Effect of vetiver grass strip (*Vetiveria nigritana*) spacing on soil and water loss and the yield of maize

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Abstract
The installation of vegetative barriers at vertical intervals of multiples of metres (1m. 2m. 3. etc) can expose a large area to the damaging influence of runoff velocity and runoff volume depending on the slope of the land. Experiments were conducted over four growing seasons in 2003 and 2004 on the effect of surface spacing of Vetiver grass strips on the gentle undulating slopes of Nigeria on runoff. soil loss nutrient loads of eroded sediments and the yield of maize. There were three treatments: Vetiver grass strips (VGS) at surface intervals of (i) 0m (ii) 5m and (iii) 10m on a 7% slope. Mean runoff was reduced by 500 percent and 123% respectively under 5m and 10m spacing. Mean runoff was reduced by 169% when 5m spacing were used instead of 10m. Soil loss followed the same pattern and magnitude as runoff. Mean plant heights were 23.5 percent and 14.9 percent higher for 5m and 10m spacing. respectively than the control. Although drought stress. during the flowering stages impacted negatively on grain yields and nearly obliterated treatment effects. mean grain yields on 5m and 10m spacing were 10percent and 0.4 percent higher than the control. Mean NO_3 contents of runoff water were 0.55. 0.81 and 1.21 percent for 5m. 10m and the control respectively. Among C. P and N contents of eroded sediments. only P contents were significantly affected by spacing. Mean base elements of eroded soils and micronutrient content were not significantly affected by grass spacing although the contents were in the increasing order of 5m. 10m and the control. The results have great implications not only for soil and water conservation but also for the protection of water bodies against pollution.

Introduction

The use of vetiver grass strips (VGS) as a cheap. reliable and sustainable method of curbing the menace of soil erosion on agricultural land is still a recent phenomenon in some parts of the world (Kon and Lim. 1991: World Bank. 1991: NRC. 1993: Grimshaw. 1993: Levan Du & Truong. 2003). Research. however continues to fine-tune the technology and to determine its efficacy in diverse ecosystems. The amount of run-off and soil loss under Vetiver grass strip should necessarily vary with the soil type. rainfall characteristics and the topography of the land since all these influence water entry into the soil. runoff volume and runoff velocity. The distance between the strips is therefore an important variable determining efficiency. Rodriquez (2001) in rainfall simulation studies has recommended vertical intervals of vegetative barrier spacing ranging from 0.5 to 6m for low. medium and high erosivity and erodibility conditions and a range of maximum slope gradient of 5% to 75%. Inthapan. *et al* (1996) studied the effect of hedgerows at 1m. 2m and 3m vertical intervals on soil and water conservation and concluded that on 20% and 30% slopes. there were no significant differences. The surface distance between grass strips in these situations may be short. However on more gentle slopes. 5 to 15%. which are the characteristics of most lands in Nigeria. the spacing of grass even at 1m vertical interval will "expose" much of the land area without any erosion intervention. In a recent study where runoff travelled 20m before encountering a barrier of strip. about 9cm of soil accumulated by the strip at the end of the two growing seasons leaving the soil so impoverished that maize grain yield was more drastically reduced in this upper portion than the lower portion behind the grass strip (Babalola. *et al.* 2003). This suggest that 20m surface spacing. even on gentle slopes. may be considered too wide for effectiveness. The other consideration. of course. is the available land area for the farmer's operations. This study was therefore carried out to investigate the effect of surface spacing of vetiver grass on soil and water loss and yield of maize on prevailing slopes of agricultural land in southwestern Nigeria.

Materials and method

The study was conducted on the Teaching and Research Farm of the University of Ibadan. Ibadan (7° 23'N, 3° 54'E) in Nigeria. Ibadan has a bimodal distribution of rainfall with peaks in June and September and a mean average annual rainfall of 1229mm. There are on the average about 175 total wet days in the year. There are two cropping/growing seasons: early season runs from March/April to August and the late season, from mid-August to October/November. Annual temperature ranges from a high of 31.2° to a low of 21.3°C. Ibadan has a percentage sunshine that ranges between 16% in August to 59% in February with an average of 44%. The soil of the area is an Alfisol of the order Oxic Paleustalf according to the USDA classification. It is classified locally as Iwo Series (Smyth and Montgomery, 1962). Table 1 presents some of the physico-chemical properties of the soil which had been under the fallow for about three years. There were three treatments imposed on a 7% slope: grass strips were established at surface intervals of (i) 0m (ii) 5m and (iii) 10m on runoff plots measuring 40m long and 3m wide. Each treatment was replicated thrice and laid out in a randomized complete block design in the late season of 2002. Maize was used as a test crop planted at spacing of 90cm X 30cm for four growing seasons between 2003 and 2004. When in the early seasons of 2003 the grass strips were fairly well established, soil and runoff water-collecting devices were installed at the bottom of each plot using oil drums, 90cm high and 58cm wide per plot as runoff collectors. The two drums were connected such that an overflow from the first drum ran into a second drum. Runoff and soil loss were estimated as described in another paper (Babalola et al. 2006). Volume of runoff water was estimated from the height of water in each drum and was later converted to depth (mm) of water. An aliquot of soil suspension was collected for NO_3-N analysis. Eroded soils were analyzed for particle size distribution using the hydrometer method; organic carbon, total nitrogen, phosphorus, macro- and micro-nutrients were determined using standard methods as described by IITA (1979).

Grain yield and yield parameters were estimated from the three inner rows of plants on each plot excluding the border plants. Maize plant heights on each plot were estimated with a metre-rule. Statistical analysis of the data collected were carried out using ANOVA to test the levels of significance due to treatments.

Results and discussion

Runoff

Runoff was significantly influenced by VGS spacings in the early and late growing seasons of 2003 and 2004 (Fig 1). The mean runoff over the four growing seasons were 5.84mm, 15.71mm and 35.04mm for 5, 10 and 0m VGS spacing, respectively. Thus, runoff was reduced by 500 percent and 123 percent under 5m and 10m VGS spacing compared to the control. Similarly, runoff was reduced by 169 percent when 5m spacing were used instead of 10m VGS spacing. Drastic reductions in runoff velocities and greater infiltration of water into the soil induced by the Vetiver strips caused the significant differences in runoff amounts. In this regard, the effect of the 5m VGS was higher than that of 10m VGS.

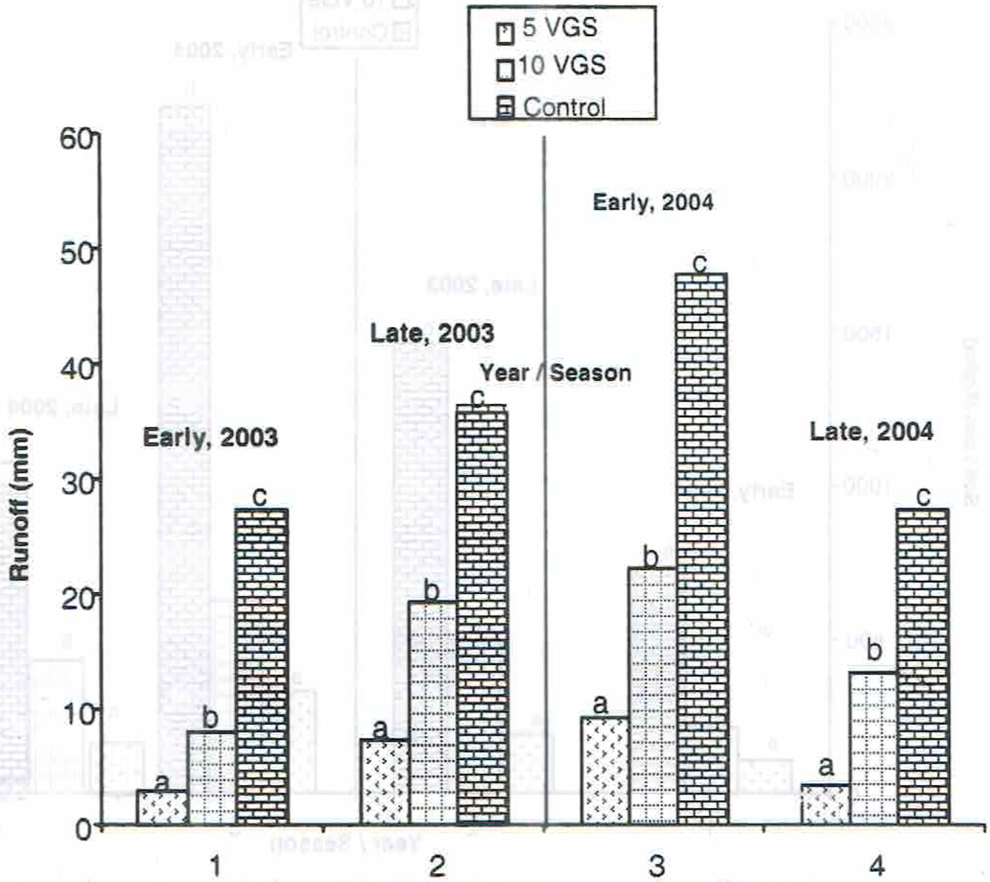

Fig.1: Effect of vetiver grass strip (VGS) at 5m and 10m spacing and a control on runoff from 40m long plots planted to maize during the early and late growing seasons of 2003 and 2004.

Note that bars within each season having the same letter are not significantly different at α = 0.05

Soil loss

Generally, soil loss followed the same pattern as runoff. (Fig 2) Except for the early season of 2004 Where there was no significant differences between soil loss on the 5m VGS and 10m VGS. Vetiver grass strip spacing significantly influenced soil loss at the 5% level. The mean soil loss over the four growing seasons were 199.30, 438.27 and 1,357.28kg/ha for 5m VGS, 10m VGS and the control, respectively. Thus, vetiver grass reduced soil loss by 581 percent and 212 percent when strips were imposed at 5m and 10m compared to the control. Similarly, 5m VGS spacing reduced soil loss by 120 percent when grass strip spacing was doubled.

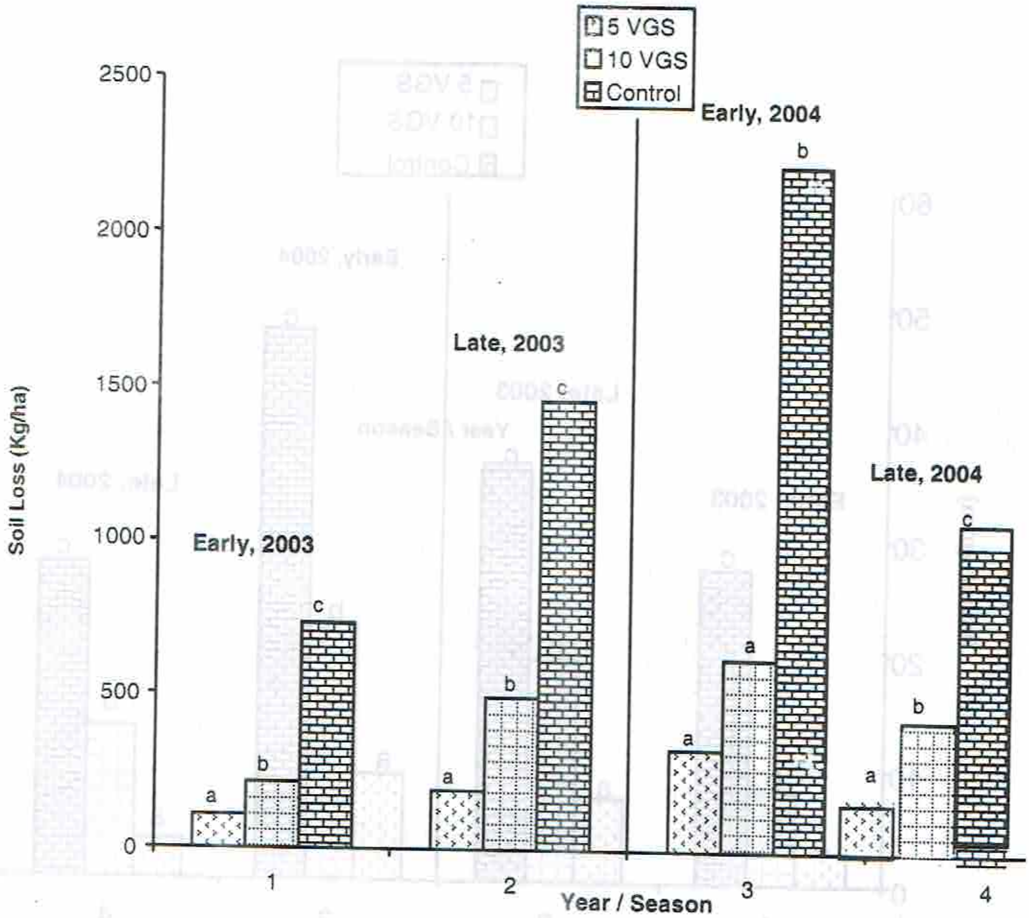

Fig.2: Effect of vetiver grass strips (VGS) at 5m and 10m spacing and a control on soil loss from 40m long runoff plots planted to maize during the early and late growing seasons of 2003 and 2004.

Note that bars within each season having the same letter are not significantly different at $\square = 0.05$

Plant height of maize

Except for the early growing season in 2003, vetiver grass strip spacing did not significantly influence the plant height of maize (Fig 3). The mean plant heights over the four growing seasons were 141.0, 161.94 and 174.16cm at 0m, 10m and 5m spacings, respectively. Thus mean plant heights were 23.5 and 14.9 percent higher for 5m and 10m spacing, respectively than the control. Mean plant height on 5m spacing was only 7.5 percent higher than on 10m spacing.

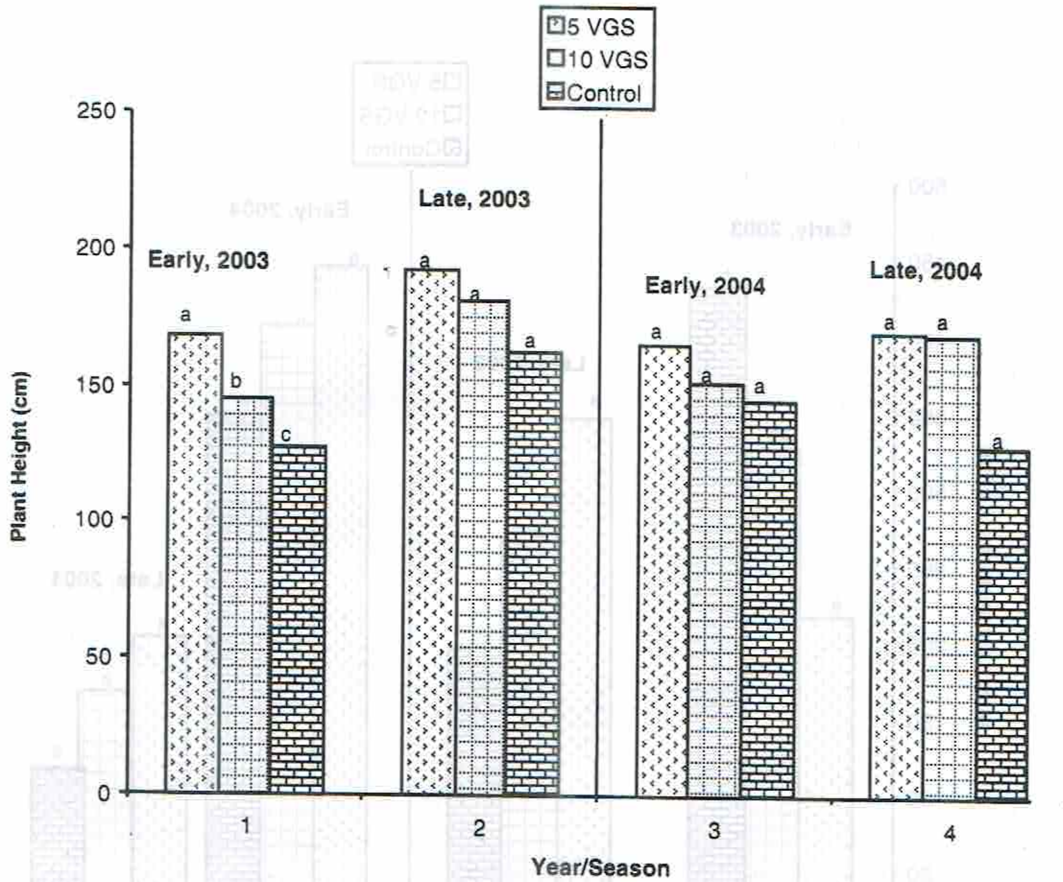

Fig.3: Effect of vetiver grass (VGS) at 5m and 10m spacing and a control on plant height from 40m long plots planted to maize during the early and late growing seasons of 2003 and 2004.

Note that bars within each season having the same letter are not significantly different at □ *= 0.05*

Grain yield of maize

Except for the early growing season in 2003 where grain yield was significantly different between the VGS plots (both 5m VGS and 10m VGS) and the control treatments, there were generally no significant differences in the grain yield amongst treatments (Fig 4). Mean grain yields over the four growing seasons were 303.76, 291.54 and 274.05 kg/ha for 5m VGS, 10m VGS and the control, respectively. Thus, grain yields on 5m VGS and 10m VGS were 10 percent and 6.4 percent

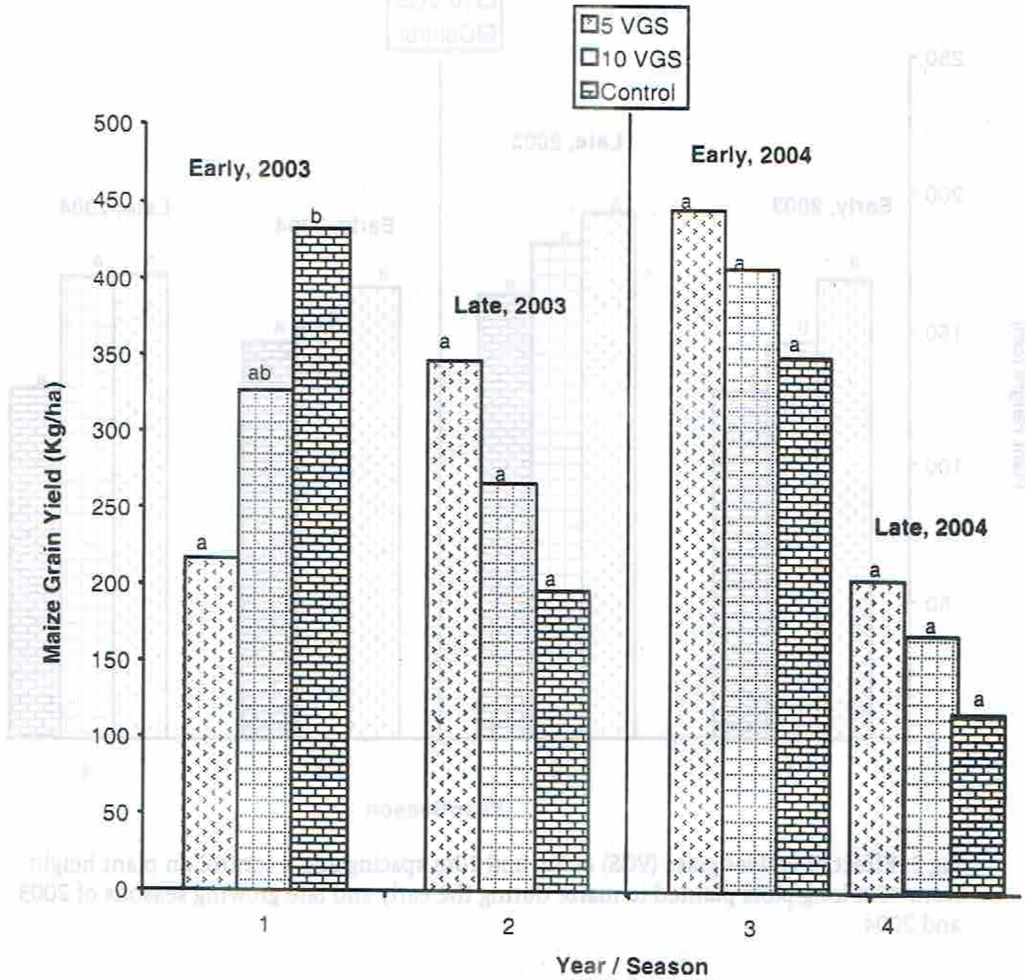

Fig.4: Effect of vetiver grass strip and a control on maize grain yield from a 40m long runoff plots planted to maize during the early and late growing seasons of 2003 and 2004

Note that bars within each season having the same letter are not significantly different at = α = -0.05 higher than the control. Increasing VGS spacing from 5m to 10m brought about a reduction of 4.2% in grain yield. Grain yields were generally low on the site due to low fertility status since no fertilizer was applied and the soil was cropped continuously. These low yields were also particularly influenced by drought stress or an abrupt cessation of rain during the flowering stages of the maize crop. This is a common problem of cultivation in South-Western Nigeria which makes timeliness in the planting of the second crop of maize a big determinant of crop yields. Generally, grain yields were lower in the late than early seasons. Nevertheless, the unfavourable site weather conditions brought clearly to the fore the benefits of using vetiver grass strips. It has already been shown in an earlier study (Babalola et al. 2003) that soil moisture storage and fertility status were enhanced under vetiver grass strips management.

Effect of vetiver grass strip (VGS) spacing on NO_3-N level of running water and the chemical properties of eroded sediments.

Nitrate –nitrogen of run off water

The spacing of vetiver grass strips did not significantly influence the levels of nitrate nitrogen in runoff water (Table 1). The NO_3 –N levels were in the increasing order of 5m VGS, 10m VGS and the control. The levels ranged from 0.16ppm for 5m VGS to 2.04ppm for the control. Whereas NO_3-N levels at 5m VGS were significantly different from the control, there was no difference between the values at 10m VGS and the control. Mean NO_3-N contents over the four growing seasons were 0.55, 0.81 and 1.12% for 5m VGS, 10m VGS and the control, respectively.

N, C & P of eroded sediments

Grass spacing did not significantly influence the nitrogen content of eroded sediments. Percent N was generally in the increasing order 5m VGS, 10m VGS and the control (Table 1). The values ranged from 0.05% to 0.49%. Although the organic carbon contents of the eroded sediments were not significantly affected by vetiver grass spacing, they increased with spacing. Mean percent carbon contents over the four growing seasons were 1.53, 1.61 and 1.85% for 5m VGS, 10m VGS and the control, respectively. Total phosphorus was significantly affected by treatments (Table 1). Mean phosphorus contents over the four growing seasons were 14.74, 15.51 and 18.80ppm for 5m VGS, 10m VGS and the control, respectively.

Table 1: Mean contents over the four growing seasons of NO_3-N levels in runoff water, N, C and P of the eroded sediments as influenced by vetiver grass spacing (VGS). (Dissimilar letters in each column indicate significance at the 5% level)

VGS (m)	NO_3-N (%)	C (%)	P (ppm)	N (%)
5	0.55a	1.53a	14.74a	0.21a
10	0.81a	1.61a	15.51b	0.17a
0	1.21a	1.65a	18.80c	0.23a

Base elements (Ca, Mg, K & Na)

With the exception of Na, all the base elements in the eroded sediment were highest for the control and least for 5m VGS although the differences were not significant. Generally the base contents were lower for 5m VGS than 10m VGS spacing (Table 2). Mean base contents of the eroded sediments were 2.45, 2.63 and 2.88 Cmol/kg for 5m VGS, 10m VGS and the control, respectively.

Micronutrient (Fe, Zn, Cu & Mn)

Mean contents of the micronutrients were lower for 5m VGS than 10m VGS although the differences were not significant (Table 2). For instance, mean Mn contents of the eroded sediments over the four growing seasons were 220, 291 and 307ppm for 5m VGS, 10m VGS and the control, respectively.

Table 2: Mean contents (over four growing seasons) of macro-and micro nutrients of eroded sediments as influenced by vetiver grass spacing (VGS)

Treatment VGS (m)	Ca	Mg	K	Na	Fe	Zn	Cu	Mn
	......(Cmol/kg)......................				..............(ppm)............			
5	2.42a	2.38a	3.43a	1.57a	249a	91a	16.8a	220a
10	2.63a	2.73a	3.34a	1.81a	251a	95a	17.2a	291a
Zero (control)	2.75a	2.89a	4.19	1.71a	253a	78a	16.0a	307a

Conclusion

Depending on soil erodibility and rainfall erosivity, runoff water can do much damage on the soil if the surface spacing of any vegetative barrier is large. Since the beneficial effect of vetiver strips is best felt behind the vetiver strip in terms of local soil quality, surface spacing of vetiver strip should not be large for maximum benefits. This study has shown that the shorter the spacing the more beneficial the effect in terms of runoff, soil loss, nutrient loss from the field and crop yield. A balance must be sought between these benefits and the adequacy of the land for maneuvering farm operations. The results have great implication for the use of vetiver grass strips in protecting water bodies against pollution in addition to the conservation of soil and water on agricultural fields.

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