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傾斜地 農業技術 改良을 위한 效果的인 土壤保全工法 開發에 관한 硏究*1

禹 保 命*2

Development of the Better Soil Conservation Measures with Special References to Yam Hillside Farming*1

Bo Myeong Woo*2

The run-off experiment plots had been established for eight sets of plot comprising four treatments with two replications on 20° slope land having the Wait-A-Bit Clay soil (locally known), at the Olive River Soil Conservation Centre, Trelawny in Jamaica. The location of plots was about 820 metres m.s.l. and sloped north-west. Each plot size was determined as 40 m² having 2.7 m wide and 15.8 m long along slope.

All of the run-off soil and water were collected by using the receiving tanks through the collection troughs and conveyance pipes. These run-off materials were measured and sampled, dried and computed for determination of the soil loss from each treatment of plots.

During the first period of experiment for about 10 month which was one crop-year cycle of yam crop, total amount of 1,295 mm rainfall was received. The heaviest daily rainfall was recorded as 116.2 mm on August 5, followed by 100.4 mm on August 6, 1980.

The soil sediment had been collected and analysed for eleven times during this experiment. Total amounts of soil sediment as over-dried weight by the treatment plot were estimated as 182 ton/ha from treatment I, 105 tons/ha from treatment II, 50 tons/ha from treatment III, 43 tons/ha from treatment IV, respectively. It is recommendable at present that the treatment III and IV measures which treated with contour mounds with the hillside ditch and grass buffer strip should be adopted for hillside farming particularly with yam cultivation in Jamaica.

傾斜地에서 얌(yam)增産을 위한 農業技術 體系를 確立하고 보다 效果的인 土壤保全 工法을 開發하기 위한 試驗硏究가 자메이카國의 트리로운리에 위치한 土壤保全센터에서 수행되고 있다. 이 試驗場은 標高 약 820 m의 20° 傾斜地에서 8개의 流水流土 試驗區(4處理 2反覆)와 기타의 試驗施設로서 구성되었다. 各 試驗區의 크기는 40m² (2.7m×15.8m 斜面長)이며 西北向으로 向한 傾斜地였다.

試驗 第1次年度(1980年 4月~1981年 3月)중에 日降雨量과 流水流土量(11回)을 測定分析하였다. 總 降雨量은 1,295mm 이었으며 最大日 降雨量은 116.2mm 이었다. 4處理中에서 土壤流失量은 第1處理區에서 182 tons/ha, 第2處理區에서 105tons/ha, 第3處理区에서 50tons/ha, 그리고 第4處理區에서 43tons/ha으로 각각 調査되었다.

이 試驗結果에 의한 效果的인 傾斜地 얌栽培 方法은 Hillside ditch 또는 Grass buffer strip 處理에 Contour mounds farming 이라고 分析된다.

INTRODUCTION

Jamaica is the largest of the British Commonwealth islands within the Caribbean Sea. It is located 18° North of latitude and longitude 77°W. The area is about 11,400 km² having about 2.2 million persons.[6]

Average annual rainfall is about 1,980 mm varying from 1,000 mm in southern areas to about 7,000 mm

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*2 서울大學校 農科大學 College of Agriculture, Seoul National University.

in the Blue Mountains. Over 50% of the island is characterized by slopes of 20° and greater and as a consequence only 20-30% of the total land area are being considered for mechanized agriculture.[11]

Soil erosion and sedimentation are definitely the most important factors confronting those who are concerned with crop production as well as water resources development in Jamaica. There are however, not much data available concerning the rate of erosion and sedimentation in Jamaica.

In the West Indies, some experiments on rates of soil erosion and measurements have been conducted in Puerto Rico, Trinidad and Tobago by the University of the West Indies in 1973 and Barbados by the IICA/Barbados in 1978.[1,2]

Champion estimated the soil loss from the Upper Yallahs Valley in Jamaica where about one third is under cultivation at any time, at 40 tons per acre per year of 14 acre-feet per square mile per year.[9]

A soil loss experiment on Wait-A-Bit clay loam conducted by Mitchell USAID Soil Advisor, at James Hill, Central Clarendon in Jamica, indicated that a bare escarpment lost an average of 1.4 inches annually in a three year period (1962-65). The method used was to place metal spikes in the ground.[9]

A series of studies over the period 1969-1973 at the Smithfield by the UNDP/FAO JAM project resulted in the following principal conclusions:[8]

(a) There was an average soil loss of 136 ton/ha/yr (54 t/ac/yr) from unprotected yam plots having a 17° slope, and as a consequence a reduction in soil fertility and productivity;

(b) when hillsides are bench-terraced soil loss was reduced to 18 ton/ha/yr (7.3 t/ac/yr), and soils cropped on a sustained basis.

The Government of Jamaica sought and obtained the assistance of IICA in addressing these problems and has established the Olive River Soil Conservation Centre at Trelawny, Jamaica. The Soil Conservation Project is aimed at the "establishment of demonstration plots for farming systems treated with soil conservation methods other than bench terracing".[11] The treatments were, therefore, designed to suit the aims above, and designed with four treatments with two replications.

This experiment has been carried out within the run-off plots having 40 m² of each plot and could be continued for more than three years at the same experiment plots. In this report, some principal procedures in design and installation of the run-off plots and the results of experiment for the first year, would be presented.

The author has been participating and co-working for about two years as an Associated Personnel at the Inter-American Institute for Co-operation on Agriculture (IICA), OAS, in Jamaica.

MATERIALS AND METHODS

1. Soils and climate

The Soil Conservation Centre is located at the Olive River Watershed, Trelawny, Jamaica. Area of the experiment site is about 2 ha having the Wait-A-Bit clay soil. The soil was very highly acidic and very high in levels of exchangeable aluminum. The total nitrogen level was medium, available phosphate was medium to low, and the base saturation is low (22%) indicating that the soil has been strongly reached.

The altitude of the area is about 820 m which is considered as the higher elevation hillside farmings. Average annual rainfall at the Wait-A-Bit which is the nearest station from the Centre, was about 2,260 mm. A standard rain gauge was installed within the run-off experiment plot area, on April 26, 1980. Daily rainfall is measured at 8.00 a.m.

2. Installation of the run-off experiment plots

1). Plot size, boundary walls and side-pavement

The ideal sized plot for measuring surface run-off and erosion sediment is a miniature of natural watershed.[3,5] Size of plot has a marked effect on the measured run-off and erosion.[4]

In this experiment for soil run-off measurement and cropping system development, the size of plot was closely related with the main crop cultivated, i.e. yam (*Dioscorea cayenensis*). It should not be too small since the size of the yam growing on about 5 to 6 metres stake resembles a tree. Yet a large plot would have required expensive installation of the run-off receiving tanks and labourious work for measurements and maintenances.[8]

To use the best site available where the land surface

slope in 20° at the Olive River Soil Conservation Centre, the size of a plot was determined for practical reasons as 2.7 m wide by 15.8 m long along the slope (14.8 m horizontally) comprising 40 m² of run-off producing area.

The plot boundary walls constructed with the common concrete blocks having dimensions of 35 cm high above ground surface and 15 cm under ground with 15 cm width and U-shaped section for drain of the rainfall water from the crest of wall.

The narrow concrete pavements at one side of each run-off plot boundary wall having 20 cm wide and 10 cm depth under ground, were constructed as a foundation work for the boundary walls as well as for use as a cultivating operation path.

2). Collection troughs and receiving tanks

The collection troughs including the insertion tongues for receiving and collecting the run-off materials from the run-off plot above were installed to reach across the entire width of the plot width.

The major elements of collection trough design are depth, width and bottom slope. Since only conveyance pipe was used (no rate measurement), the depth of collective trough was based on the outlet pipe size needed to carry the run-off load. Width of the trough, within limits, is largely a matter of preference. Bottom slope was determined by 5 percent minimum slope. The collection trough has a dimension of 270 cm long, 30 cm wide, 25 cm depth with a shape of rectangular made of the galvanized sheets.

A collection trough has such attachments as an outlet conveyance pipe, five supporting bars, insertion tongue, and a cover. Outlet conveyance pipe for the run-off materials from the collection trough to the sediment tank (A) was made of the galvanized sheet having 100 cm long, 20 cm wide and 15 cm high with rectangular section.

Metal drums (55 gallon capacity: 220 litres) were used for the run-off receiving tanks. Each collection trough (each plot) has two tanks; one for sediment tank (A) and the other for the suspension tank (B). The sediment tank (A) is to retain and store all the soil materials and pass only a suspended sediment mixture with water to the next tank unit (B). Two metal pipe connections of 60 cm long (one 2 inch pipe and the other 4 inch pipe used) were welded on the same side of the sediment tank (A) for conveyance of the over flow run-off from the sediment tank (A) to the suspension tank (B). Also each tank has a drain pipe of 20 cm long (2 inch diameter pipe) for using the final drainage from the bottom of drum. The suspension tanks (B) have one welded metal pipe (2 inch pipe) of 60 cm long at the top level of the drum and have a final drain pipe as the tank (A).

Top-view of layout of the run-off experiment plots is presented in Figure 1.

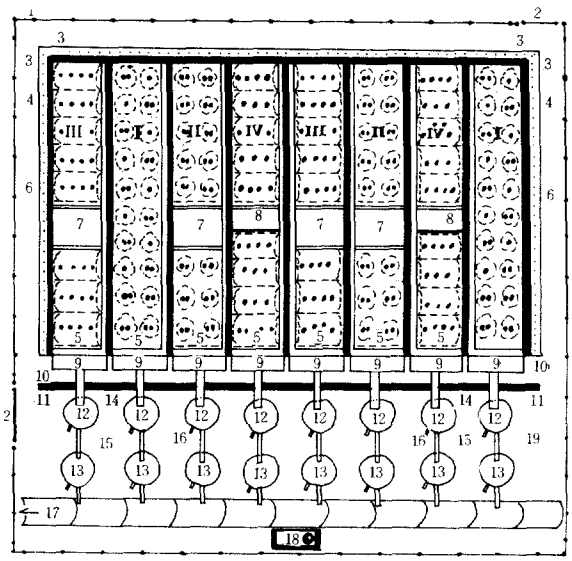

Fig. 1. Top-view of layout of the run-off experiment plots

Legends

1 Barb-wire fence	12 Storage tank (A)
2 Entrance gate	13 Storage tank (B)
3 Earth wall	14 Outlet pipe (a)
4 Plot boundary wall	15 Outlet pipe (b)
5 Plot area	16 Drainage pipe
6 Plot payvement	17 Drainage way
7 Hillside ditch	18 Rain gauge
8 Grass buffer strip	19 Mettle pavement
9 Collection trough	I, II, III, IV: Treatment No.
10 Concrete base	• • Yams on individual hill
11 Retaining tank	•••• Yams on contour mound

3. Treatments for soil conservation measures cropping systems.

The treatments were designed to evaluate the effects of the soil conservation measures adopted in

this experiment affecting on the soil erosion losses as well as the crop yields.

The experiment was consisted of four soil conservation treatments with two replications comprising eight plots.

a) Treatment I:—Only yam planted without inter-crops on the individual hills without soil conservation measures as practised by farmers traditionally. The method is to roughly clear the bush fallow and draw up hills with a fork. The individual hills have a 510 cm spacing along the contour and a 140 cm spacing along the up-and-down slopes developing its height of about 45 cm.

In this plot, there were 20 individual hills and 32 yam seed-heads were planted. Eight hills had only one yam seed-head while the other twelve hills had two seed-heads, so as to plant the same number of 32 yams per plot. One 4 m long bamboo-stake was erected for claiming of yam for each hill.

b) Treatment II:—Yam cultivated with inter-crops on the individual hills using the hillside ditch as soil conservation measures. A hillside ditch having the width of 2.3 m was constructed between the portion of 7.6 m from the top wall and 4.9 m from the lower boundary wall. The specifications of hillside ditch on 20° slope land were determined such as: total width 2.3 m, reverse slope 10%, riser slope 1:0.75, height of riser 57 cm, and reverse height 18 cm, respectively. Cross-section of the hillside ditch is shown in Figure 2.

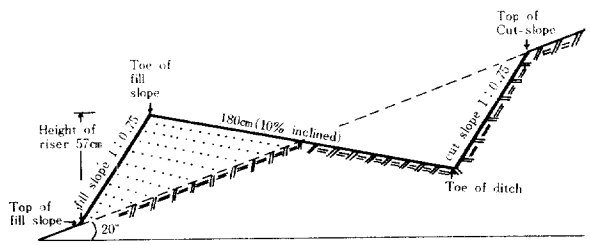

Fig. 2. Cross section of Hillside ditch.

There were 16 individual hills and a hillside ditch in this treatment plot. Total 32 yam seed-heads (two per hill) planted, and one 4 m long bamboo-stake was erected per hill. Irish potatoes as a first inter-crop were planted. 8 seed-heads for both side of a hill were planted making total 128 seed-heads per plot. For the second inter-crop, radishes were planted as rows of both side of hill. Peanuts as the third inter-crops were planted as rows on both sides of the hill.

c) Treatment III:—Yam cultivated with inter-crops on the continuous contour mounds using the hillside ditch as treatment II. The contour mounds keep an average 150 cm width and about 45 cm height. The continuous contour mounds were expected to have such advantages as more holding capacity of run-off materials than individual hills, and also have more population of yam seed-heads with uniform intervals, and less establishment of yam stakes than the individual hills.

There was a hillside ditch and eight contour mounds in this plot. Four yam seed-heads per mound having 62 cm spacing were planted so as to make total 32 seed-heads in the plot. 4 m long bamboo-stakes were also placed between pair of mounds and carry four yam vines, two from each mound.

Irish potatoes were planted as the first inter-crop. 16 seed-heads for both side of a mound were planted, totalling 128 seed-heads. For second inter-crop, radishes were planted as rows on both side of mound on Auguat 5, 1980. Peanuts as the third inter-crops were planted as rows on both side of mound.

d) Treatment IV:—Yam planted with the inter-crops on the contour mounds as treatment III, but using the grass buffer strip as soil cnservation measures. A grass buffer strip having its width of 1.3 m was established between the portion of 7.6 m from the top wall and 5.9 m from the lower wall. To make a grass buffer strip, napiar grass (*Pennisetum purpureum*) locally grown were transplanted with a spacing of 30 x 30 cm. Plane view of the grass buffer strip is shown in Figure. 3.

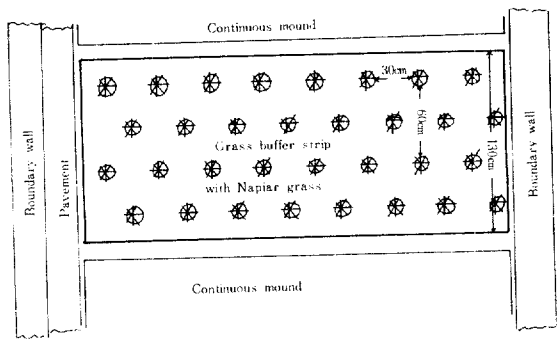

Fig. 3. Plane view of Grass buffer strip.

There was a grass buffer strip and nine contour mounds in this plot. Four yam seed-heads per mound for five mounds were planted, and three heads per mound for the remaining mounds were planted so as to make total 32 heads in the plot. The staking was same as the treatment III. Irish potatoes were planted as the first inter-crop. 16 seed-heads for both side of a mound were planted, totalling 144 heads. Radishes and peanuts were planted as inter-crops as the treatment III.

Yams as main crop for all plots were planted on March 25, 1980, and potatoes as the first inter-crops were planted on March 25, 1980. Radishes as the second inter-crops on August 5, 1980, and peanuts as the third inter-crops on October 5, 1980.

An arrangement for the four treatments of a replication was provided by random. Because of land space at field and limitation of expenditure, only two replications were established.

4. Measurement of soil loss

Following "very heavy run-off" producing storm, or after several rainfalls, total volume and wet weight of soil sediment in the tanks and troughs were measured and recorded on the "calculation sheet for measurement of soil loss" and also on the "soil moisture data sheet". (Detailed procedures for recording and calculating the data sheets refer to the IICA Pub. No. V-II, 1981).[12]

For determination of dry weight of soil loss, the following procedures were used:

(a) The weight of the wet soil sediment contained in both troughs and tanks was measured and recorded.

(b) From these sediment materials three subsamples (aliquots) were collected for moisture content determination. The soil-water sediment cans were oven-dried at 105 °C for 72 hours and weighed.

(c) The moisture percent of the sediment sample was then calculated. The moisture of the soil-sediment within the troughs and tanks was estimated by average moisture percent of the three samples collected at the field.

(d) The weight of dry sediment could then be computed by multiplying the net wet weight of sediment with the moisture % of the samples.

The soil loss from each treatment plot in dry weight could be estimated as same amount of total dry sediment weight occured from the relevant plot.

For these measurements, the following instruments were used:

(a) Weighing scale for field use.
(b) Graduated plastic buckets.
(c) Plastic basins.
(d) Rectangular type hoes and brushes.
(e) Draining hoses.
(f) Aluminum cans for soil sediment samples.
(g) Electrical ovens.
(h) Weighing balance for laboratory uses.
(i) Electronic calculator.
(j) Trestles.

RESULTS AND DISCUSSIONS

It is rather a tentative description for further discussion on the effects of the soil conservation treatments compared with soil loss during only one crop-year cycle of yam cultivation. During a period of about 10 months from April 26, 1980, after immediately ready for measurement and recording, total numbers of rainfall days were recorded as 89 making a total amount of 1,295 mm. Total amount of rainfall was much smaller as compared with the record of the Wait-A-Bit station. It is, therefore, considered a rather dry year generally.

The highest monthly rainfall was recorded in May 1980 having 332.0 mm with 17 days of rainfall, followed by August 1980 having 272.7 mm with 8 days. The lowest monthly rainfall having 35.8 mm with only 4 days was recorded in February 1981, followed by January 1981 having 43.2 mm with 7 days rainfall. The heaviest daily rainfall was recorded on August 5, 1980, having 116.4 mm which created much soil erosion.

The soil sediments had been collected for eleven times from beginning of operation of the run-off plot to March 3, 1981 which was a crop-year cycle of yam cultivation and the summarized figures including rainfall are presented in table 1.

As presented in table 1, duration required for storage and collection of the soil sediment had not been fixed as same interval. These durations were determined according to the amount of soil-sediment storages in the receiving tanks.

Total amounts of soil-sediment as oven-dried

Table 1. Mean oven-dry weight of soil sediment and rainfall by sampling interval

Sample Collection No.	Period occured			Oven-dry weight of soil sediment (kg)				Rainfall during period (mm)
	days	from	to	T-I	T-II	T-III	T-IV	
1	13	1980 April 26	1980 May 8	77.23	54.49	22.92	24.10	87.9
2	12	May 9	May 20	174.93	93.64	42.54	33.98	92.8
3	7	May 21	May 27	79.14	35.71	10.05	8.12	83.3
4	14	May 28	June 10	108.44	27.04	5.65	3.59	157.2
5	24	June 11	July 4	38.15	2.79	0.86	0.91	55.0
6	18	July 5	July 22	93.01	74.88	30.88	36.23	81.9
7	21	July 23	Aug. 12	83.50	72.21	52.48	32.68	229.1
8	28	Aug. 13	Sept. 9	17.21	17.01	9.94	7.20	65.2
9	28	Sept. 10	Oct. 7	27.35	21.30	11.40	10.59	67.5
10	64	Oct. 8	Dec. 10	24.79	13.99	8.49	8.47	154.5
11	83	Dec. 11	March 3 1981	4.93	8.04	5.78	6.21	220.7
Total	312			728.65	421.07	200.96	172.08	1,295.1

Table 2. Results analysed and relative effects of the treatments

Treatment No.	Oven-dried weight of soil loss				Rate to T-I (%)	% reduction T-I	Effects as compared with each treatment (times)		
	per plot (kg)	ton/ha	ton/ac	depth (mm/yr)					
T-I	728.65	182.16	72.89	12.41	100.0	–	0	0	
T-II	421.07	105.27	42.11	7.17	57.79	42.21	1.7	0	
T-III	200.96	50.24	20.10	3.42	27.58	72.42	3.6	2.1	0
T-IV	172.08	43.02	17.21	2.93	23.36	76.64	4.2	2.5	1.2

weight by each treatment plot during the experiment period had been calculated as 728.65 kg from the treatment I, 421.07 kg from the treatment II, 200.96 kg from the treatment III, and 172.08 kg from the treatment IV, respectively.

The total weight of soil loss converted into the acreage of hectare and acre including the effects of each treatments are shown in table 2.

As shown in table 2, total weights of soil loss converted into the acreage unit were calculated as 182.16 tons/ha from treatment I, 105.27 tons/ha from treatment II, 50.24 tons/ha from treatment III, and 43.02 tons/ha from treatment IV, respectively.

Based on the consideration that a one-six inch furrow-slice common in minerals soils can have a dry weight of 2,000,000 pounds, it is seen that depth of an-nual soil loss could be estimated about 12.4 mm from treatment I, 7.2 mm from treatment II, 3.4 mm from treatment III, and 2.9 mm from treatment IV, respectively.[12]

If the amount of soil loss from treatment I plot is 100 units, i.e. rate to treatment I, the soil losses from the other treatment plots could be estimated as about 57.8% from treatment II, 27.6% from treatment III, and 23.4% from treatment IV, respectively.

In relative effects among four treatments, treatment II was about 1.7 times, treatment III was about 3.6 times, and treatment IV was about 4.2 times more effective than treatment I, respectively. As it was compared with treatment II, treatment III was about 2.1 times more effective than treatment II.

In practice the control plot could be considered as not having any crop canopy whatsoever since it was cropped to yam alone which initiates sprouting during

the first 8 weeks followed by another 8 weeks of rapid shoot elongation and leaf development. In the other plots although yam crops were developing at the same rate as in the control plots by 44 days the Irish potato crops had germinated and established a good crop cover and by 50 days floral initiation had completed.

As Irish potato crops had been developed and attained full crop cover it was evident that, in addition to the physical soil conservation measures adopted, good crop cover affected to significant reduction in soil loss from the 20 degree hillside farming lands. Yam crops were growing their most active phase of increment developing the maximum crop canopy during the period from late July to September 1980. The results of crop yields had not been analysed for this paper and it would be reported separately.

CONCLUSION

1. The run-off experiment plots had been established for eight sets of plot comprising four treatments with two replications on 20° slope land having the Wait-A-Bit clay soil, at the Olive River Soil Conservation Centre, Trelawny in Jamaica. The elevation of plots was about 820 metres and sloped northwest. Each plot size was determined as 40 m^2 having 2.7 m wide and 15.8 m long along slope. All of the run-off soil and water were collected by the receiving tanks through the collection troughs and conveyance pipes. These run-off materials were measured and sampled, dried and calculated for determination of the soil loss from each treatment of plot.

2. Hillside farming practice with an appropriate bench terracings is considered as one of the best measures for both soil conservation and crop production from up-land. In this experiment, however, "soil conservation measures other than bench terracing" should be adopted as main treatments according to the Plan Operation. The Project, therefore, finally determined both hillside ditch measures and grass buffer strip measures as the major treatment, and also individual hill and continuous contour mound practices were selected for the main husbandry method.

3. This experiment consisted of four treatments. Treatment I is yam cultivation only on individual hills using the clean cultivation and considered as a check plot. Treatment II is yam cultivation on individual hills using inter-croppings and hillside ditch measures. Treatment III is yam cultivation on continuous contour mounds with inter-croppings and hillside ditch measures. Treatment IV is yam cultivation on continuous contour mounds with inter-croppings and grass buffer strip measures.

4. During the first period of experiment for about 10 months which was one crop-year cycle of yam, total amount of 1,295 mm rainfall was recorded. it is considered that this period was dried year as compared with the record from Wait-A-Bit station. The heaviest daily rainfall was recorded as 116.2 mm on August 5, followed by 100.4 mm on August 6, 1980. The number of days which occured more than 30 mm of daily rainfall were 13 days and the amount of rainfall during these 13 days took about 51.5% of the total rainfall. The soil erosion could be affected largely by these heavy rainfall.

5. The soil sediments had been collected and analysed for eleven times during one crop-cycle of yam from April 26, 1980 to March 3, 1981. Total amount of soil sediment as oven-dried weight by the treatment plot calculated as 728.65 kg from the treatment I plot, 421.07 kg from treatment II plot, 200.96 kg from treatment III, and 172.08 kg from treatment IV, respectively. If these figures are converted into the acreage unit, it could be an amount of 182.16 tons/ha (72.87 tons/acre) from the treatment I plot, 105.27 tons/ha (42.11 tons/acre) from the treatment II plot, 50.24 tons/ha (20.10 tons/acre) and 43.02 tons/ha (17.21 tons/acre) from the treatment IV, respectively. It is estimated that soil losses of the upper 15 cm soil layer on a 20 degree slope land could be taken for about 10 years in the treatment I situation, about 17 years in the treatment II situation, about 36 years in the Treatment III situation, and about 43 years in the treatment IV situation, respectively.

LITERATURE CITED

1. Ahomad, N. and E. Breckner. 1973. Soil erosion on three Tobago soils. Paper presented at the conference on soils of the Caribbean and Tropical America. University of the West Indies, Trinidad, W.I.

2. Forsythe, Warren M. and Jose Noia Rocha. 1978. Design of an inexpensive soil erosion control demonstration plot. Inter-American Institute of Agricultural Sciences in Barbados.
3. Garcia George, Wayne C. Hickey, Jr., and E.J. Dortignac. 1960. An inexpensive run-off plot. U.S. Forest Service Research note RM-12.
4. Hudson N.W. 1957. The design of field experiments on soil erosion. Journal of Agricultural Research 2 (1): 56-67.
5. Hudson, N.W. 1971. Soil Conservation. Cornell University Press N.Y. 320 p.
6. Ministry of Finance. 1971. The National Atlas of Jamaica. 1971. 8 p.
7. Mutchler, Calvink. 1963. Run-off plot design and installation for soil erosion studies. USDA. Agricultural Research Service ARS 41-79.
8. Sheng, T.C. and T. Michaelson. 1973. Run-off and soil loss studies in Yellow Yams. Forestry Development and Watershed Management in the upland regions Jamaica. FAO: SF/JAM 505 Project Working Document. 60 p.
9. Sheng, T.C. and H.R. Stennet. 1975. Lecture Notes—Watershed Management and soil conservation training course. Forestry Development and Watershed Management in the Upland Regions, Jamaica. UNDP-FAO/JAM 505 Project Working Document. 245 p.
10. Stennet, H.R. 1978. Soil loss in Jamaica's Hilly Watersheds, Hillside Farming in Jamaica Training Seminar. IICA/Jamaica pub. No. 1-9. pp. 1-11.
11. Wahab, A.H., P. Aitken, I. Johnson, Bo Myeong Woo, H. Murray and J. Dehaney. 1981. The experience of Jamaica in the management of agricultural production on Hillsides. IICA-OAS/Jamaica. Pub. No. V-8. 68 p.
12. Woo, Bo Myeong, A. Wahab, H. Stennet, and J. Dehaney. 1981. Results of the Olive River soil loss *cum* cropping system studies. IICA-OSA/Jamaica Pub. No. 11. 1981.