Trashlines and runoff, erosion, and crop yields in semi-arid eastern Kenya

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Abstract

Smallholder farmers in many arid and semi-arid regions use wide spaced trashlines to control runoff and erosion. The objective of this work was to study the effects of close spaced trashlines on runoff, erosion and crop yield in a cowpea - maize rotation. Big trashlines, small trashlines, and control (without trashlines) were evaluated in 12 runoff plots constructed at 10% slope in a semi-arid area in Kenya, during five consecutive rainy seasons. Big trashlines reduced runoff and soil loss about two-fold and three-fold respectively and increased crop biomass yield two-fold compared to the control treatment. In the small trashlines treatment runoff, soil loss and crop biomass yield were about half that in big trashlines. The seasonal biomass increased linearly and significantly ($P \leq 0.01$) with increasing water infiltration. As more water infiltrated, more water was available for crop production, and the higher was the yield. However, the scatter of the points around this regression line was relatively high, which was probably because the distribution of rainfall amounts and rainstorm frequency influenced the crop yield.

Media summary

Close spaced trashlines is an improved indigenous technology developed by Kenyan and Israeli soil scientists to reduce runoff, erosions and boost crop yield semi-arid regions.

Key words

Water conservation, soil degradation, land rehabilitation, arid soils, Africa.

Introduction

Runoff and soil erosion are serious and widespread land degradation problems in many parts of the world especially in arid and semi-arid regions (Hudson 1992). To combat the massive problems of runoff and erosion, poor smallholder farmers in many arid and semi-arid regions often use trashlines (Critchley et al. 1994). Trash lines are made up of crop material that remains after harvesting the grains or pulses. The material is formed into ridges across the slope to form semi permeable barriers that decrease the runoff velocity and increase the infiltration duration, but allow passage of excess runoff. As a result, the amount of infiltrated water increases and the runoff volume and its erosive power decrease. Likewise, retention of sediment in the trashlines results in reduced soil and nutrient losses (Gachene et al. 1997). Gichuki (1992) observed that farmers in Kenya placed the trashlines about 15 m apart in the field. However, in semi-arid regions, seal formation is common (Kemper and Miller 1974), decreasing the infiltration rate and increasing runoff and soil erosion (Ben-Hur et al. 1985). Under seal-formation conditions, the 15-m spacing between the trashlines is probably too large to prevent surface runoff and soil erosion in the cultivated field during rainstorms. In a semi-arid region in eastern Kenya, Okoba et al. (1998) observed significant reductions in runoff and soil erosion in Luvisols protected by trashlines spaced at 7.5 m. Furthermore, when the trashlines were applied under seal-formation conditions, it limited seal formation under the line, so that surface runoff flowing across the area between the trashlines could infiltrate beneath the trash, thus decreasing the total runoff. We hypothesized that decreasing the spacing between the trashlines to 2 m would significantly increase the efficiency of this technique in reducing runoff and erosion and in increasing crop yield under seal formation conditions. Moreover, in this case, two rows of plants are sown between the trashlines to attempt to optimize any benefits from the water that infiltrates in the trash-covered area. The objective of the present work was to study the effects of decreasing the space between the trashlines to 2 m and of the size of the trashlines on runoff, erosion, and crop yields during consecutive rainy seasons under semi-arid conditions.

Methods

The experiment was conducted at Tunyai in eastern Kenya. The site is located at approximately 37?50?E and 0?2?S. The long-term average annual rainfall in this region is 600 mm, which is distributed almost equally between two rainy seasons: March - May and October - December, referred to below as seasons 1 and 2, respectively. The land at the experimental site had previously lain fallow for about 5 years, being used for cattle grazing. In February 1997, this land was cleared and cultivated with hand tools. Twelve runoff plots measuring 2 m by 6 m each were constructed along a contour on a 10% slope. Each plot was enclosed by galvanized iron sheets embedded 0.2 m into the ground and projecting 0.2 m above it, and an end plate was installed at the end of each plot to block the runoff and direct it into a trough. Each trough was covered with a lid to prevent direct entry of rainfall. The trough delivered the runoff into a 1-m^3 tank via a conveyor pipe. The tanks containing runoff were emptied each morning. The runoff in each tank was mixed thoroughly and 3 subsamples were taken to determine soil loss by weighing the sediment after oven drying at 105?C.

Three treatments, each with 3 replicates, were randomly assigned to the runoff plots. The treatments were: (1) big trashlines with trash content of 2.5 t/ha; (2) small trashlines with trash content of 1.5 t/ha; and (3) control without trashlines. These treatments are abbreviated hereafter as $T_{big,}$, T_{small}, and T_o respectively. All the trashlines were aligned across the slope at a 2-m spacing (Fig. 1). Agronomic aspects (e.g. time of planting, plant population, etc.) at the experimental site were in accordance with the local practices and conditions. Katumani composite, a drought-escaping maize (*Zea mays* L.) variety, was planted as a sole crop during the first season of each year of the study. The spacing between the maize plants was 0.25 m within the rows and 0.75 m between the rows. Two rows were planted between the trashlines, in the plots where these techniques were applied. In the second season in each year of the study, maize was intercropped with cowpea (*Vigna unguiculata*) variety M66 in all the treatment plots. A single row of this crop was planted between the two rows of maize at a spacing of 0.25 m within the row. The spacing between the plants in the control treatment was the same as in the other treatments. At the end of each season, the crop was harvested by hand and the dry weights of crop grains and straw from each plot were determined. The daily rainfall was recorded with a rain gauge at the nearby Tunyai meteorological station.

Data were analyzed as a complete randomized design using procedures described by Steel and Torrie (1997) for analysis of variance. Separation of means was tested using Tukey’s honestly significant difference with a 0.05 significant level.

Results and discussion

The distribution of daily rainfall for the 5 consecutive rainy seasons is presented in Fig. 2. Rainfall distributions over the five seasons showed marked variations in both frequency of storms and amount of rainfall. Daily runoff during the 5 rainy seasons and for the various treatments is presented in Fig. 3, as percentages of daily rainfall. In general, the changes in runoff percentage with time showed similar patterns in all the treatments, and the runoff percentage in T_0 was higher, in most cases, than those in T_{big} and T_{small} (Fig. 2).

The runoff percentages in T_0 were, in general, significantly ($P \leq 0.05$) higher in the early part of the growing seasons than towards the end. This was apparently because early in the growing season, most of the soil surface was bare and exposed to the raindrops that formed a seal and led to a low infiltration rate. In contrast, towards the end of the growing season, the crop canopy was dense, and so protected the soil surface from impacts and limited the renewal of the seal and the increase of the runoff. Moreover T_{big} and T_{small} limited the seal formation in the area beneath them, which led to increased infiltration and decreased runoff (Wakindiki and Ben-Hur 2002).

The amount of soil loss is shown in Table 1. T_{big} and T_{small} significantly ($P \leq 0.05$) decreased the soil loss compared with T_0 in all the rainy seasons studied. The decrease of the soil loss was due to the action of T_{big} and T_{small} in reducing runoff and in trapping sediment. Table 2 shows the crop biomass yield while Fig. 4 shows the crop biomass yield as functions of the infiltrated water and the regression line for the various treatments and rainy seasons. T_{big} and T_{small} increased the crop yield significantly ($P \leq 0.05$). The seasonal biomass yield in T_{big}, T_{small} and T_0 increased linearly and significantly with increasing water infiltration. This indicated that the main reason for the increased crop yield in T_{big} and T_{small} was the lower runoff that increased the available water for crop production.

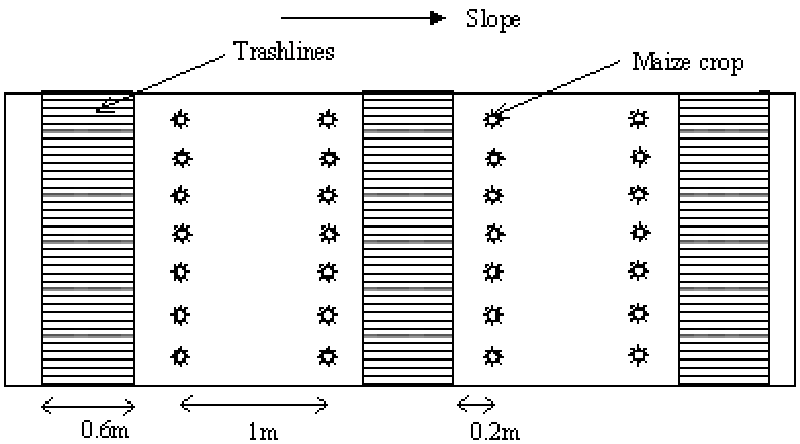

Fig 1. Schematic layout of the runoff plot with trashlines

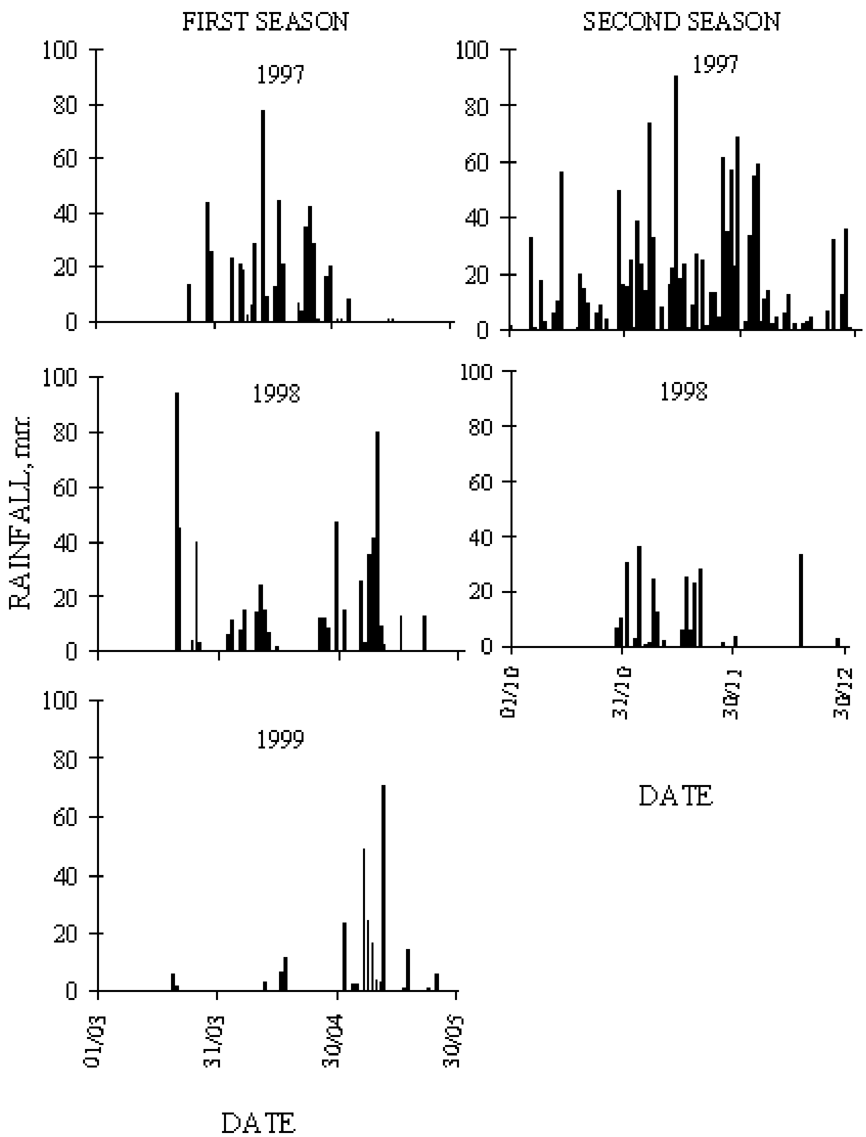

Fig. 2: Distribution of daily rainfall for five consecutive rainy seasons

Table 1. Soil loss for the various rainy seasons and treatments

Season	Control	Big trash lines	Small trash lines
1, 1997	0.69 a	0.26 c	0.44 b
2, 1997	0.84 a	0.43 c	0.53 b

1, 1998	0.56 a	0.15 c	0.21 b
2, 1998	0.79 a	0.24 c	0.35 b
1, 1999	0.47 a	0.09 c	0.10 b

Within rows, values followed by the same letters are not significantly different at $P \leq 0.05$.

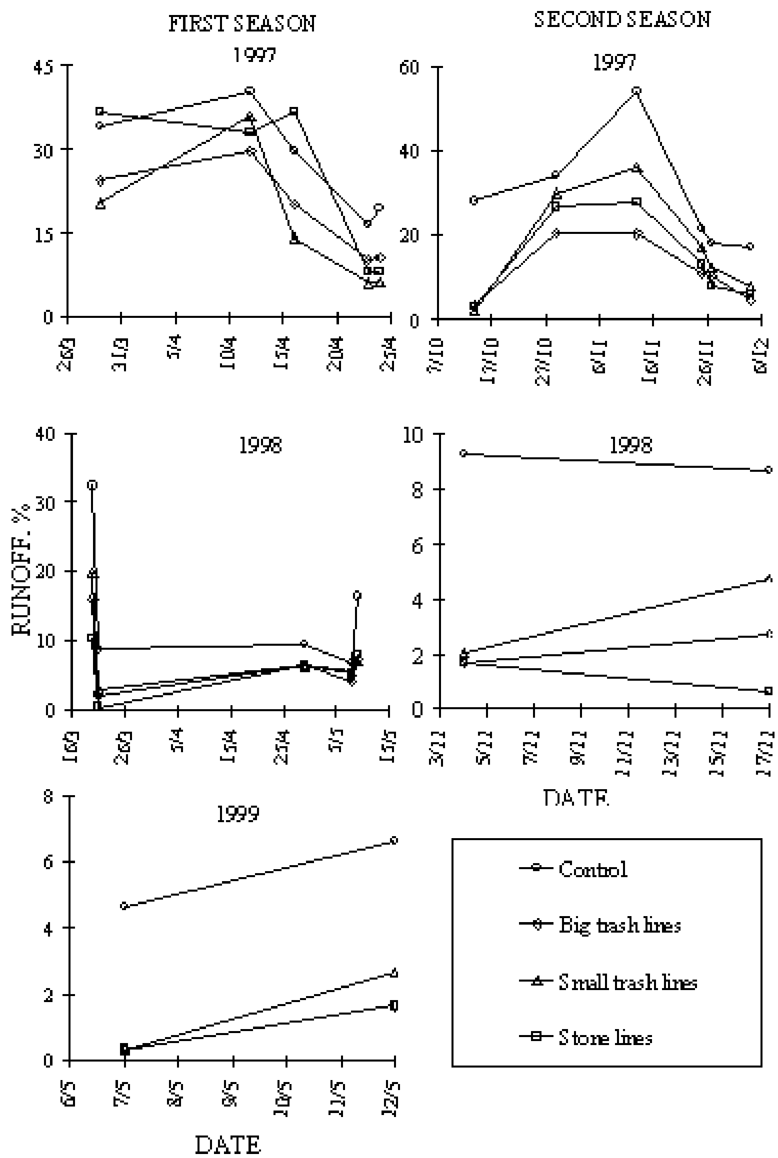

Fig. 3. Daily runoff as percentage of daily rainfall (note: Y-axes scales vary)

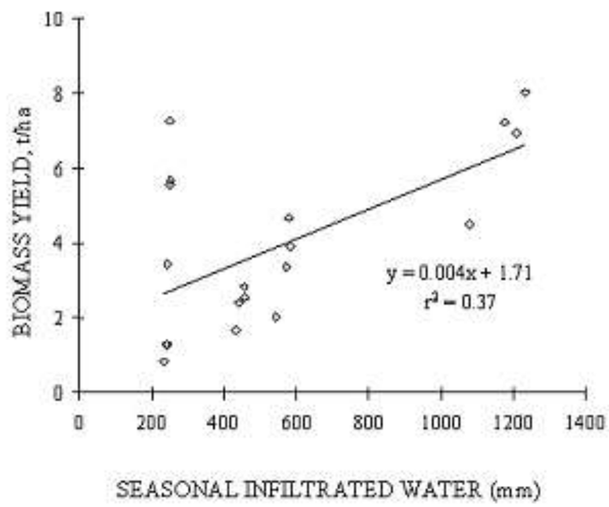

Fig. 4: Seasonal biomass yield as a function of the seasonal infiltrated water

Table 2. Seasonal yields (t/ha) of maize and cowpea

Season	Control		Big trashlines		Small trashlines	
	Grain	Straw	Grain	Straw	Grain	Straw
			Maize (t/ha)			
1, 1997	0.42b	1.25b	0.74a	2.1a	0.54b	2.02a
2, 1997	0.56c	1.42c	1.22a	4.2a	0.84b	3.82b
1, 1998	0.54c	1.49c	1.47a	3.2a	0.86b	2.52b
2, 1998	0.25d	0.65c	1.11a	2.84a	0.66c	1.51b
1, 1999	0.16b	0.67b	0.42a	0.86a	0.46a	0.84a
			Cowpea (t/ha)			
2, 1997	0.44b	2.09a	0.56a	2.05a	0.41b	2.16a
2, 1998	0.56c	1.94d	0.94a	2.39b	0.84b	2.55a

Within rows, values followed by the same letters for grain or straw are not significantly different at $P \leq 0.05$.

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