INTERCROPPING MAIZE WITH COWPEAS AND BEANS FOR SOIL AND WATER MANAGEMENT IN WESTERN KENYA

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Abstract
This study compares runoff and soil loss from sole maize with three inter-cropping systems. There were five treatments: sole maize, maize inter-cropped with beans, maize inter-cropped with cowpeas, and maize inter-cropped with beans and cowpeas. Sole maize produced the highest runoff while maize inter-cropped with cowpeas produced the lowest runoff in the cropped plots. The results show that cowpeas are better at covering the ground surface than beans and when inter-cropped with maize give a better protection of the soil against erosion than when inter-cropped with beans and maize.

Additional Keywords: soil loss, runoff

Introduction
In Sub-Saharan Africa, the traditional farming system of rotational bush-fallow, also synonymous with shifting cultivation or slash and burn agriculture, was considered to be in equilibrium with the environmental conditions of tropical Africa and was therefore a sustainable system (Okigbo, 1975; Barrow, 1989). Fertility losses were not due to erosion but due to the removal of nutrients by the crops and leaching (Bonsu and Obeng, 1979). Land was left to rest after being cropped for a couple of years so that it could regenerate and replenish its fertility. And while the land rested it reverted to its natural cover of vegetation. This ingenuity on the part of the traditional African farmer has helped to conserve the environment for thousands of years since the beginning of agriculture on the continent (Bonsu, 1981).

The introduction of mono-cropping by the white farmers and the colonial government in Kenya and the adoption of the same by the post-colonial government has over the years grossly degraded the soil in the rural areas where 80% of the people live (Dune *et al*., 1978). Lands which were once productive are now extensively gullied. Therefore, there is need to revert to the multiple cropping system if soil erosion is to be contained and land returned to production (Tiffen *et al*., 1995).

The current methods which are being promoted, like terracing and contour ridging are expensive, farmers are not adopting them, and consequently soil erosion is increasing at an alarming rate. The objective of this research is to investigate the effectiveness of multiple-cropping in reducing soil and water losses in the Uasin Gishu District of Kenya.

Materials and Methods
Field sites
This investigation was carried out at Moi Unviersity, Uasin Gishu District, Kenya. The experimental site was located around 00 17’N latitude and 35 17’E longitude. A randomized complete block design (RCBD) was employed in the field with five treatments and three replications. The five treatments were: (i) sole maize, (ii) maize intercropped with beans, (iii) maize intercropped with cow-peas, (iv) maize inter-cropped with beans and cow-peas, and (v) bare ground as a control. There were a total of fifteen runoff plots each measuring 7 m by 2 m established on a 5% slope.

Hybrid maize (variety 614) was planted at 75cm row spacing and 25cm between plants. The plots were prepared using hand hoes and tilled to a depth of 10cm. Fertilizer was banded along the seed row during planting time at the rate of 18 kg ha^{-1}N and 46 kg ha^{-1}P in all cropped treatments. The maize stand was thinned 20 days after germination to one plant per hole to give a final plant population of about 44000 plants per hectare. Five weeks after germination maize was top-dressed with 26 kg ha^{-1}N. These fertilizer rates and spacing were similar to those practiced by local farmers.

Roscoco beans were used for inter-cropping with maize. They were planted at 25 cm row spacing and 10 cm between plants. Two rows of beans were therefore planted between the 75 cm maize rows. Fertilizer was banded along the bean seed rows at a rate similar to maize. The beans were top dressed with 26kg ha^{-1}N three weeks after germination and thinned to one plant per hole. The same spacing and rates of fertilizer application used in the maize and beans inter-crop was also used in the maize and cow-peas inter-crop. In the multiple-crop system of maize, beans, and cow-peas, one row of beans and one row of cow-peas were planted between two rows of maize and spaced and fertilized as above.

The runoff equipment used for the study was similar to the one designed by Hudson (1957) in Zimbabwe. The equipment consisted of plot boundaries, soil and runoff collector at the end of the plot, a conveyance channel and a sludge tank containing soil and water. The runoff plot boundary to prevent water and soil from entering or leaving the plot was constructed with 24 gauge galvanized sheet metal strips. The sheet metal was 7 m long and 2 m wide. The metal strips were placed along the boundary such that the down slope strip overlapped on the outside of the up slope strip and held together by round iron bars to form water tight joints. The metal strips were then pushed into the ground to a depth of 10 cm. Soils were packed against the outer strips to stabilize them and prevent seepage.

A runoff collector trough was made of 24 gauge galvanized sheet metal. The collector was designed to reach across the entire 2 m width of the plot with a bottom slope of 6%. A sheet metal cover was placed on top of the collector trough to prevent rain from entering the system. A 10 cm diameter PVC pipe was installed to carry runoff and soil loss from the runoff collector outlet into the circular shape of the sludge tank.

The function of the sludge tank was to store all the soil and water from the runoff plot. In the absence of valid documented quantities of runoff and soil loss to assist in the design, the storage capacity of sludge tank was arbitrarily set at 600 litres runoff capacity. In setting this storage capacity, it was assumed that the sludge tanks could be emptied after every rainstorm.

Removable cans with storage capacity of 20 litres were placed directly below the inflow pipe of the sludge tanks. The main function of the cans was to reduce the time taken and the labour required to sample and clean up after a small rainstorm and to improve the accuracy of measurement. The sludge tank was covered to prevent direct rainfall entry. The tanks were placed on level platforms on the ground.

Measurements of Runoff and Soil Loss

The following routine procedures were carried out whenever a rainstorm occurred the runoff collector trough and conveyance channel were checked for plant material and debris that might block entry of water and soil andwhenever soil material was present in the runoff collector trough and conveyance channel it was flushed into the sludge tank using water taken from the sludge tank. Runoff events were identified as either a small runoff event or large runoff events.

Small runoff events

These were the runoff events in which the small cans placed in the sludge tank (referred hereafter as simply can “S”) had not over-flowed.

1) 5g of aluminium sulphate pellet was placed into the can and all the contents stirred thoroughly and then allowed to flocculate until clear runoff water remained standing on the sludge;
2) All runoff water was carefully siphoned into a bucket. The precise volume of water was measured using a graduated 1-litre measuring cylinder. The runoff volume was then recorded in the field note book;
3) The sludge was then mixed thoroughly and allowed to settle for 1 hour and its depth recorded;
4) Three replicate samples of fixed volume ($200cm^3$) were then taken for laboratory analyses.

Large runoff event

These were runoff events in which the can “S” in the sludge tank had overflowed. There were no runoff events in which the sludge tanks over-flowed.

1) The contents of can “S” were emptied into the sludge tank and the can removed;
2) Aluminum sulphate pellet was placed into the sludge tank and all the contents of tank stirred thoroughly and then allowed to flocculate until clear runoff water remained standing on the sludge;
3) All runoff was then carefully siphoned into a bucket. The precise volume of water was measured as above;
4) The sludge was then mixed thoroughly and the depth of the sludge in the tank recorded;
5) Three replicate samples of fixed volume ($500cm^3$) were taken from three different points in the sludge tank and taken for laboratory analysis.

Sludge volume
The sludge volume produced by each rainstorm was calculated as follows:

(i) If the sludge was only in can "S" then:

$$Q_v = (A_C H_S)10^{-6} \quad (1)$$

where Q_v = the total sludge volume in m^3
A_C = the base area of can
H_S = the height of the sludge in the can

(ii) If the sludge was in the sludge tank then:

$$Q_V = (A_S H_P)10^{-6} \quad (2)$$

Where Q_v = the total sludge volume in m^3
A_S = the base of the sludge tank
H_P = the height of the sludge in the sludge tank

Sludge dry weight
The sludge samples from the field were transferred into labeled and weighed beakers and weighed. The sludge samples were then dried in a conventional oven at 105°C to 110°C to a constant mass, cooled, and weighed to the nearest 0.1g. The dry weight of sludge material in each sample was determined as follows:

$$D_W = \frac{(W_m - B_e)}{F_v} 10^3 \quad (3)$$

Where: D_w = The weight of dry sludge material in the sample in kg m^{-3}
W_m = Weight of oven dry sludge and beaker in g.
B_e = the weight of empty beaker.
F_v = the fixed volume of the sludge sample in cm^3.

Soil Loss
The soil loss T_s was calculated in kilograms from the 14m^2 runoff plot as follows:

$$T_s = D_w Q_V \quad (4)$$

Where Dw = the weight of dry sludge material in the sample in kg m^{-3}
Q_V = the total sludge volume in m^3

The total loss, L_s, in tonnes per hectare was calculated as:

$$L_s = 0.71 T_s \quad (5)$$

Results and Discussion
Table 1 shows the amount of runoff from various treatments compared to bare ground. While runoff under sole maize is 67.6% of bare ground, maize inter-cropped with cow-peas is only 14.3% that of bare ground. This means there is 4.73 times more runoff under maize as a mono-crop than under maize inter-cropped with cow-peas. Table 2 shows that soil loss under sole maize is 35% that of bare ground while under maize inter-cropped with cow-peas it is 14% of bare ground which means that soil loss under mono-cropping with maize is 2.5 times higher than soil loss under maize inter-cropped with cow-peas. The highest runoff and soil loss from cropped plots were obtained from sole maize and the lowest amount from maize intercropped with cow-peas.

There was no significant difference at $p>0.05$ between the runoff and soil loss produced by maize inter-cropped with cow-peas, and the multi-crop of maize, beans and cow peas. However, maize inter-cropped with beans had a significantly higher runoff and soil loss ($p<0.05$) than the other two inter-crops. This indicates that it is not as effective in controlling soil and water losses as maize intercropped with cowpeas or the multiple-crop of maize, beans and cow-peas. Given that beans and cow-peas had the same spacing and therefore the same plant population it shows that cow-peas provide a better protection of the soil against erosion than beans. It appears that beans do not provide a dense foliage as cow-peas and therefore rows occupied by bean plants leave some open space through which raindrops hit the ground and cause runoff and erosion. It should, however, be noted that the difference in runoff and soil losses between maize inter-cropped with cow-peas and the multiple-crop of maize, beans and cow-peas is not significant (p>0.05) which means either system is the most sustainable (Figures 1 and 2).

Table 1: Runoff for various treatments[1]

Treatment	Runoff (L)	Percent of bare fallow
Bare fallow	1226.3	100
Sole maize	856.6	67.6
Maize inter-cropped with beans	434.7	34.6
Maize inter-cropped with cow-peas	180.7a[1]	14.3
Maize inter-cropped with beans & cow-peas	222.6a	17.6

[1]LSD Procedure: Values followed by the same letter were not significantly different at p > 0.05

Table 2. Soil loss for various treatments[1]

Treatment	Soil loss ($t\ ha^{-1}$)	Percent of bare fallow
Bare fallow	83.0	100
Sole maize	28.9	35.0
Maize inter-cropped with beans	16.3	19.9
Maize inter-cropped with cow-peas	11.6a[1]	14.0
Maize inter-cropped with beans & cow-peas	12.5a	15.2

[1] LSD Procedure: Values followed by the same letter were not significantly different at p > 0.05

The low production of runoff and soil loss where maize was inter-cropped with either beans or cow-peas or both demonstrate the importance of dense ground cover in reducing soil and water losses. The multi-storey crop canopy structure provided by the inter-crop systems were effective in cushioning the rain drop impact. The low growing crops of beans and cow-peas were effective in creating a surface roughness that helped in retarding the flow of runoff thereby enhancing infiltration and reducing movement of water and soil on the ground surface. The upper maize canopy layer served as the first interceptor and absorbed some of the raindrop impact. The bean and cow-peas layer intercepted the remainder of the raindrops. As the rain water dropped off the bean and cow-peas layer it was no longer effective in causing erosion as its terminal velocity had been greatly reduced by the interception.

Conclusions

Maize growing as practiced in Uasin Gishu District of Kenya is normally mono-cultural. This study has demonstrated that the practice of planting maize as a sole crop, although widespread in the district is not sustainable and in the long run the soil will be eroded beyond the tolerance level. As this region is one of the districts which make up what is commonly called the "granary of Kenya", the whole nation is bound to suffer as food shortages may increase. The solution is for the government to have a policy which encourages farmers to inter-crop maize with other low growing legumes like cow-peas and beans.

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