 | 4.91 | −0.71 (0.09) | −0.88 (0.02)* |
| Pearson Correlation with moisture | | 0.81* | 0.33 | | |
| Determination ($R^2$) with moisture | | 0.65 | 0.11 | | |
| Covariance with moisture | | 32.71 | 0.74 | | |
| P-value with moisture (one side) | | 0.05 | 0.29 | | |

* Significant at α level 0.05.

## 3.6 *Effect of root physical characteristic on SLCH*

Table 5 shows the overall correlation between root characteristics and SLCH parameters. No significant difference was found between root characteristic and SLCH parameters. SLCH parameters depend not only on root characteristics but also on soil moisture, soil properties agronomic practice and harvesting technique.

**Table 5 Pearson correlation coefficient between SLCH variables of $SLCH_{spec/p}$, $SLCH_{crop}$, total root weight, total tuber length, total tuber surface area and number of root**

| Pearson correlation | Root characteristics per plant | | | | Soil Loss due to Crop Harvest | |
|---|---|---|---|---|---|---|
| | Total weight (g) | Total Length (cm) | Total surface area ($cm^2$) | Number of roots | $SLCH_{spec/p}$ (g $root^{-1}$) | $SLCH_{crop}$ (kg $ha^{-1}$ $harvest^{-1}$) |
| Moisture (%) | 0.19 | 0.19 | 0.28 | 0.03 | 0.42 | 0.08 |
| Weight | | 0.57 | 0.84* | 0.42 | −0.16 | −0.54 |
| Length | | | 0.86* | 0.73* | −0.46 | −0.38 |
| Surface area | | | | 0.55 | −0.26 | −0.45 |
| Tuber numbers | | | | | −0.62 | −0.38 |
| $SLCH_{spec/p}$ | | | | | | 0.81* |

* Significant at α level 0.05.

**Root tuber weight**: The average root tuber weight was (350±300) g; maximum 1, 600 g and minimum 85 g.

Average total weight of tubers per plant was (3.4±0.9) kg; maximum 4.7 kg and minimum 0.85 kg. Table 5 shows total root weight of tuber had negative correlation with $SLCH_{spec/p}$ (r -0.16) and $SLCH_{crop}$ (r-0.54). There are limited or no information about effect of root weight but it had impact on soil loss during harvesting. If the mass of the individual root/tuber increases by that resulted crop yield increases. Crop yield is a parameter that directly affects $SLCH_{crop}$, but equally influences $SLCH_{spec}$ too.

**Root tuber length**: Measured average length was 17.4±8.1 cm. Total tuber length had negative correlation with $SLCH_{spec/p}$ (r-0.46) and $SLCH_{crop}$ (r-0.38).

**Root tuber surface area**: Total surface area has negative correlation with $SLCH_{spec/p}$ (r-0.26) and $SLCH_{crop}$ (r-0.45). But theoretically soil loss increases by increasing surface but soil loss had negative correlation with total surface area. Isabirye et al. (2007) also obtained negative relationship between $SLCH_{spec}$ for cassava and highlighted that crop age was expected as older crops were assumed to have larger roots and, as a consequence, smaller surface to mass ratios to which soil could adhere. However, that study had crop age positively related to $SLCH_{spec}$. This was possibly due to increased skin roughness and the development of side branches, to which soil could adhere, during crop aging.

**Number of root tuber**: Number of tuber in plant depends on variety, soil characteristics, and agronomic practices. In this study average number of tuber per plant was 6±3. Plant specific $SLCH_{spec}$ and mass specific $SLCH_{crop}$ had negative correlation with number of tuber but $SLCH_{spec}$ (r-0.62) had stronger correlation than $SLCH_{crop}$ (r-0.38).

Table 6 shows overall Pearson product movement partial correlation of soil moisture ($x$), root tuber characteristics ($y$) and SLCH parameters ($z$). No significant correlation was found but all had positive correlation.

**Table 6 Pearson product moment partial correlation analysis of ungrouped data of soil moisture, SLCH variables and root characteristics**

| Partial Correlation | | r(xy. z) | | Moisture(x) | |
|---|---|---|---|---|---|
| | | $SLCH_{spec}$ (z) | $SLCH_{spec/p}$ (z) | $SLCH_{spec}$ (z) | $SLCH_{spec/p}$ (z) |
| Moisture(x) | Surface area(y) | 0.36 | 0.45 | | |
| | Number of root(y) | 0.00 | 0.33 | | |
| | Length(y) | 0.25 | 0.48 | | |
| | Wight(y) | 0.29 | 0.30 | | |
| r(xz. y) | Surface area(y) | | | 0.25 | 0.53 |
| | Number of root(y) | | | 0.08 | 0.51 |
| | Length(y) | | | 0.18 | 0.59 |
| | Wight(y) | | | 0.24 | 0.47 |

### 3.7 *Soil nutrient loss*

Isabirye et al. (2007) found that soil nutrient loss by removal of soil during harvesting cassava from crop specific $SLCH_{crop}$ (kg $ha^{-1}$ $harvest^{-1}$) was nitrogen (N) 1.71, phosphorus (P) 0.61 and potassium (K) 1.08. Soil nutrient of N, P and K by removal soil was 1.15, 1.99 and 2.91 kg $ha^{-1}$ $harvest^{-1}$ respectively. This loss depended on soil fertility level and agronomic practices.

## 4 Conclusions

Average soil loss by cassava harvesting in Jaffna Valligamam area was 7.64 kg $ha^{-1}$ $harvest^{-1}$. Soil water content was a major factor affecting the amount of soil loss. Soil moisture content had positive linear relationship with plant specific $SLCH_{spec}$. Harvesting time after irrigation had significant correlation with first day to last day harvesting and again this also influenced by soil moisture level. Harvesting time after irrigation had negative correlation with $R^2$ value of 0.59 with $SLCH_{crop}$. Root characteristics were not in strong correlation with SLCH parameters. Soil nutrient loss during cassava harvesting by removal of adhering soil with root tuber was 1.15 kg of N, 1.99 kg of P and 2.91 kg of K per ha per harvest. Given the areal importance and more research is needed to assess SLCH for cassava and other crop mentioned above in a wider range of soil and climatic conditions, to investigate the impact of a wider range of soil textures on SLCH intensities and to unravel the main factors controlling variations in the masses of harvested soil clods.

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