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Rainwater harvesting from roads enhanced indigenous pasture establishment in a typical African dryland environment

MGANGA K.Z.[1*], AMOLLO K.O.[1], BOSMA L.[2], KIOKO T.[2], KADENYI N.[2], MUSYOKI G.[1], NDATHI A.J.N.[1], WAMBUA S.[1], van STEERNBERGEN F.[3], and MUSIMBA N.K.R[1]

[1] Department of Agricultural Sciences, South Eastern Kenya University (SEKU), P.O. Box 170-90200, Kitui, Kenya
[2] MetaMeta Research, Postelstraat 2, 5211 EA's Hertogenbosch, The Netherlands

*Corresponding author
E-mail: kmganga@seku.ac.ke

Abstract: African drylands are a key source forage for pastoral livestock herds. However, land degradation and recurrent droughts have resulted to shrinkage of natural grazing pastures. This poses the greatest challenge to livestock production in African drylands. Combining innovative sustainable land management practices notably rainwater harvesting from roads and grass seeding using native grasses have been identified as a viable option for increased pasture production and rehabilitation of degraded pasturelands. Morpho-ecological characteristics of indigenous grasses *Cenchrus ciliaris* L. (African foxtail grass), *Eragrostis superba* Peyr. (Maasai love grass) and *Enteropogon macrostachyus* (Hochst. Ex A. Rich.) Monro ex Benth. (Wild rye grass) were planted to determine the suitability of rainwater harvesting from roads using trenches for pasture establishment and rehabilitation in a semi-arid landscape in Africa. Plant densities (plants m^{-2}), plant frequency (%) and biomass yields (DM g m^{-2}) significantly declined ($P < 0.05$) with distance away from the water trenches (0 m, 5 m and 10 m). In conclusion, harvesting and diverting runoff from roads into trenches prolong soil moisture availability to enhance indigenous pasture production and rehabilitation of degraded grazing lands in African dryland environments.

Keywords: Indigenous Pastures, Runoff, Roads, Rainwater Harvesting, African Drylands

1. Introduction

African drylands cover about 41% of sub-Saharan Africa landmass (Vohland and Barry, 2009) and about one-third of the global drylands (Darkoh, 2003). They are generally characterised by low erratic annual rainfall (300-600 mm) and nutrient poor soils (Sanchez, 2002). Extensive utilisation of multiple grazing resources by different livestock species (cattle, goats, sheep and camels) in African drylands remains an important way of life among pastoral communities. Indigenous pastures make-up the bulk of the feed in most ruminant production systems in the developing world (Ngwa et al. 2000) and have been cited in numerous previous studies to be among the most important sources of forage for grazing herbivores in Africa. This is because, indigenous pastures have evolved over many decades within their ecological range. Consequently, they have become tolerant to the harsh dryland environments and can withstand pressure from grazing herbivores. However, despite the ecological adaptation of the indigenous pastures to African dryland environments, emerging global challenges such as land use changes, increased pressure on natural resources utilisation and climate variability and change have greatly contributed to their decline in the natural environment. Seasonal nature of forage supply due to changes in climatic patterns contributes to the low livestock productivity (Ngwa et al. 2000). Combining innovative sustainable land management practices notably rainwater harvesting and indigenous grass seeding have been promoted as viable interventions to restore denuded pastures in African drylands (Mganga et al. 2015; Mnene et al. 2005). Indigenous grass seeding plays a pivotal role in detached dryland landscapes (via seed dispersal or seedbanks) to existing populations of desirable forage species (Sheley et al. 2006). Rainwater harvesting technologies ensure sufficient capture of water and prolong soil moisture availability for seed germination and subsequent establishment. Interestingly, despite the large volumes of runoff generated from roads and footpaths as water catchments, its potential to improve rural livelihoods in African drylands has not yet been fully exploited.

In an attempt to address this research gap, indigenous tropical Africa grasses namely: *Cenchrus ciliaris* (African Foxtail Grass), *E. superba* (Maasai Love Grass) and *E. macrostachyus* (Wild Rye Grass) were established in a typical semi-arid environment in Africa. Selection criteria of the grasses was primarily based on their evolved adaptive mechanisms for survival in African drylands, seed availability and their multipurpose uses to the pastoralists i.e. source of animal feed and income through the sale of seed and hay. The main objective of this study was to determine the potential of rainwater harvesting from roads and diverting the generated runoff into established trenches for enhanced pasture production and rehabilitation of degraded African dryland landscape.

2. Materials and Methods

This study was conducted in South Eastern Kenya University (SEKU) research farm located in Kitui County, a typical semi-arid environment in Africa. Rainfall pattern is bimodal with long rains in March-May and short rains in October-December. Annual average rainfall ranges between 300-800 mm and mean annual temperatures range between 14-34°C (Schmitt et al. 2018). Rainwater harvesting structures (runoff diversions from roads and trenches) were created in September, 2018 and seeding (rate 5 kg ha^{-1}) done in prior to the onset of the October short-rains. Plant biomass was estimated (in April 2019) using the quadrat method. Harvested biomass was placed in brown paper bags and oven dried at 60º C for 48 h to estimate DM yields and % moisture content in the herbage. Plant densities (plants m^{-2}) and frequencies (%) were also estimated using quadrats method. All measured plant attributes were determined in three (3) transects, T1, T2 and T3 located 0 m, 5 m and 10 m away from the trenches, respectively, for the each of the grass species (Figure 1).

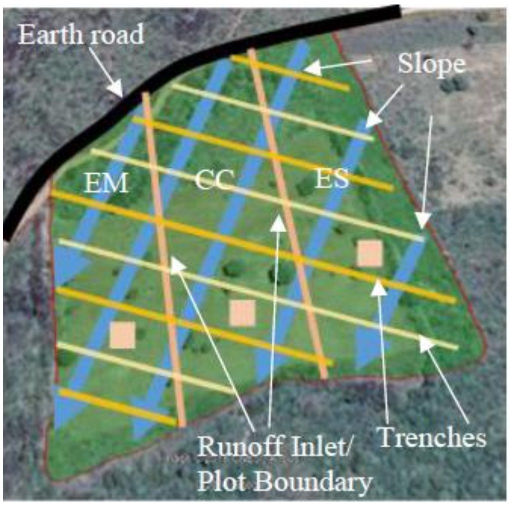

Figure1. General layout of project site and grass plots
EM – *Enteropogon macrostachyus*
CC - Cenchrus *ciliaris*
ES – *Eragrostis superba*

3. Key Results and Discussion

There was a general and significant difference (*P<0.05*) in biomass yields across the three grass species as influenced by the distance from the trench. Biomass yield declined with distance from the trench 0m >5m >10m (Figure 2). This results strongly suggest that harvesting runoff from roads and storing the water in trenches is a viable innovation that can prolong soil moisture availability and consequently enhance pasture production. *Eragrostis superba* and *Cenchrus ciliaris* demonstrated higher biomass yields compared to *Enteropogon macrostachyus.* However, in terms of plant frequency (%) and plant density (plants m^{-2}), *E. macrostachyus* demonstrated significantly higher (*P<0.05*) compared to *E. superba* and *C. ciliaris.* Higher biomass yields in *E. superba* and *C. ciliaris* despite low frequencies and densities can be attributed to their higher stem:leaf biomass ratio compared to *E. macrostachyus*. Significantly higher frequency and densities in *E. macrostachyus* is attributed to its larger seed size that enhances faster germination.

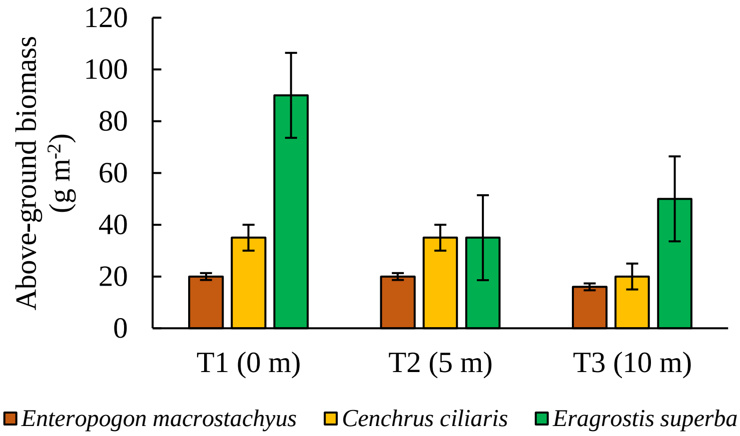

Figure 2. Biomass yields at different transects (T) and distance (m) from trenches harvesting rainwater.

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