EFFECT OF VETIVER GRASS STRIP IN CONTROLLING SOIL EROSION IN TRADITIONAL FARMING PRACTICES AND IMPROVEMENTS IN THE YIELDS OF CROPS

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ABSTRACT

Traditional farmers are generally not aware of the considerable losses of soil and water, which occur under traditional farming practices in the tropics. Experiments were conducted over six growing seasons to investigate the use of vetiver grass strips in curbing the menace and improving crop yields. Losses from flat cultivations were generally lower than from mound cultivation. Runoff values from flat cultivations ranged from 5.3 percent to 15.7 percent of total rainfall whereas on the mounds the values ranged from 15.7 percent to 26.5 percent on the control plots when vetiver grass strip was not imposed. Soil erodibility values ranged from 2.01 to 7.26 for flat cultivations as compared to 3.75 to 14.7 for mound cultivation. Runoff and soil loss were higher on scattered mounds than mounds on the contour. Vetiver grass placed at 5,10 and 20m surface spacings reduced runoff on the flat by a range of 115.0% to 406.5% and 72.1% to 485.2% on the mound, the shorter the grass spacing, the greater was the reduction. On the other hand, vetiver grass reduced soil loss by a range of 124.5% to 1031% on the flat and a range of 68% to 500% on the mound cultivation. Vetiver grass strips were thus more beneficial on flat cultivation than on mound cultivation. Soil accumulation by vetiver grass strips was significantly affected by vetiver grass strips. Soil accumulations were 32.8% to 42.1% greater on 13% slope than 7% slope. Vetiver grass strips at 5.10m and 20m surface spacing had significant effects on the yields of most crops. Plant height of maize was increased by a range of 7 to 20%, cowpea yield was increased by a range of 28 to 70.9%, maize by a range of 17.0 to 63.1%, potato by a range of 48.6 – 109.5% and cassava by a range of 10 to 55% over the control when crops were planted in mixtures on the mound. Mean gravimetric moisture contents of the soils on the mounds increased by a range of 6.5 to 28.5% over the control under cassava plantations.

INTRODUCTION

Huge losses of soil and water concomitant with severe nutrient depletion is the bane of agricultural practice amongst peasant farmers especially in most parts of the humid and semiarid tropical environments of Africa. This inevitably results in poor crop yields leading to poverty and malnutrition as about two-thirds of Africans depends on a agriculture for their livelihoods. Inadequate and low use of commercial organic and inorganic fertilizer encourages the situation. Most farmers do not appreciate the "fertilizing" influence, which good soil and water management practices have on crop yields and the environment in general.

Traditional, tuber crops such as cassava, yam and sweet potatoes, major staples of most Africans, are planted on heaps, mounds or ridges in association with other crops such as maize, okro, cowpea and mellon. In most cases, mound cultivation is done for ease of harvesting of the crops without any regard to the physical condition of the soil. In some parts of Nigeria, and indeed the humid tropics, some farmers raise their crops on the flat especially on the coastal plain sands of Nigeria. When heaps or mounds are made on flat or relatively flat land, the intermound spaces serve as temporary water storage during the rains. If the soil is well drained, such storage is advantageous. On slopy lands however, the water storage contributes largely to overland flow. This is not only due to the force of gravity but also because the physical properties of the soil on the furrow is inferior to that on the mound in terms of bulk density, porosity and pore size distribution (Babalola and Opara – Nadi, 1993). Lal (1997) has reported that cumulative infiltration at 3hours on an Alfisol in Ibadan, Nigeria was 6 times higher on ridges or mounds than on the furrow and that equilibrium infiltration rates was 10 times lower than the furrows. He attributed this partly to crust formation by the silt and clay washed in from the mound. Consequently on slopy grounds, the stage is set for accelerated soil erosion in humid environments. Such losses of soil and water and nutrients proceed without notice by many farmers as little is done to curb it. The use of vetiver grass strip as a simple, cheap and effective method of control (World Bank, 1993, Grimshaw, 1993; Grimshaw, 1995) has been little reported or investigated especially in traditional farming practices. In a farmer's participatory research project, Howeller et al (2003) concluded that out of six conservation practices, vetiver grass hedgerows reduced soil loss by 75% and increased cassava yield by 3.2 percent. The arrangement of the mounds on the slope could influence the loss of water and soil. Some farmers establish mounds up and down the slope without any regard for the contour. Other farmers scatter the mounds as found convenient. Experiments were therefore conducted to (i) determine the effect of surface spacings of vetiver grass on soil and water conservation and yield of crops in a traditional farming practice of mixed cropping on mounds and (ii) to determine the effect of slope and the arrangement of mounds on a slope on soil and water conservation as influenced by vetiver grass spacings and (iii) to compare soil and water losses from flat cultivation with mound cultivation.

MATERIALS AND METHOD

The experiments was conducted at the Teaching and Research Farm of the University of Ibadan ($7^0 24\ ^1$N $3^0 54^1$ E) in Nigeria. The rainfall pattern is biomodal and averages 1230mm per annum. Rainfall peaks occur in June and September. There are 175 total wet days in the year. There are two growing seasons: early season runs from March/April to August and late season, from mid-August to October/November. Annual temperatures range from a high of 31.2^0c to a low of 21.3^0c. Ibadan has a percentage sunshine that ranges between 16% in August to 59% in February and December with an average of 44%. The soil of the area is an Alfisol of the order Oxic Palueustalf according to the USDA classification. It is classified locally as Iwo series (Smyth and Montgomery, 1962).

There were three main experiments carried out in 2003, 2004 and 2005 growing seasons. In these experiments, the traditional farming practices of flat cultivation and mound cultivations were employed. Mounds were roughly 70cm in diameter and 20cm high and were spaced at 1m intervals (Babalola & Opara Nadi, 1993). The test crops used in mixtures on mounds were cassava, maize, cowpea and okra. Cassava stakes were planted on the mounds. Maize, cowpea and okro were planted on the neck of the mounds.

In the flat cultivation, maize was used as a test crop planted at 90cm x 30cm spacings. In the **first** experiment, there were four treatments of vetiver grass spacings (VGS) at (i) 0m (ii) 5m (iii) 10m and (iv) 20m. These were imposed on two slopes, a 7% and a 13% slope. On the 7% slope, cassava cuttings, variety TMS 30572 and maize, variety white maize ACR95TZE comp 4 C_3 were used as test crops. Maize was planted on June 25, 2003 and cassava cuttings were planted on July 18, 2003. Calibrated metal rods, 3mm in diameter and 20cm high were inserted 5cm deep into the soil at 15cm from the edge of the vetiver strips on July 15, 2003 for monitoring soil accumulation due to erosion. Vetiver strips were established on June 12, 2003. Readings of the calibrated rods were made periodically during the growth of the crops. Plot size was 40m long and 3m wide and the treatments which were replicated thrice were arranged in a randomized compete block design on both slopes. On the 13% slope, cassava cuttings, variety 91/02324 and maize variety (yellow maize) Oba super II were planted on June 4, 2004 and May 21, 2004 respectively. Vetiver strips were established in October 4, 2003 and calibrated erosion rods were installed on June 10, 2004. Readings of the calibrated rods were made periodically during the growth of the crops. On the 7% slope, moisture contents at 0 - 15cm depths on the mounds were determined gravimetrically over 5m intervals down the slope at the cessation of the rains in the late seasons of 2003 and 2004. Samples from about 10 mounds were bulked to give an idea of the moisture content on the mounds over 5m intervals. Cassava was harvested on the 7% slope at 18months and on the 13% slope at 15months. Other crops were harvested at maturities. After the harvest of cassava on the 7% slopes, the mounds were re-established and planted to maize and cowpea in the late season of 2004. Tuber yields in terms of total fresh weight of tubers and tuber numbers per hectare, maize and cowpea grain yields were determined at harvest.

In the **second** experiment, maize and sweet potato were used as t-test crops. Maize, at a spacing of 90cm x 30cm was initially planted on the flat for four growing seasons. Subsequently, flat cultivation was converted to mounds at the same spacings and planted to sweet potato vines. There were two treatments: vetiver grass strip established at surface intervals of 20m (V) and no-vetiver strip (NV). The vetiver strips were established in 2001and the plots had been cultivated to maize on the flat for six growing seasons. The treatments were replicated thrice in a randomized complete block design. Plot sizes were also 40m long and 3m wide. Soil and water collecting devices were installed at the base of each plot as already described in an earlier paper (Babalola et al, 2003). Runoff and soil loss were determined after every major storm from flat and mound cultivations. Tubers were harvested and weighed at maturity in December 2005.

In the **third** experiment, there were three vetiver grass surface spacings: 0m, 5m and 10m established in three replicates in a randomized complete block design on runoff plots measuring 40m long and 3m wide. In the late seasons of 2004 and 2005 mounds were established on the contours and in the early season of 2005, the mounds were established in a scattered form on the slope to simulate farmers practice. Both maize and cowpea in a mixture were used as test crops and these were planted at the edges of the mounds as practised by the farmers. Soil and water collecting devices were installed at the bases of the runoff plots as described earlier. Runoff and soil loss data from the mound cultivation were compared with similar data collected from the same plots when maize planting was done on the flat. Crop yields were determined at harvests.

All the data collected were subjected to statistical analyses using ANOVA.

RESULTS AND DISCUSSION

Experiment I

Soil Accumulation

Vetiver grass strips significantly kept back soil from the field as evidenced by the accumulation of soil by the vetiver strips (Table 1) under cassava plantations. Soil accumulation was significantly influenced by the vetiver grass spacings. The longer the spacing the higher the accumulation of soils. Indeed soil accumulation was 305 and 173 percent higher at the 20m spacing than at 5 and 10m spacings, respectively on the 7% slope. Correspondingly, the values were 344 percent and 177 percent on the 13% slope. Soil accumulation was 32.8%, 33.0 and 42.0 percent higher on the 13% slope than on the 7% slope at 5m, 10m and 20m grass spacings, respectively. The data confirm that under a close canopy of cassava, huge losses of soil take place without the farmer's awareness.

Plant Height of Maize

The mean heights of maize on the two slopes were significantly affected by vetiver grass spacings (Table 2). On both slopes, plant heights on 0m and 20m grass spacings were not significantly different. Similarly, the plant heights on 5m and 10m spacings were not significantly different. However, plant heights were in the decreasing order of 5,10,20 and 0m grass spacings on both slopes. Plant heights were 20.1, 15.3 and 8.4 percent higher on the 5,10 and 20m spacings than no vetiver plot on the 7% slope. On the 13% slope, the corresponding values were 7.0, 7.9 and 1.0 percent. The lower percent differences for the steeper slope may have to do with the higher fertility status of a freshly cleared land after a few years of fallow.

Tables 3 and 4 show the effect of vetiver grass spacings (VGS) on mean cassava and maize yields as influenced by slope. In terms of cassava tuber weights and cassava tuber numbers, there were no significant differences due to vetiver grass spacings on the 7% and 13% slopes. However, cassava tuber weights were in the decreasing order of 5m, 10m, 20m and 0m spacings of vetiver grass. Vetiver grass spacing (VGS) increased cassava tuber weights by 13.7, 9.7 and 10.2% when grass was spaced at 5,10 and 20m, respectively on the 7% slope. Corresponding figures for the 13% slope were 55.3,53.0 and 36.7%, respectively. Thus vetiver grass strips increased tuber weights of cassava by a range of 10 to 55% on both slopes. These figures are higher than the 3.2% increase in cassava tuber recorded by Howeller et al (1997). The number of tubers did not reveal any particular trend (Table 4). However, the highest numbers of tubers per hectare were recorded on the 7% slope at 10m-vetiver grass spacing. Maize grain yield in the mixtures were significantly affected by vetiver grass spacings on both slopes. Maize yields were in the decreasing order of 5m, 10m, 20m, and 0m on both slopes.

Vetiver grass increased maize grain yields by 121.7, 57.7 and 10.8% when spaced at 5, 10 and 20m on the 7% slope and 58.0, 40.0 and 30% correspondingly on the 13% slope. Thus maize in the intercrop was more sensitive to grass spacing than cassava. Maize and cassava yield were higher on the 7% slope than the 13% slope. This may be due to the differences in crop varieties used in both cases as well as differences in the fertility status of the soils.

Table 5 shows that when maize and cowpea were planted in a mixture, only cowpea grain yield under 5 m grass spacing was significantly higher than no-vetiver plot by 70.9% maize and cowpea yields were however in the decreasing order of 5m, 10m, 20m, and 0m. Total maize and cowpea yields were 65.2%, 33.6%, and 20% greater at 5, 10 and 20m grass spacings than no-vetiver plots.

In the second experiment where potato was used as a test crop on mounds and when vetiver grass was spaced at 20m surface intervals, vetiver grass reduced mean runoff by 72.1%, and soil loss by 68.0% (Table 6). Mean potato tuber yields were 850.0Kg/ha for vetiver plots and 572.2 kg/ha for no-vetiver plot. Thus vetiver grass increased potato tuber yield by 48.6%. Mean runoff and soil loss recorded under flat cultivation (Babalola et al, 2006) on the same site are presented in Table 6. Runoff is presented as a percentage of rainfall amount and soil erodibility (k) was estimated from the ratio of soil loss to rainfall erosivity, (which is equated to rainfall amount). Mean runoff values under mound cultivation were 15.7% and 27.0% for vetiver and non-vetiver plots respectively. The corresponding values for flat cultivation, 5.3% and 11.8% were lower. Whereas on flat cultivation vetiver reduced runoff more than no-vetiver plot by 124.5% on the same site, the reduction or effectiveness was 72.1% on the mound plots Similarly, vetiver reduced soil loss by 121.7% on the flat whereas on the mound, the corresponding value was 68%. Soil erodibility values (K) were higher under mound cultivation than flat cultivation (Table 6). Higher soil loss on the mound cultivation could be attributed to a larger surface area of the soil exposed to raindrop impact and runoff water. The higher runoff may be a confirmation of the report of Lal (1997) and which is confined in this study, that water infiltration in the furrows or inter-mound areas was drastically reduced because of soil crusting. In this study, the mean bulk densities were $1.37 g/cm^3$ and $1.44 gkm^3$ for flat cultivation and the inter-mound or furrow spaces, respectively. The conclusion that emanates is that flat cultivation is preferable to mound cultivation in terms of soil and water management and conservation. The indiscriminate use of mounds to raise crops, especially, tuber crops, when the soil conditions (bulk density and soil volume and soil strength) are conducive to good tuber development on the flat needs to be discouraged.

Experiment III

Table 7 compares the effects of vetiver grass spacing on runoff and soil loss when mounds were established on the contours M(c) and when scattered (Ms). Runoff and soil loss were significantly influenced by vetiver grass spacing. Mean runoff losses were generally higher on the mound plots than on the flat plots. Under no vetiver plot runoff values were 15.7, 26.4 and 21.9% of total rainfall for the period under flat, M(s) and M (c) cultivations, respectively. These values were reduced to 3.1, 3.4 and 5.6% under vetiver grass spacing at 5m and to 7.3, 11.2 and 11.1% under 10m vetiver grass spacing. Thus, runoff was lower under flat cultivation than mound cultivation and runoff was slightly, higher under scattered (Ms) than contoured mounds (Mc).Indeed, mean runoff as a percentage of rainfall on M(s) plots and the M c) plots were 13.7% and 12.9% respectively. Soil erodibility K as calculated was higher on M(s) than the M(c). Mean K values for M(s) plots and M(c) plots were 6.22 and 3.77 respectively, a 65% difference. Mean K values for mound and flat cultivations were 5.4 and 3.46 kg/ha/mm respectively, a 56% difference (Table 7). K value was 73% higher on mound cultivation than flat cultivation when vetiver grass was not in place. This value decreased to 23.4% and 17.6% for 5m and 10m vetiver grass spacings, respectively.

Crop Yields

Crop yields were not significantly affected by vetiver grass spacing when crops were raised on mound (Table 8). For both M (s) and M(c) grain yields were in the decreasing order of O_m, 10m and 5m vetiver grass spacings. When the mounds were scattered, maize grain yields were 35.1% and 28.0% higher respectively on 10m and 5m spacings than no vetiver plots. These values are lower than values obtained when maize crops were raised on the flat in an earlier study (Babalola et al (In press). Indeed, mean grain yield on the flat over these three growing seasons were 60.5 and 31.4% higher on 5m and 10m grass spacings than on no vetiver plots. This demonstrates that vetiver grass is more beneficial and effective on the flat than on the mound in terms of maize grain yield.

The yield of potato tubers on mounds were not significantly influenced by vetiver grass spacing (Table 9). However, potato yields were 109.5% and 95.25% higher on 5m and 10m vetiver grass spacing than no vetiver plots. In the earlier experiment in this study, potato yield was 49.6percent higher when vetiver grass was spaced at 20m than no vetiver plots.

Gravimetric moisture contents of the soils on the mounds decreased generally in the order 5m, 10m, 20m and 0m in both years, 2003 and 2004. Steadily, moisture content decreased weekly between November and December of each year after the cessation of rainfall. Moisture content was significantly influenced by vetiver grass spacing. Mean moisture contents in 2003 were 28.5%, 23.2% and 6.5% higher at 5m, 10m and 20m spacings than no-vetiver plot, respectively. In 2004, similar values were 18.3%, 10.2% and zero percent, correspondingly. Thus, on mound cultivation, moisture stress under cassava could be alleviated by vetiver grass strips and is no doubt a factor causing increased yields. In an earlier experimental when moisture content was monitored by the neutron thermalization technique on flat cultivation of maize, soil moisture content on the vetiver plots was higher than on the control by a mean of 25.6% at 40cm depth and 50.1% at 20cm depth (Babalola et al, 2003) The higher moisture content under vetiver strip management is the result of reduced run-off velocity and enhanced water infiltration during the rains.

Tables 10 and 11 show the effect of vetiver grass strip at 10m surface spacings on a 10% slope on cassava and yam yields as obtained in the fourth experiment. Yam and cassava tuber yields and tuber numbers per hectare were not significantly affected by vetiver grass strip. However both weights and number of cassava and yam tubers increased down the slope on the vetiver plots. This may be attributed to higher moisture content on the mounds on vetiver plots. Mean cassava and yam tuber weights were 12.08% and 9.52%, respectively higher on vetiver plots than no-vetiver plots. Number of yam tubers per hectare was higher on vetiver plots than non-vetiver plots by 4.3% (Table 11).

CONCLUSIONS

Considerable losses of soil and water occurred under traditional mounding farming practices. Losses from flat cultivations were generally lower than mound cultivation. The poorer physical conditions of the furrows or intermound spaces in terms of soil crusting, and the exposure of a soil layer with higher bulk density than the original surface soil after the surface soil have been scraped and packed into a mound, tend to aggravate soil erosion in traditional farming practices. The indiscriminate use of mounds, especially for tuber crops when the soil conditions (bulk density and soil strength) are conducive to good tuber development on the flat should be discouraged.

Vetiver grass strip at surface intervals of 5, 10 or 20m significantly curtailed soil and water losses to variable degrees. The shorter the vetiver grass spacing the lower was the loss. The reduction of such losses was reflected in significant increases in moisture content of the mounds and increases in the yields of cassava, maize, cowpea and sweet potato to varying degrees. The percent reduction in soil and water losses by vetiver grass was much higher on the flat by about 40% than on the mounds.

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