EFFECT OF WATER HARVESTING TECHNOLOGIES ON DRY MATTER PRODUCTION OF SELECTED FORAGES IN COASTAL KENYA ASALS

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ABSTRACT

Coast *ASAL* comprises 80% of the land area of coast province of Kenya. Lack of water for livestock and domestic use is a major constraint to land productivity in *ASAL*s, as it affects feed quantity and quality for all year feeding of livestock. The *ASAL* community's livelihoods depend largely on livestock as source of income to buy food and meet domestic and social obligations. Livestock in these areas depend on natural vegetation, as cultivation of forages is non-existent due to lack of water. Once developed, these areas could account for nearly all the meat requirements for the coastal region, improve food security status, generate income and reduce the milk deficit. KARI is endowed with forage production technologies for more humid areas which could be adapted for *ASAL* areas to improve productivity. Experiments were carried out at Bamba research site, in Agro-ecological zone Coastal Lowlands (CL5), in the *ASAL*s, to determine suitability of selected pasture grasses grown in furrows or zai pits as water harvesting techniques. Five grass varieties (*Eragrostis superb, Cenchrus ciliaris, Chloris gayana (*var. ex-Tozi), *Panicum maximum* (giant) and *Panicum maximum* (Local) were randomly allocated to the two treatments and replicated three times. The grasses were planted using splits spaced 0.5 m apart. Napier grass var. Bana was used in the experiment. For this experiment, three levels of manure: none, low and high were also studied along with the zai pit water harvesting technique. The results showed that furrows contributed to better establishment of pasture grasses in *ASAL*s. Under the prevailing low moisture conditions, use of manure in Zai pit for fodder grass production in *ASALs* tended not to influence survivability and DM production. However, these results are preliminary and data collection will continue to ascertain the interactive effects of nutrient supply and moisture availability in ASALS.

INTRODUCTION

About 80% of coastal lowland (CL) is in arid and semi-arid is described as livestock millet (CL 5) and Rangelands (CL 6) agro ecological zones with unreliable and erratic rainfall (Jaetzold and Schmidt, 1983). The natural vegetation is dominated by thicket bush land and natural pasture grasses which are primarily grazed by cattle, sheep and goats and wildlife mainly for meat production. Coast *ASAL*s are characterized by food insecurity and high poverty levels arising from the impacts of prolonged drought. The *ASAL* community's livelihoods depend largely on livestock as source of income to buy food and meet domestic and social obligations. Lack of water for livestock and domestic use is a major constraint to land productivity in *ASALs* (Ramadhan *et al*, 2008) as it affects feed quantity and quality for all year feeding of livestock. Livestock in these areas depend on natural vegetation, as cultivation of forages is limited by low rainfall amount (average 800 mm). Low productivity of livestock could be attributed to the low availability of forages coupled with the poor quality fodder. Considering the demand for food grains, more land in *ASAL*s is being used for food crops especially near water pans hence reducing the natural vegetation available as feed resource. There is therefore, need to explore alternative ways of increasing feed availability these areas by identifying technologies that enhance forage availability especially near the water pans. Past research in the region identified several productive pasture and fodder species (Njunie et al, 1992). The grasses included *Chloris gayana*, *Eragrositis superba, Panicum maximum* and *Cenchrus ciliaris*. Those grasses had been evaluated without irrigation or use of water harvesting structures. Two trials were therefore conducted to investigate whether Zai pits and deep-furrow techniques could enhance forage dry matter (DM) production of selected forage species. It is anticipated that such forages are likely to be more effective in utilizing the scarce water resource in the *ASAL*s.

The Zai pits technology has been widely adopted as a water harvesting technique for maize production in the region (Saha *et al* 2007). The technique (also known as *Tumbukiza*) was widely adopted by smallholder farmers in Western Kenya as an alternative method of Napier grass production (Orodho, 2007). The method produced significantly higher DM yields than conventional method in several sites (Muyekho *et al*, 2000). The study showed that farmers could use any source of manure and different sizes of holes provided the nutrients applied match with pant density.

Deep-Furrow planting of small seeded plants is widely practised in dry areas for better plant establishment (Heady and heady 1982). The use of deep-furrow ensures that the seed is covered with the normal depth (not too deep) yet in contact with moist soil at the bottom of the furrow. Besides, seed is protected from being blown away by wind.

MATERIALS AND METHODS

The study was conducted in Bamba division, Ganze district in (CL5), with unreliable and erratic rainfall (Jaetzold and Schmidt, 1983). The annual rainfall ranges from 500 to 900 mm in CL5 and CL6 transition area, obtained in two rainfall seasons (long and short) which often fail.

Two experiments, one on pasture and the second on fodder grasses were carried out at different seasons. Experiment 1 which evaluated the influence of furrow planting on DM production from five pasture grasses was planted in November 2009. Experiment 2 which evaluated the influence of Zai pits on Napier grass DM fodder production was planted in March 2010.

Experiment 1 comprised of 30 plots measuring 5 by 5 m each was established to determine DM productivity of *Panicum maximum* (Giant), *Panicum maximum* (Local), *Chloris gayana* (var. ex-Tozi), *Cenchrus ciliaris* and *Eragrostis superba*. Fifteen randomly selected plots received conventional tillage treatment (land tilled 3 inches deep) while the other fifteen plots received furrow treatment (furrows tilled 6 inches deep). The five grass varieties were planted at spacing of 0.5 by 0.5 m, using splits. The trial was replicated three times. A similar experiment was setup using seeds. Two harvestings of pasture grasses were done on 27th October 2010 and 18th January 2011. To determine DM production, 200 g sample was taken from each harvest and plot, oven dried at 105^{o}C to constant weight and % DM calculated.

Experiment 2 was planted in March 2010. It comprised of nine plots of 4.2 x 4.2m with 16 *zai* pits per plot. Pit was planted with one rooted Napier split. Three manure levels were used in *zai* pits as follows: (1) hole dug and filled with same soil without any additive (no manure), (2) low manure, hole dug and filled with a mixture of 18kg of animal manure and 26kg of soil and (3) high level manure, hole dug and filled with a mixture of 36 kg manure and 13kg soil mixture. The treatments were replicated three times. Two harvestings were carried out in October 2010 and January 2011. Forage fresh weight and 200g sample was taken from each plot for DM determination. Data analysis was carried out using GLM SAS procedure, and means separated using least significant difference (LSD)

TABLE I - PERCENT LIVE PLANTS AND CUMULATIVE DRY MATTER YIELD FOR TWO WATER HARVESTING TECHNIQUES AND FIVE PASTURE GRASSES FOR EXP 1

Water harvesting techniques/ Grass species	Percent life plants, 3 months after planting	First harvest DM prodution (t ha^{-1})	Second harvest DM prodution (t ha^{-1})	Cumulative DM prodution (t ha^{-1})
Furrow tillage	44^a	1.64^a	1.83^a	3.14^a
Deep tillage	34^b	1.66^a	1.66^a	3.54^a
LSD	8	0.95	0.39	1.34
Grass species				
Eragrostis superba	77^a	1.81^{ab}	1.43^a	3.24^a
Cenchrus ciliaris	42^b	1.91^a	2.09^a	4.00^a
Chloris gayana (Var. ex-Tozi)	32^{bc}	1.78^{ab}	1.83^a	3.56^a
Panicum maximum (Giant)	25^c	1.85^a	1.73^a	3.89^a
Panicum maximum (Local)	20^c	0.82^b	1.28^a	2.10^a
LSD	12	0.95	1.33	2.15

RESULTS

The rainfall obtained during the experimental period was summed up for 10 day periods as shown in Figure 1.

Results showed no significant differences (p>0.05) in plants counts across three levels of soil:manure ratio mixtures (Table 2). The manure:soil mixture had also not shown any effects (p>0.05) on DM production with the two harvestings.

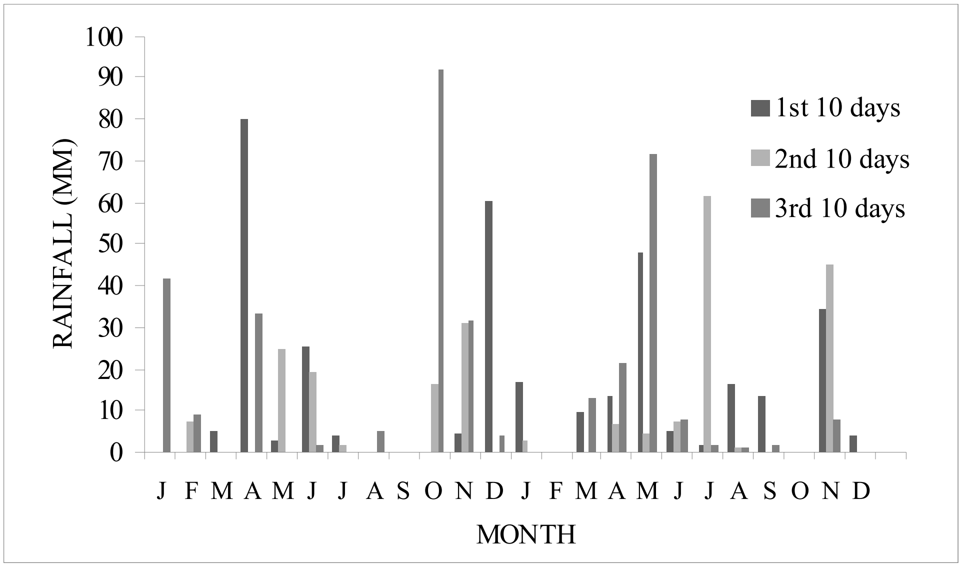

Figure 1. Rainfall for year 2009 and 2010 at KARI Bamba in ASALs, 10- day totals within a calendar month.

The results of Experiment 1 where grasses were planted using splits are summarized in Table 1. There were no results for the adjacent experiment planted using seeds because the rainfall received after planting was inadequate to initiate germination.

Figures bearing same superscript letter within a cullumn are not significant (p>0.05)

This was probably because low rainfall started at the beginning of the season in year 2010 (Figure 1.).

DISCUSSION

The annual rainfall obtained in year 2009 (502 mm) and year 2010 (418 mm) was below the long term average of 800 mm expected in the area (Jaetzold and Schmidt, 1983). The growth of the grasses was

TABLE II- PERCENT SURVIVING PLANTS COUNTS AND CUMULATIVE DRY MATTER YIELD FOR THREE MANURE SOIL MIXTURES

Manure level	Plant counts	Cumulative yield	1st harvest	2nd harvest
No manure	78[a]	1.20[a]	0.70[a]	0.43[a]
Low manure	54[a]	0.98[a]	0.68[a]	0.32[a]
High manure	59[a]	0.72[a]	0.39[a]	0.33[a]
LSD	32	0.9 0	0.56	0.39

influenced by rainfall at establishment considering the proportion of plants surviving, three months after planting. The experiments were planted as soon as the short rain season of 2009 began in November. There was adequate moisture at planting (57 mm rainfall was received six days before planting) to enable plant establishment (Figure 1). However, the rainfall declined thereafter (only 6.6 mm was received in nine days after planting) leading to death of plants which varied among the grass species (Table 1).

In Exp1, the mean live plants counted per plot were 39 out of the expected maximum of 70 for all the grasses planted in the trial. *Eragrostis superba* and *Cenchrus ciliaris* had highest proportion of live plants ($P<0.05$); *Chloris gayana* was intermediate while the two *Panicum* species were most affected by the drought. The percentage of live plants was greater ($P<0.05$) where grasses were planted in furrows compared to conventional (Table 1). Heady and Heady (1982) indicated that furrows conserve moisture at the furrow- bottom that may have contributed to better plant survival. The results also confirmed that grasses established better using splits especially in low rainfall and moisture conditions experienced in the *ASALs*, considering that the adjacent experiment in which the same grass species were planted using seeds never germinated as the rainfall obtained was too low. Other grasses would probably need relatively higher rainfall in order to establish well.

The live plants in the experiment were maintained and DM production determined. From the two harvests, the mean yield obtained per harvest was 1.7 t ha^{-1}. The yield recorded is low considering that mean yield per harvest ranging from 2.3 to 3.8 tones have been recorded for the same species grown at Mariakani (Njunie and Ogora, 1992). The low yields at Bamba could be due to the low rainfall amounts obtained during the experimental period (Figure 1). However, DM production was different ($p<0.05$) among the five grass species for the first harvest. *Cenchrus ciliaris* and *Panicum maximum* (Giant) produced the highest ($p<0.05$) DM yield. While *Eragrostis superba* and Chloris *gayana* were intermediate. The local Panicum produced the lowest DM production. Considering the second harvest, the overall mean DM yield was 1.68 t ha^{-1}. There were no differences ($p>0.05$) in DM production among the five grasses for the second harvest. Compared to number of live plants recorded for each grass species at establishment, the results showed clear differential DM production responses by different species based on their ecological and physiological adaptation to environment (Barbour 1980). Though *Eragrostis superba* had a good stand early at establishment, the cumulative yields obtained after second harvest were similar to those of other grasses despite their low initial stand counts. Overall, the results highlight the challenges in establishing forage crops in the *ASAL*s To ensure better establishment of pasture species in *ASAL*, they should be planted when there is enough moisture in the soil (cumulative rainfall received greater than 57 mm within six days before planting). The cumulative rainfall expected within nine days after planting should be greater than 6 mm to ensure uniform grass establishment.

Results of experiment 2 are summarized in Table 2. Two harvests were carried out. Available results of live plants and DM production of Napier grass Var. Bana did not show any significant differences ($P>0.05$) for different soil: manure mixtures. The lack of response to manure levels could be due to limited soil moisture received following establishment (Figure 1). Total rainfall received from planting to first harvest was only 480 mm and was not well distributed. The lack of response to *Zai* pit technology was probably due to inadequate moisture to conserve. It is noted that Napier grass grows best in areas of high rainfall (in excess of 1000 mm) and may require irrigation if grown in ASALs.

CONCLUSIONS

Planting pasture grass in furrows contributed to better plant establishment compared to no furrow system. Pasture grasses planted using splits established well, while the use of grass seeds resulted in crop failure due to low rainfall amounts and distribution.

Considering fodder grass production, varying manure levels in *Zai* pits did not affect Napier grass plant survival and Dm production probably due to high nutrient levels in the less depleted soils of ASALs and the low soil moisture conditions.

RECOMMENDATIONS

- Establishment of pasture grasses in ASALs can be improved by use of furrow as a water harvesting technique.

- Under low soil moisture conditions, grasses will establish better by using splits rather than seeds
- Growing of Napier grass in the ASALS requires an effective water harvesting strategy as rainfall distribution and amounts received are unreliable.

- The results are preliminary and data collection shall continue for two more years to ascertain the interactive effects of nutrient supply and moisture availability in ASALS.

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