THE EFFTECT OF ELEPHANT GRASS (PENNISETUM PURPUREUM) IN CONTROLLING SOIL EROSION IN KONDOA ERODED AREA

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ABSTRACT

This study was conducted in the Kondoa eroded area (KEA), Kondoa District, central Tanzania. The main objective was to evaluate the effect of elephant grass (Pennisetum purpureum) in controlling soil erosion. Specific objectives were: to assess the extent of elephant grass coverage in the area; to assess the interaction of elephant grass with other plants; and to identify other plant species which have the same effect as elephant grass.The study was based on field observations on plots planted with or without elephant grass. The data obtained was analysed by Spearman's Rank Correlation for independence of two groups of areas regarding the extent of erosion; the extent of improvement achieved; the vigour of the vegetation and the depth of A-horizon (cm). The study showed that land conservation measures in the study area had led to changes in land use practices. It was observed that some farmers are actively involved in planting elephant grass to combat soil degradation. However, some farmers are not using this species for the following reasons. First, the grass competes for soil moisture and nutrients with agricultural crops. Secondly, the species is a tall grass which when mature, shelters destructive birds, including Quelea quelea, which eat grain crops such as millet and sorghum. Thirdly, various diseases such as rust disease that can spread to agricultural crops infect the grass.It is concluded that elephant grass has much merit depending on where it is planted and what types of crops it is mixed with. Elephant grass is very valuable in controlling soil erosion in sand rivers where because of its special features, it can grow in sand with low nutrient status, and sprouts quickly and covers the area within a short period. Also for soil stabilisation, the study indicated that elephant grass is valuable in stabilising the contour ridges if the distance between adjacent crops is carefully selected. Lastly the study showed that apart from controlling soil erosion, elephant grass also serves as fodder as it has high protein content and also grows fast.To facilitate the increased use of elephant grass, it is recommended that short varieties, which are less competitive with adjacent crops, be planted, and farmers should be encouraged to use elephant grass in sand river stabilisation. This can later be succeeded with sugarcane, which has higher commercial value.

INTRODUCTION

Soil erosion and nutrient depletion from agricultural lands are perceived as the greatest threat to agricultural productivity in many developing countries. Unless adequate and appropriate measures are adopted to halt and reverse these processes, the sustainability of production systems in the affected areas will be seriously affected (Shehgal and Abrol, 1992). In Tanzania, soil erosion is a major problem in the semi-arid region, which include all areas receiving less than 800mm of rainfall per annum (Mission to Dodoma, 1987). It is most severe in Kondoa District in Dodoma region, dating back to the days of slave caravans when the natural vegetation of the area was extensively cleared for shifting cultivation to raise grain

crops to feed the caravans as well as tsetse fly eradication (Mbegu and Mlenge, 1984; Mbegu, 1988; Nshubemuki and Mugasha 1985). Later on, overgrazing due to overstocking and frequent bush fires during the dry season further accelerated the vegetation disappearance (Christiansson, 1978; Lundgren, 1993). By 1973 over 120,500ha in Kondoa district were considered unproductive due to the presence of large gullies up to 20m depth (Mbegu and Mlenge, 1983)

The government of Tanzania in 1973 initiated a soil conservation Programme known as Hifadhi Ardhi Dodoma (HADO) to rehabilitate the Kondoa Eroded Area (KEA) and prevent further erosion on the less affected areas. Rehabilitation initially included use of heavy machinery to fill the gullies, installation of physical structures such as cut-off drains, contour ridges and runoff diversion ditches. Agronomic control measures included planting of grasses, sisal, and trees to increase ground cover and protect the physical structures. These measures achieved a limited success because the problem of overgrazing still persisted (Mbegu and Mlenge, 1984). It was therefore decided to completely de-stock the area and this was implemented in 1979. In addition, the rehabilitation approach shifted from heavy reliance on construction of physical structures to biological approach relying more on regeneration of vegetation either naturally or through replanting of selected grass and tree species.

Extensive planting of elephant grass (*Pennisetum purpureum*) in Kondoa eroded area started in 1974 when it was planted with trees and other grass species to control soil erosion as primary objective, and secondly for fodder provision (Mbegu and Mlenge, 1983). Elephant grass was selected because it is one of the drought resistant species and can grow in areas of rainfall between 600 to 1200m per year. Despite of its long time usage, no evaluation has yet been made on the impact of elephant grass on soil erosion. The aim of this study was therefore to evaluate the effect of elephant grass (*Pennisetum purpureum*) in controlling soil erosion.

Generally, woodland and grassland have great ability of water regulation and can reduce runoff and soil loss by 74.8% - 88.7% and 97.8% - 99.8% respectively (Qinxiao *et al.*, 1995). Elephant grass planted along shallow meander bows decreases the velocity of stream and prevent erosion in gully bends and water channel stabilisation (Wenner, 1984). Infiltration totals and rates increases strongly with increasing vegetative cover thereby reducing runoff and erosion, even in steeper slopes the erosion declines to negligible levels (Carroll *et al.*, 2000; Loch, 2000).

MATERIALS AND METHODS

DESCRIPTION OF THE STUDY AREA

The study was conducted in Haubi village and surrounding areas, in Kondoa District IN Central Tanzania. The Kondoa eroded area lies between latitudes 4^{o} to $5^{o}44$ S and longitudes $34^{o}54$,to 3628 East, and has an altitude between 1200– 2000 m above sea level. The area receives 600 to 900mm rainfall per year with a mean annual rainfall of 640mm (Mbegu, 1998). The soils in the area are naturally of poor fertility and low in organic matter with moderate to poor permeability. Poor permeability is due to the fact that the soils are thin (subsoil) due to erosion and overlies heavy and thick impermeable clay layers (clay pans).

The soil texture varies from coarse loamy sand to sand loams and brown clay loams, often being sandy in the surface horizon. The natural vegetation is degraded Miombo woodland. Remnants of indigenous, widely scattered trees and shrubs, which include *Brachystegia* spp, *Acacia spp, Adansonia digitata, Euphorbia spp, Combretum spp, Tamarindus indica, Terminalia spp., Erthyrina spp, Dodonaea viscosa, Balanites aegyptiaca, Annona spp.* etc are present. Planted tree and shrub species include, *Grevillea robusta, Eucalyptus spp, Mangifera indica, Senna siamea, Azadirachta indica, Psidium guajava, Leucaena leucocephala, Delonix regia*, etc.

The majority of the farmers depend on farming with a few keeping livestock under zero grazing. Agroforestry to provide fodder and fuel wood, *interalia*, widely practised in the study area. The major agricultural crops include maize, sorghum, finger millet, sugar cane and sweet potatoes. Farmers appear to be aware of soil degradation problem and its causal factors.

Methodology

Field study

Ten farms planted with elephant grass were selected in Haubi village and the surrounding areas. In each farm, two plots each measuring 10 x 10 m were laid out, one in the area planted with elephant grass and another without elephant grass. From each plot, the following data were collected:

a) The extent of erosion observed and ranked as follows:
   No erosion (1), Low erosion (2), Moderate erosion (3) and Extreme erosion (4).

b) The improvement achieved was subjectively ranked as follows:
   No improvement (1), Low improvement (2), and High improvement (3).

c) The vigour of the plants on those plots was ranked as follows:
   Low vigour (1), Intermediate vigour (2), and High vigour (3).

d) The depth of A horizon (cm) was measured at five points in each plot using a ruler. Units were ranked in approximate fives i.e. 5cm as (1), 10 cm as (2), (3) 15cm, (4) 20cm and (5) 25 cm.

Plant species in those plots were identified using field keys, and local names were obtained from the local residents in the areas.

Data analysis

The data obtained from the field was analysed using Spearman's rank correlation coefficient. Formula used for correlation coefficient (Yamane, 1973) was:

$$r_s = 1-[6 \sum d^2/n\ (n^2-1)]$$

where

r_s = Spearman's Correlation coefficient

d = differences in ranks of corresponding plots
n = number of plots used.

RESULTS AND DISCUSSION

The success of conservation initiatives have tended to be judged from the performance of vegetative growth which on the same line has acted as an indicator of the soil recovery The recovery is a long process due to the fact that biological soil conservation is a slow process which varies with the extent and degree of degradation (Kikula, 1999)

It was generally observed that elephant grass, trees and other grass species were planted in different areas to control soil erosion and for fodder. It was observed that farmer's preference varied, with some using elephant grass to control soil erosion while others avoided it for fear of competition with agricultural crops. While some farmers are actively involved in planting elephant grass to combat soil degradation, other farmers are not using this species for the following reason. Fist, the grass completes for soil moisture and nutrients with agricultural crops. Secondly the species is a tall grass which when mature, shelter s destructive birds, including *Quelea quelea*, which eat grain crops such as millet and sorghum Thirdly, various disease such as rust disease that can spread to agricultural crop infect the grass.

The Extent of Coverage of Elephant Grass

Elephant grass was widely planted and comprised about 12.5% of all vegetation in the study area. It was often mixed with other plants in the same area, although it was the dominant species. The practice of mixing different plant species for soil conservation has been reported in China (Qinxiao *et al.*, 1995), Queensland (Loch, 2000; Carroll *et al.*, 2000), India (Soni *et al.*, 1989) and Kenya (Wenner, 1981).

Tables 1 and 2 indicate the resulting ranks, whereas Table 3 shows the actual means.

Table 1: Soil and vegetation vigour where elephant grass was planted.

Plot No.	Extent of erosion A	Improvement achieved B	Vigour of plants C	Depth of A-horizon (cm) D	
1	2	3	2	25	(5)
2	2	2	1	13	(3)
3	1	3	2	18	(4)
4	3	2	1	11	(2)
5	1	3	3	13	(3)
6	2	2	2	13	(3)
7	1	3	2	17	(3)
8	2	2	2	12	(2)
9	3	1	1	9	(2)
10	2	2	2	17	(3)
Average	1.9	2.3	1.8	13.8	3.0

Key:
A: Extent of erosion
1. No erosion, 2. Low erosion, 3. Moderate erosion, and 4.Extreme erosion.
B: Improvement achieved
1. No improvement, 2.Low improvement, 3.High improvement.

C: Vigour of vegetation
1. Low vigour, 2.Intermediate vigour, and 3. High vigour.
D: Depth of "A" (Ranks based on approximate 5 units intervals).

Table 2: Soil erosion and vegetation vigour where elephant grass was not planted

Plot No.	Extent of erosion A	Improvement achieved B	Vigour of vegetation C	Depth of A-horizon (cm) D	
1	2	3	3	16	(3)
2	3	2	2	12	(2)
3	2	3	3	18	(4)
4	3	2	2	18	(4)
5	2	2	3	11	(2)
6	3	1	2	9	(2)
7	1	2	3	12	(2)
8	2	3	3	16	(3)
9	3	1	2	10	(2)
10	3	2	3	13	(3)
Average	2.4	2.1	2.6	13.5	(2.7)

Key:
A: Extent of erosion
1. No erosion, 2. Low erosion, 3. Moderate erosion, and 4. Extreme erosion.
B: Improvement achieved
1. No improvement, 2. Low improvement, 3. High improvement.
C: Vigour of vegetation
1. Low vigour, 2. Intermediate vigour, 3. High vigour

Table 3: Summary of mean values of soil erosion and plant vigour

Variable	Treatment	No. of observations	Mean	SD	CV
Extent of erosion	1	10	1.9	0.7379	38.8350
	2	10	2.4	0.3162	10..9044
Improvement	1	10	2.3	0.6992	29.1336
Rate	2	10	2.1	0.7879	35.1364
Vigour of	1	10	1.8	0.6325	35.1364
vegetation	2	10	2.6	0.4830	17.8906
Depth of	1	10	13.8	2.8983	21.0020
A-horizon	2	10	13.5	3.2745	24.2554

Statistical results indicate a significant difference of extent of soil erosion, improvement achieved due to planting of elephant grass, plant vigour and depth of the A-horizon.

According to Spearman's rank correlation method, the observed values are not independent (Table 4). However, in magnitude, there was low correlation in extent of erosion and improvement whereas plant vigour and horizon A-depth were moderately correlated.

Table 4: Summary of statistical results in values of soil erosion extent, improvement, rate, vigour of vegetation and depth of A-horizon

Variable	Treatment	Mean	r_s	Corresponding 5% level of significance
Extent of erosion	1	1.9	0.955	0.978
	2	2.4		
Improvement rate	1	2.3	0.976	0.985
	2	2.1		
Vigour of vegetation	1	1.8	0.952	0.971
	2	2.6		
Depth of A-horizon	1	3.0	0.921	0.953
	2	2.7		

Key:

r_s – Spearman's Rank Correlation coefficient

N.B. The lower the coefficient value the higher the significance (correlation).

The effect of soil erosion has been reduced to a great extent by using different measures. Like in other areas such as China where planting of trees and grass had been practised on the Loess plateau (Qinxiao *et al.*, 1995), tree and grass planting was one of the measures adopted in the area. The species planted were those thought to be with special adaptability to the environmental conditions of the area such as root system, drought resistance and ability to sprout.

Table 5: Plant species observed in the study area

NO.	BOTANICAL NAME	LOCAL NAME
a)	Tree species:	
1	Faidherbia albida	Mkababu
2	Acacia saligna	Msaligna
3	Adansonia digitata	Mbuyu
4	Albizia lebbeck	Mkenge
5	Albizia schimperiana	Mshai
6	Azadirachta indica	Mwarobaini
7	Brachystegia spiciformis	Myombo
8	Senna spectabilis	Mjohoro
9	Casuarina equisetifolia	Mvinje
10	Cupressus lusitanica	Msanduku
11	Delonix regia	Mkakaya
12	Dodonaea viscosa	Mhami
13	Eucalyptus camaldulensis	Mkaratusi

14	Eucalyptus citriodora	Mkaratusi
15	Eucalyptus grandis	Mkaratusi
16	Eucalyptus maidenii	Mkaratusi
17	Gardenia ternifolia	Mtulankondo
18	Grewia similis	Mkole
19	Grevillea robusta	Mgrivelea
20	Khaya anthotheca	Mkangazi
21	Leucaena leucocephala	Mlusiana
22	Parkisonia aculeata	Mkeketa
23	Peltophorum pterocarpum	-
24	Pinus patula	Msindano
25	Prosopis nigra	-
26	Pterocarpus angolensis	Mninga
27	Samanea saman	Mafura
28	Sapindus saponaria	Mharita
29	Sesban grandiflora	
30	Sesbania sesban	Mlindaziwa
31	Tamarindus indica	Mkwaju
32	Tamarix nilotica	Mchamwino
33	Schinus molle	Mpilipili
b)	Fruit Species:	
1	Annona muricata	Mstafeli
2	Artocarpus heterophyllus	Mfenesi
3	Carica papaya	Mpapai
4	Citrus limon	Mlimau
5	Citrus sinensis	Mchungwa
6	Mangifera indica	Mwembe
7	Morus alba	Mforosadi
8	Psidium guajava	Mpera
9	Syzygium cuminii	Mzambarau
c)	Grass species in multiplication plots:	
1	Bothriochloa insculpta	-
2	Cenchrus siliaris	-
3	Chloris gayana	-
4	Crotalaria ochroleuca	Marejea
5	Macropitium atropulperium	Sirato
6	Panicum coloratum	Mkarikari
7	Pennisetum purpureum	Elephant grass
8	Stylosanthes scabra	-
d)	Crops cultivated in the surveyed village:	
1	Arachis hypogaea	Groundnut
2	Cajanus cajan	Pigeon pea
3	Eleus ine coracana	Finger millet
4	Helianthus annuus	Sun flower

5	Ipomoea batatas	Sweet potatoes
6	Manihot esculenta	Cassava
7	Musa species	Banana
8	Pennisetum typhoides	Pearl millet
9	Phaseolus vulgaris	Beans
10	Saccharum officinarum	Sugar cane
11	Solanum tuberosum	Irish potatoes
12	Sorghum vulgare	Sorghum
13	Vigna unguiculata	Cow peas
14	Zea mays	Maize

The results above, show that elephant grass plays a great role in controlling soil erosion if planted on contour ridges to stabilise the contour, and is especially effective as it has many long fibrous roots which are able to trap soil particles into clumps hence stabilisation and improvement of soil structure. On the other hand the planting of *P. purpureum* for soil erosion control has been observed also by Wenner (1981), Mureithi and Thorpe (1996) and Soni *et al.*, (1989).

The Vigour of Plants and Competitive Effect of Elephant Grass on the Adjacent Crops

There was improvement in vigour of plants in both groups of the plots, but plants were more vigorous in the areas where elephant grass was not planted. It appears that elephant grass competes strongly for soil moisture and nutrients with other plants since it has many long fibrous roots, and grows faster. It therefore consumes large amount of soil water and nutrients relative to other plants, which are in turn weakened. The results conforms to the observation by Mureithi and Thorpe (1996) where under *P. purpureum* var. Bana only *Clitoria ternatea* survived and remained productive whereas *Microptilium atropurpureum, Macrotyloma axillare* and *Stylosanthes guianensis* failed due to competition for light.

The majority of the farmers who use the grass are aware of the competitive effects of it. As the result they plant maize at a distance of 90-160cm on each side of the contour ridges. To avoid the great loss of land in between the ridges, they plant one or two rows of beans in between, even by so doing, farmers have experienced a reduction in beans in the first row at distance of about 30cm. Furthermore, farmers plough deeply along the ditches to cut the spreading roots of elephant grass. On the other hand, some farmers use Makarikari (*Panicum coloratum*), which they consider less competitive than elephant grass but even this should not be left to grow for too long without cutting as its creeping effect can interfere with crops also.

The art of mixing crops with grass or grass with trees have been reported, like *Gliricidia sepium* and *P. purpureum* in Nigeria (Davies and Onwuka, 1996), *P. purpureum* and *Clitoria ternatea* in Kenya (Mureithi and Thorpe, 1996), *Cymbopogon flexuosus* (Lemon grass) and *Eucalyptus citriodora* (Lemon scented gum) (Chand *et al.*, 1998), *Cynodon dactylon* and *Trifolium* and *Trifolium subterranean* (clover) (Overman *et al.*, 1992).

In general, mixing plants aims at obtaining bonus of yields of the mixtures (Chand *et al.*, 1998). On the other hand, in addition to increased yield of diverse nature (Brummer, 1998), mixing nitrogen-fixing plants with grass results to increased N-content in grass (Mureithi *et al.*, 1995; Overman *et al.*, 1998). However, the main task is to select those trees and grass or grass and herbaceous plant species, which finally fit the local environment, to quickly cover the degraded (barren) lands (Qinxiao *et al.*, 1995; Loch, 2000).

CONCLUSION AND RECOMMENDATIONS

Conclusion

- The planting of elephant grass to control soil erosion as well as the soil degradation is very important. Due to water channel stabilisation and catching of the soil in gullies and sand rivers elephant grass enables the revival and prolonged water supply of such sand rivers as subsurface and surface water.

- Elephant grass is not suiTable to be mixed with some agricultural crops or to grow near it as it has a negative effect on them due to competition.
- Apart from controlling soil erosion, elephant grass has desirable characteristics to be used as a good source of fodder.

Recommendations

- For less effect on reduced adjacent crop vigour, and natural terracing of sloping farmland, *Makarikari* (*Panicum coloratum*) grass is recommended rather than elephant grass which is more effective in sand fixation in gullies and sand rivers.
- Sugarcane growing can be done in later stages after sand and moisture stabilisation has been effected by elephant grass. Bands or strips of elephant grass should be left undisturbed when portions are planted with sugarcane.
- To improve the value and yield of elephant grass for fodder in fodder plots, nitrogen fixing legumes combinations are recommended.

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