Use of Integrated Range Management Practices for Improving Growth and Dry Matter Yield of Forage Species in Mvomero district, Morogoro, Tanzania

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Abstract

Scarcity of forage particularly during dry seasons is among the major factors which limit improved meat production from livestock in many pastoral communities in tropical countries. The scarcity is associated with low level of soil nutrients, irregularity in weather patterns and climate change. One way of making more feeds available for livestock in such times include the adoption of Integrated Range Management practices (IRM), rangelands management technique which involve a range of practices including application of manure, furrowing the land and oversowing among others. The IRM was a focus for this study which was conducted in one pastoral village namely Mela, in Mvomero District in Morogoro Region, Tanzania. Field trials were conducted based on a Completely Randomized Block Design (CRBD) and aimed to assess the influence of oversowing Cenchrus ciliaris on grazing lands, the effect of manure application on growth performance and dry matter yield of the specie, and the effect of furrowing on grazing land. Fifteen plots of equal sizes (16m²) were needed for this study and from which the dry matter (DM), number and height of tillers of the target specie were determined. Comparison on the study factors among the plots were done based on the One -way analysis of variance (ANOVA), results obtained from the Statistical Package for Social Sciences (SPSS) version 25.0. In general, growth was significant ($p \leq 0.05$) among the different plots being fast in the plots which combined manure, oversowing and furrowing followed by those which had manure and oversowing, and least were those which oversowing and furrowing was the option. The major reason for high growth in the three factors plot was with no doubt shown to be high level of IRM with three or more factors (practices) for increased fodder productivity.

Keywords: *Cenchrus ciliaris*, Oversowing, Furrowing, Manure application, Dry matter yield (DM), Growth performance, Mela

Introduction

Scarcity of forage particularly during dry seasons is among the major factors which limit improved meat production from livestock in many pastoral communities in tropical countries (Mwilawa *et al.,* 2008). Since most natural pastures are made up of rapidly maturing perennial grasses, poor nutritional values and relatively low digestibility. About 1-2 billion people mostly disparage rural areas, depend upon rangelands. Worldwide, it covers about 30-40% of the land on the earth (Sayne *et al.,* 2013). In many places of the world, pasture serves as a primary source of animal feeds (Sayne *et al.,* 2013). In Africa, due to the extended dry seasons, many pastoralists experienced the severe feed shortages (Lelamo *et al.,* 2022), results to loss of pastoralists' wealth. According to Sarwatt and Mollel (2002), reported that over 90% of domestic animal feeds depends on natural pasture.

In Tanzania, about 60 million hectares covered by rangeland resources. Also, it is the second-largest livestock producer in Africa, after Ethiopia, with 92.8 million poultry, 3.4 million pigs, 25.6 million goats, 8.8 million sheep, and 35.3 million cattle (NBS, 2021: MLF, 2021). The increase in livestock unit geared up by population growth and high demands of animal products, this resulted to fall of supplying of forage, further dramatic decline in livestock productivity, low milk and meat output and further worsening poverty among the 50% of the population dependent on the livestock value chain (URT, 2022).

One of the major obstacles to increasing dairy output is the lack of high-quality pasture and scarce feed particularly during dry seasons (Maleko *et al.,* 2019). The detrimental effects of climatic variability and climatic change also make this situation worse (FAO, 2006). According to Kavana and Msangi (2005), fall in pasture availability during the dry season causes a decline over 40% in milk production. In 2021, 2017 and 2016, Tanzania experienced an extended dry season which caused scarcity of water and pasture for the livestock (MLF, 2022), This resulted to 62,585 deaths of animals in Simanjiro District. (MLF, 2022) due to conflicts between farmers and pastoralists. Furthermore, according to Sangeda *et al.* (2013), reported the same case, whereby many farmers lost their animals due to shortage of forage particularly in prolonged dry seasons.

Despite numerous efforts in research and development initiatives to address the issues of dry season fodder scarcity, but it is still challenge in many pastoral societies in Tanzania to adopt forage conservation, preservation and production techniques in the form of silage or hay (Lukuyu *et al.,* 2015). Since, pastoralists have their own drought-coping strategies, such as reserving areas for dry season grazing, moving from one place to another to search water and pasture and overstocking coupled with shrinking grazing lands.

Buffel grass is one of forage grasses that is widely established in various parts of the tropics because of its desirable characteristics. According to Lutatenekwa *et al.* (2021). The grass is deep rooted and tufted-rhizomatous characteristics which make the grass fairly adaptive to heavy grazing pressure and tolerant to drought conditions. Pastoralists may be able to boost their rangelands' carrying capacity by introducing buffel grass. This may results gearing up their productivity and quick financial return for pastoralists. The introduction of improved grass can help to control soil erosion in semi- arid rangelands, by compacting and binding the soil to reduce risks by water and winds.

Scarcity of forage particularly during dry seasons is among the major factors which limit improved meat production from livestock in many pastoral communities in tropical countries. The scarcity is associated with irregularity in weather patterns and climate change, low level of soil nutrients less water infiltration, bush encroachment, high soil erosion and prolonged time spent by their livestock in grazing, this increased bare spots and decreased soil seed bank.

Since, the majority of pastoralists in Mela, have not been practiced using Integrated Range Management (IRM) techniques, resulted some pastoralists to migrate with their livestock to search of water and pasture, but the recorded success is still low. This study aiming to test different methods of integrated management practices to improve forage productivity particularly in dry seasons by using improved pasture seed of African foxtail.

Material and Methods

Description of the Study site

The study was carried out in Mela village, which is mostly populated by Maasai pastoralists and is situated in the arid areas southern part of the Mvomero district. The district is situated between latitude 8-100S and longitude 28-370E. Highland and lowland rainforests are found in the northern west and center north belt of the district, whilst drier woodlands are found in the south. The topography and temperature of the district also vary widely. With a long-wet season from March to May and a short-wet season from October to December, the district's annual rainfall is distributed bimodally. The temperature in the Mvomero district ranges from 20 to 30°C on average, while the northern region experiences humid to sub-humid conditions with annual rainfall between 1500 and 2000 mm. The major economic activities are livestock keeping, indigenous knowledge on preservation of native pasture and water-feed conservation.

Experimental design

The study utilized the Complete

Randomized Block Design (CRBD), whereby the experimental plots in this study were divided into 15 plots, each measuring 26 by 16 meters, with a distance between them of 1 meter and each plot measured 4 x 4 m. Treatments were assigned at random within blocks of adjacent subjects, each treatment once per block. A total of five treatments includes Control (T0)- No range improvement practice was applied, Oversowing (T1), Manure application and Oversowing (T2), Furrowing and Manure application (T3) and Furrowing, Manure application, and Oversowing (T4) were adopted in this experiment. CRBD with 5 treatments replicated three times in the study foci. The diagrammatic representation of the experimental layout is shown in Figure 1. The demarcated plots were cleared by using bush knives and axe to remove undesirable vegetation. The pasture seeds were planted between 1 cm deep after establishment of furrows 20cm wide. Approximately 7 kg of seeds were sown per acre in designated rows that were spaced 50 cm apart. All experimental plots were oversown at the beginning of the rainy season in March 2020.

collected at a depth of 0 to 20 cm below the soil's surface by using a soil auger. The sample were mixed thoroughly and sub-sampled to obtain to obtain one composite sample. The sample was weighed, air-dried and crushed to pass through a 2mm sieves, thereafter were sent to soil science laboratory analysis for subsequent chemical and physical analysis. pH, Total Phosphorus (P), Potassium (K) and Nitrogen (N), were analyzed using Micro- Kjeldahl, Olsen methods, flame emission and Electrode method respectively (Bremner and Mulvaney 1982; Olsen and Sommer 1982).

The application of cattle manure in pasture plot was established, with application rate of 100kg/ha. Data were gathered on the growth performance metric of oversowed improved seed of Cenchrus Ciliaris, the parameters of plant species were gathered after every two weeks for six weeks included: height of plants (in cm), number of tillers, and destructive method was used to harvest buffel grass. At the booting and flowering stages, each plot's quadrat (0.5 m×0.5 m) was used to collect a sample. The quadrant was randomly thrown three times

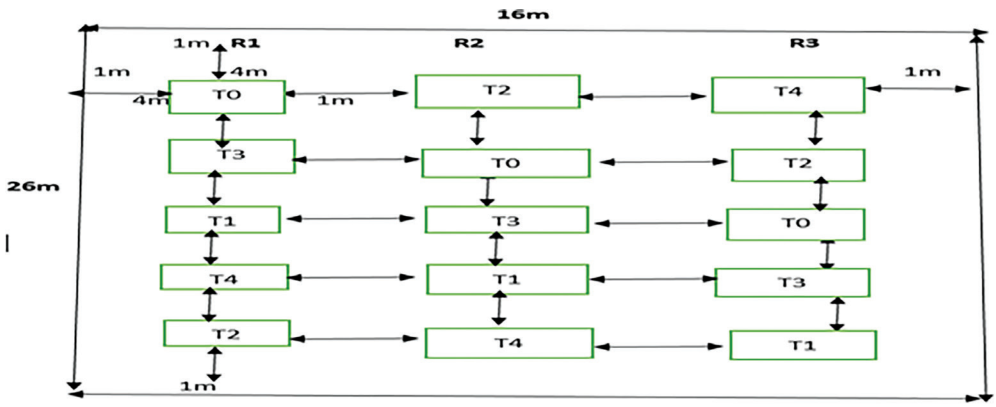

Figure 1: Treatment allocation (Integrated Range Management Practices) in a Randomized Complete Block Design in an experimental plot at Mela village

Sampling procedure

Before the experiment, soil testing was done. Whereby the soil samples were collected randomly in the pastoral grazing land to obtain a representative sample. The sample point selection was done randomly by random walking within the demarcated experimental area using a 1m2 quadrant, which was thrown at different sites. The individual soil sample was

in all fifteen (15) plots resulted to a total of 45 quadrants. Sample were cut above the ground cover (at height of 15cm) by using knife, then collected samples were packed in a clean empty bag and well labelled for easy identification, thereafter, samples were taken in the laboratory for dry matter determination, Other species were allowed to recover for next season after each experimental sward were removed. Digital weighing balance was used to weigh sample in the laboratory. Then for 2-4, samples were forced dried in oven at (60-70) °C. After drying to the constant weight to calculate DM content and anticipated to kg DM per hectare.

Statistical analysis

The data were stored into the spreadsheet of Microsoft Excel Window 2007 and analyzed using Statistical Package for Social Sciences (SPSS) version 25.0. (IBM, 2022). One -way analysis of variance (ANOVA) was used to compare mean values using the general linear model (GLM) procedure of the statistical analysis system on the study factors among the plots and were considered statistically significant differences at $p \leq 0.05$. To distinguish the difference among the mean values, Least Square Difference (LSD) was used at 5%. The statistical model utilized was according to equation 1:

$Y_{ij}=\mu+Ʈ_i+B_j+Ɛ_{ij}$ …………….………......(1)

Whereby Ti=Treatment effect of level of sowing, manure application and furrowing (Independent variable),

μ = Overall mean,

Bj = the effect for being in block j,

Ɛij =Random error and

Yij = Forage Yield Production, tillers and height of plants (Dependent variable).

Results

Soil Characteristics

The pH of the soil at Mela ranged was alkaline (7.14), and the soil exhibited crucial low nutrients for pasture growth. The high pH interfered with plants' ability to take some nutrients, which led to some nutrients not being absorbed effectively. Total nitrogen, phosphorus, potassium, and soil texture were all found, with nitrogen being 0.14 percent, phosphorus being 0.059 mg/kg, the soil having a texture of 32% sand, 11% silt, and 57% clay (Table 1).

Table 1: Soil parameters

Soil parameters	Number
pH	7.14
Nitrogen (%)	0.14
Potassium (cmol(+)/kg)	0.50
Phosphorus (mg/kg)	0.059
Clay texture (%)	57
Silt texture (%)	11
Sand texture (%)	32

Growth performance of *Cenchrus ciliaris*

The growth performance of improved pasture seed in terms of estimated marginal means of plant height and tillers number per plant was significant ($p \leq 0.05$) among the different plots being fast in the plots which combined manure, oversowing and furrowing followed by those which had manure and oversowing. The estimated marginal means of plant height and number of tillers per plants of *C. ciliaris* was fast in plots applied with three treatments (manure, oversowing and furrowing) followed by those applied with manure and oversowing (Table 2&3). In contrast, estimated marginal means of plant height and number of tillers was not significant ($P \geq 0.05$) in plots applied with furrowing and oversowing, control only (natural

Table 2: Effect of Range Management Practices (Treatments) on growth performance of Cenchrus ciliaris in terms of estimated marginal means of plant height

Integrated Range Management Practices (IRM)	Estimated marginal Means of Height (cm)	95% Confidence Interval	P-value
Control	12.6 ± 0.12a	10.2-15	----
Oversowing	11.0 ± 0.12a	8.6-13.3	0.328
Manure application + Oversowing	16.8 ± 0.12b	14.4-19.2	0.016
Furrowing + Oversowing	12.7 ± 0.12a	10.4-15.1	0.94
Furrowing +Manure application + Oversowing	23.4± 0.12c	21.o-25.8	0.000

Table 3: Effect of Range Management Practices (Treatments) on growth performance of Cenchrus ciliaris in terms of estimated marginal means of number of tillers per plants

Integrated Range Management Practices (IRM)	Estimated marginal Means of number of tillers	95% Confidence Interval	P-value
Control	4.33 ± 0.42a	3.5-5.2	----
Oversowing	4.0 ± 0.42a	3.2-4.8	0.58
Manure application + Oversowing	6.0 ± 0.42b	5.2-6.8	0.01
Furrowing + Oversowing	4.34 ± 0.42a	3.5-5.2	0.90
Furrowing +Manure application + Oversowing	7.7 ± 0.42c	6.8-8.5	0.000

NB: The same letters within the column indicates there is no significant different, different letters within the column indicate significant differences at the 5% level.

grass) and oversowing only respectively. The least growth performances were observed those which oversowing and furrowing was the option.

The current study established linear relationship between estimated marginal means of number of tillers per plants and plant height of *C. ciliaris* with time. Number of tillers were increased exponentially with time, starting with four tillers per plant at second week, to seven and nine tillers per individual plant at fourth to sixth week respectively (Fig. 2&3). Likewise, our study showed that there was significant variation ($p<0.05$), in estimated marginal means of number of tillers per plant and plant height of improved seeds with time. The improved seed exhibited higher mean height and number of tillers in the sixth week in the experimental plot, followed with moderate mean height and number of tillers of plants on the fourth week. On contrary, the improved pasture seed had significantly low average mean height and number of tillers on the first week in the demarcated experimental area. Both tillers and heights increased exponentially with time. Additionally, on the second week and fourth week control (native grass) outperformed the improved grass oversowing was option and with combination of furrowing and oversowing in the study area, may probably due to environmental stress, competitive ability, adaptation and nutrients levels in the soil. Over time, on the sixth week, the improved grass catched up and outperformed the control.

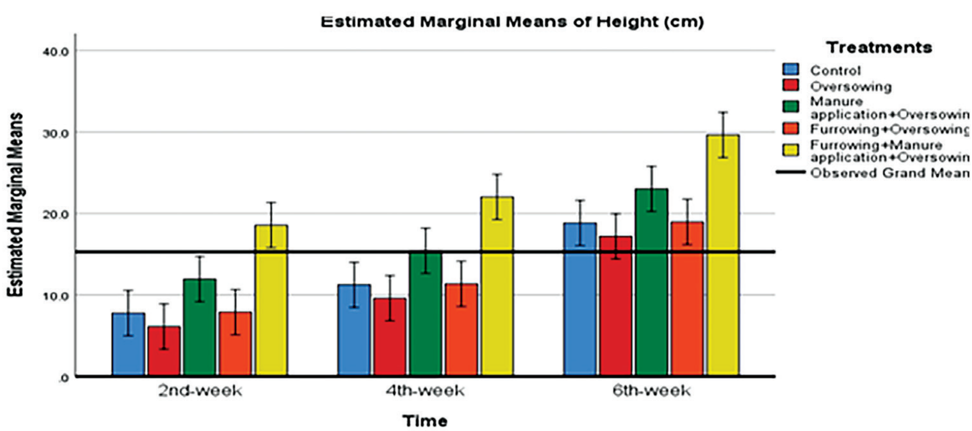

Figure 2: Estimated marginal means of plant height of Cenchrus ciliaris over time (weeks)

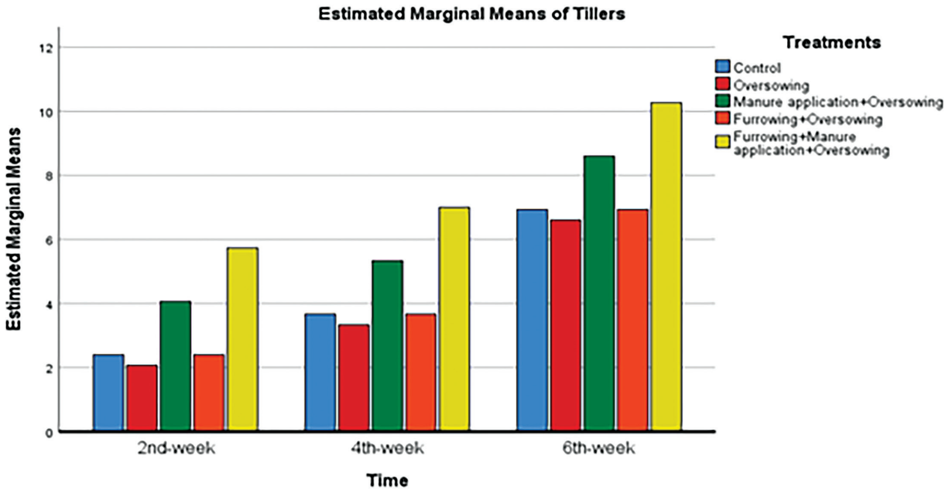

Figure 3: Estimated marginal means number of Tillers of Cenchrus ciliaris over time (weeks)

DM yield was significant ($p \leq 0.05$) among different plots, being high in plots which combined manure, oversowing and furrowing (2.7tDM/ha), followed by those applied with manure application and oversowing (2.0tDM/ha). In contrast, least Dm yield was observed on plots with control only (1.6tDM/ha), furrowing and oversowing (1.58tDM/ha) and oversowing only (1.5tDm/ha) respectively (Fig. 4).

Discussion

The selected pastoral rangeland had critical low soil nutrients available for forage growth, with pH (7.14), The plants' ability to absorb some nutrients was interfered with by the elevated pH. A pH range of 6.5-7 is preferred by the majority of pasture grasses and legumes, this implies that low soil nutrients may probably due to reduction of ground cover and organic matter, Likewise, may be contributed by

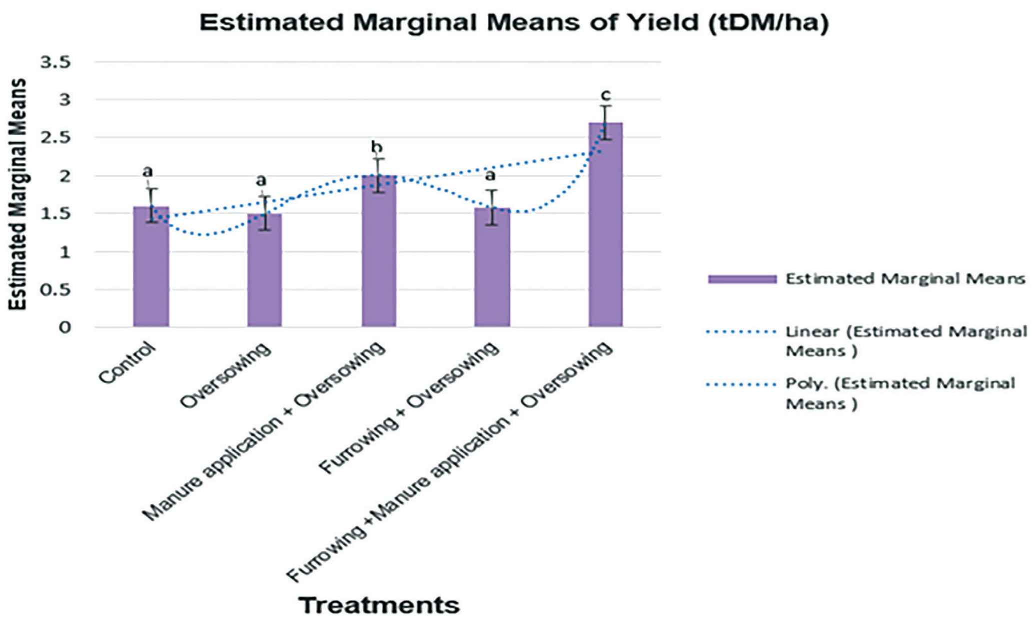

Figure 4: Estimated marginal means of Yield (tDM/ha) with different Range management practices (Treatments)

overgrazing commonly practiced in grazing land resulted to reduce the ability of soil to bind the cation. Our study resembles with previous report documented by Kizima *et al.* (2015) from Kibaha–Coast region, Tanzania. Additionally, Low organ carbon and cation exchange capacity may result in soil grabbing very little amount of water and soil nutrients (NPK) (MAFSC, 2006). The cow manure was used for supplementation of nutrient deficit (NPK) for forage growth in pastoral grazing area. This study is in agreement by MAFSC, (2006) from Tanga, Tanzania reported the rapid growth of pasture influenced by nutrient availability, soil moisture and improved soil conditions.

Manure contains sufficient plant nutrients and has longer-lasting effects than artificial fertilizers with comparable nutrition levels (Bayu *et al.,* 2005). Cattle dung increases soil nutrients because of microbial activity, which also improves soil fertility essential for pasture growth, root development, storage of moisture and soil structure. The dry matter of pasture species increases as growth performance rises. Hence, manure application has a significant impact on buffel grass growth performance and biomass yield. The findings are in agreement with the report by Maleko *et al.* (2015) in Western Usambara highlands, Tanzania, cow manure increase forage productivity by boosting stem growth, tiller and leaf number and DM yield. Furthermore, farmyard manure, which is made from cattle dung and other animal waste is extremely beneficial since it includes high amounts of NPK, its application considerably enhances DM yield, nutritional makeup of pasture and soil fertility (Goyal *et al.,* 1993). The improvement of buffel grass biomass yield and growth performance is strongly influenced by furrowing. The contour furrows required for rangeland restoration, helps control erosion and floods, conserve soil, improve rangeland conditions, and boost buffel grass soil moisture retention. Furrowing is therefore a practical option in integrated rangeland management strategies for enhancing forage productivity during dry seasons. Increased soil moisture storage and pasture productivity are results of furrowing techniques (Branson *et al.,* 1966). Oversowing increases the carrying capacity of rangeland by decreasing bare areas of ground and increasing the pasture yield output per areas and improves growth performance (Lissu, 2016). Also, according to Mwebaze (2002), oversowing is a technique for increasing the productivity of deteriorated grazing pasture with bare patches of soil. This method requires minimal land preparation, minimal management, less seed and labor. Likewise, forage yield is improved, soil erosion is controlled, soil fertility is improved, forage quality and productivity of natural pasture are increased, making it the simplest and most cost-effective method of enhancing natural pasture. However, there is linkage between soil fertility and oversown pasture. Low soil nutrients and soil moisture hinder the pasture establishment. This is in agreement with study by Kusekwa *et al.* (1998) in Tanga, Northern, Tanzania reported that the oversowing increase the carrying capacity of rangeland through reduction of soil bare patches and increase dry matter yield.

The current study revealed that on the second week, the control (natural grass) had high number of tillers and mean height, this may be attributed to the fact that the improved grass may require some time to adjust to their new environment and establish their roots systems (Martinelli *et al.,* 2015). But also, improved grass might prioritize root growth over top growth, resulted to slow growth compared to control, which was already adapted to the local environment. On the issue of nutrients, the control (native grass) seems to be well adapted to the nutrient's levels present in their environment. In contrast, *C. ciliaris* requires some time to acclimate to the nutrient levels in the demarcated experimental area. Additionally, the native forage species were more competitive for resources such as water, sunlight and nutrients and may have evolved better mechanisms to cope with environmental stress giving advantage during this time while improved seed took some time to develop their competitive ability in the new environment. These findings resemble the report by Mdegela *et al.,* (2022) from Lubungo, Mvomero- Morogoro.

The findings of this study demonstrate that oversowing and manure treatment have a significant impact on buffel grass growth performance and dry matter production. Oversowing practices control the soil erosion and improves rangeland health. In the other hands, there are strong interactions between oversowing and manure application on boosting growth performance and biomass production of forage species because manure increases soil nutrients, which improve soil fertility needed for pasture to thrive. This is comparable to the study by Dowling *et al.* (1997) from New South Wales, Australia, which found that the interaction of manure and oversowing has been proven to boost germination and early seedling vigor.

The current study showed that there is close interaction between the number of tillers, height of plants and biomass production when combined furrowing and oversowing towards improving pasture productivity (Mustaring *et al.,* 2014; Yang *et al.,* 2019). According to the study's findings by Qin *et al.* (2019) from Loess Plateau, North China Plain, stated that oversowing and furrowing have a significant impact on buffel grass ability to grow and produce dry matter, whereby furrowing increasing soil moisture conservation and rangeland improvement. Moreover, other research by Muraina *et al.* (2017) from Oja-Odan, Nigeria reported that there are strong interactions between oversowing and furrowing towards improving growth performance and biomass yield of improved pasture seeds.

Tillering is a potential attribute of forage plants due to its influence on dry matter yield and production of leaf areas (Lafarge, 2002; Benjaminsen *et al.,* 2009). the higher number of tillers imply that the higher DM yield per unit area. The present study reported that the integrated rangeland practices was achieved in the plot with combination of manure application, furrowing, and oversowing. As a result, this combination has an impact on both growth performance and high dry matter production per hectare. Whereby, oversowing reduces the amount of bare soil, increases soil moisture through furrowing, and increases the amount of nutrients needed by pasture for growth that are supplied by manure. This is comparable to the work of Qin *et al.* (2019), which found that adding manure, preparing a furrow, and oversowing the soil improve soil moisture and photosynthetic uptake.

The current study noted that forage growth rates varied significantly ($p \leq 0.05$), almost all treatments in experimental plots. The study found low DM yield production ranging from 1.5 to 2.7t/ha DM in an experimental plot, this may probably due to low soil moisture and fertility of soil, slow growth of pasture, frequent bare soil spots and poor soil seed bank. In contrary, high DM yields were seen in experimental plots that had been furrowed, oversown, and treated with manure, may probably due to presence of desirable pasture species in the pastoral grazing area (Sangeda and Maleko, 2018). Additionally, the least were those which oversowing and furrowing was the option may probably due to presence of high bush encroachment and tree density. High bush encroachment prevented the direct light falling to the forage growth that affected the photosynthesis process. This observation is in agreement with the study by Sangeda and Maleko (2018) in Simanjiro district, Central Tanzania, reported that low pasture yield seen in high bush encroachment. Furthermore, buffel grass yields are highly dependent on soil fertility and growing conditions, the yield may range from 2 to 9 tDM/ha under ideal conditions, can reach up to 24 t/ha DM (Bogdan, 1977: Kimambo *et al.,* 2014). Cattle feed intake and performance are influenced by DM yield, which also supplies the nutrients in feeds needed by animals for maintenance, development, pregnancy, and lactation. Therefore, oversowing, furrowing and manure application have all had an impact on high dry matter yield per hectare.

Conclusion

The results of this study showed the selected pastoral grazing rangeland had low level of soil nutrients, irregularity in weather patterns and climate change, resulted into scarcity of forages especially during dry seasons. Therefore, an urgent call needed to ensure more feeds available for livestock in such times, whereby forced to adopt of Integrated Range Management (IRM) practices. The fast pasture growth was observed in plots applied with three treatments of manure application, oversowing and furrowing and the least performance was observed in plots applied with oversowing and Control were an option. The study recommends an integrated range Management (IRM) practices with three combinations of treatments (manure application, oversowing and furrowing) to improve growth performance and dry matter yield of forage species during dry seasons. Thus, we recommend that further research should be conducted to find out indigenous grasses can be a perfect to improve forage productivity in semi-arid particularly during dry seasons.

Acknowledgements

We acknowledge the financial support from Sustainable Agriculture Tanzania (SAT), through which the completion of this study was possible. The organization supported the 6th workshop for participatory research design (WPRD) from which the research problem and study objectives arose. We appreciate the willingness of Maasai pastoralists and their specific contribution for experimental plots.

Conflict of Interest

We declare that no conflict of interest exists for this article

References

Benjaminsen, T.A., Maganga, F. and Abdallah, J. (2009). The Kilosa Killings: Political Ecology of a Farmer–Herder Conflict in Tanzania. Development & Change, 40:3, p. 423-445.

Bayu, W., Rethman, N.F.G. and Hammes, P.S. (2005). The role of animal manure in sustainable soil fertility management in sub-Saharan Africa: a review. *Journal of Sustainable Agriculture* 25(2): 113-136

Branson, F.A., Miller, R.F. and McQueen, I.S. (1966). Contour furrowing, pitting, and ripping on rangelands of the western United States. *Journal of range management,* 19 (4): 182-190.

Bogdan, A.V. (1977). Tropical pasture and fodder plants. Longman Group Ltd: London, Uk. p.432-461

Dowling, P.M; Kemp, D.R., Michalk, D.L.; Klein, T.A; Priest, S; King, McG. M; Packer, I.J.; Holst, P.J. and Tarleton, J. A. (1997). Sustainable grazing systems for the Central Tablelands of New South Wales. 2. Effect of pasture type and grazing management on pasture productivity and composition. *Australian Journal of Experimental Agriculture,* 46, 457–469doi: 10.1071/RJ996030

FAO (2006). Food and Agriculture Indicators. Country: Madagascar. ESSGA [http://www.fao.org/ES/ess/compendium_2006/pdf/MAG_ESS_E.pdf] site visited on 01/01/2023

FAO. (2010). Status of and prospects for smallholder milk production – A Global Perspective, by Hemme, T. and Otte, J. Available at <http:// www.fao.org/docrep/012/i1522e/i1522e.pdf> Accessed 25th July 2022

Goyal S, Mishra M.M., Dhankar S.S., Kapoor K.K., Batra R. (1993) Microbial biomass turnover and enzyme activities following the application of farmyard manure to field soils with and without previous long-term applications. Biol Fertil Soils 15:60–64

Kavana, P.Y. and Msangi, B.S.J. (2005). On farm dairy cattle feeding experience in eastern zone of Tanzania. Livestock Research for Rural Development. Volume 17, Article #62. Retrieved August 13, 2022, from <http://www.lrrd.org/lrrd17/6/kava17062.htm>

Kimambo, A.E. Laswai, G.H., Wassena, F.J, Maass, B.L., Bwire, J.M.N., Mangesho, W.E. and Lukuyu, B. (2014). Past dairy feeding interventions and lessons learnt in Tanzania. Poster. Presented at 6th All African Conference on Animal Agriculture (AACAA), 27-30, Nairobi, Kenya

Kizima, J.B., Mtengeti, E.J., & Nchimbi-Msolla, S. (2013). Viability status of *Cenchrus ciliaris* seeds in the three farms of the sub-humid eastern agro-ecological zone of Tanzania. Livestock Research for Rural Development, 25(5).

Kusekwa, M.L., Bitende, S.N. and Ngowi, M.D. (1988). Productivity of oversown natural pastures in northern Tanzania. Green leaf 11142 (13965): 3629-5.

Lafarge, M. and Loiseau, P. (2002). Tiller density and stand structure of tall fescue swards differing in age and nitrogen level, *European Journal of Agronomy;* 17 (3) pp, 209-219.

Lelamo, l.l., Shenkut, B.T. and Abdilahi, A.H. (2022). Drought characteristics and pastoralists' response strategies in Korahey zone, Somali regional state, Eastern Ethiopia, Scientific African; 16, e01254,

Lissu, C.S. (2016). The influence of desmodium and manure on the agronomic performance of fodder plants in Lushoto District, Tanzania. Doctoral dissertation, Sokoine University of Agriculture. 120pp

Lukuyu, B.A., Ravichandran, T., Maass, B., Laswai, G., Bwire, J. and Duncan, A.J. (2015). Enhancing livestock productivity through feed and feeding interventions in India and Tanzania. ILRI Project Report. Nairobi, Kenya: ILRI. Retrieved December 12, 2022, from <https://cgspace.cgiar.org/handle/10568/68753>

Lukuyu, B., Franzel, S., Ongadi, P.M. and Duncan, A.J. (2011). Livestock feed resources: Current production and management practices in central and northern rift valley provinces of Kenya. Livestock Research for Rural Development. 23 (112). Retrieved October 9, 2022, from http://www.lrrd.org/lrrd23/5/luku23112.htm

Lutatenekwa, D.L., Mtengeti, E.J. and Msalya, G.M. (2021). Morphological Characterization of Selected Ecotypes of African Foxtail Grass (Cenchrus ciliaris) from Selected Areas of Tanzania. *Tanzania Journal of Agricultural Sciences,* 20(2), 268-277

Maleko, D., Ng, W. T., Msalya, G., Mwilawa, A., Pasape, L. and Mtei, K. (2018). Seasonal variation in the availability of fodder resources and practices of dairy cattle feeding among the smallholder farmers in western Usambara highlands, Tanzania. Tropical Animal health production 50, 1653-1664, doi:10.1007/s11250-018-1609-4.

Martinelli, F., Scalenghe, R., Davino, S., Panno, S., Scuderi, G., Ruisi, P., and Dandekar, A. M. (2015). Advanced methods of plant disease detection. A review. Agronomy for Sustainable Development, 35, 1-25.

Mdegela, T.E., Maleko, D.D., Msalya, G.M., and Mtengeti, E.J. (2022). Vegetation Composition, Forage Biomass and Soil Seed Bank of a Continuously Grazed Rangeland Site in Tropical Sub-Humid Environment, Tanzania.

Ministry of Agriculture Food security and Cooperatives (MAFSC) (2006). Soils of Tanzania and their potential for Agriculture Development. https://www.fao.org ›3›PDF.doc.visited 8/09/2020. Ministry of Livestock and Fisheries budget speech 2021-2022 https://www.mifugouvuvi.go.tz/PDF. Browsed in 12 Nov 2021] site visited on 04/05/2023.

Muraina, T.O., Olanite, J.A., Onifade, O.S., Ojo, V.O.A., Ewetola, I.A., Akinlolu, O.A., Mustapha, S.O., Oladepo, O., Emiola, C.B. and Akintunde, E. (2017). Influence of tillage and over-sowing methods on growth, population dynamics and biomass yield of two Stylosanthes species in natural pasture. *Journal of Animal Production Research,* 29 (2): 222-230

Mustaring I, Subagyo, Soebarinoto, Marsetyo (2014). Growth, yield and nutritive value of new introduced Brachiaria species and legume herbs as ruminant feed in Central Sulawesi, Indonesia. *Pakistan Journal of Agriculture Research.* 27:89-98

Mwebaze, S. (2002). Pasture improvement technologies based on an on-farm study in Uganda. Regional land management unit (RELMA). Department of Animal Production and Marketing, MAAIF, PO Box, 513.Working Paper No. 18.

Mtengeti, E.J., Phiri, E., Urio ,N,A., Mhando , D.G., Mvena, Z., Ryoba, R., Mdegela, R., Singh, B.R., Wetlesen, A., Lorken ,T. and Reksen, O. (2008). Forage availability and its quality in the dry seasons on small holder dairy farmer in Tanzania, Acta agriculturae scandinavica, section A- Animal science , 58:4, 196-204.

National Bureau of Statistics (2021). National Sample Census of Agriculture 2019/20 Key Findings Report, for Crops and Livestock Sectors and Fish Farming, Dar es saalam. Tanzani, nbs., pp.45. http://www.nbs.go.tz

› nbs› PDF).

Olsen, S.R. and Sommers L.E. (1982). Phosphorus In:Methods of soil analysis part 2 (Edited by Page A.L) Chemical and microbiological properties. pp403 – 429.

Sangeda A Z., Maleko D.D. and Mtengeti, E, J. (2013). Socio-economic and ecological dimensions of climate variability and change for agro-pastoral communities in central Tanzania. Livestock Research for Rural Development. Volume 25, Article #209. Retrieved January 16, 2023 http://www.lrrd.org/lrrd25/12/sang25209.htm.

Sangeda, A.Z. and Maleko, D.D. (2018). Rangeland condition and livestock carrying capacity under the traditional rotational grazing system in northern Tanzania. Livestock Research for Rural Development, 30 (5).

Sustainable Agriculture Tanzania, SAT (2018). Sustainable Agriculture of Tanzania 5th workshop for participatory research design (WPRD), 2018-2019

Yang, D., Cai, T., Luo, Y., Wang, Z. (2019). Optimizing plant density and nitrogen application to manipulate tiller growth and increase grain yield and nitrogen-use efficiency in winter wheat. PeerJ 7: e6484

Qin, A., Fang, Y., Ning, D., Liu, Z., Zhao, B., Xiao, J., Duan, A. and Yong, B. (2019). Incorporation of Manure into Ridge and Furrow Planting System Boosts Yields of Maize by Optimizing Soil Moisture and Improving Photosynthesis in North China Plain. Natl. Acad. Sci. Lett., 42, 1–6.

SAS, (2008). SAS User's Guide Statistics, SAS System for Windows Version 9.2. Cary North Carolina SAS Institute Inc.

United Republic of Tanzania, URT (2017). National adaptation programme of action (NAPA). Vice president’s office, division of environment. Government printers, Dar es Salaam. http://unfccc.int/resource/docs/napa/tza01.pdf. Accessed 16 September 2022.

United Republic of Tanzania, URT (2010). The Grazing lands and Animal Feed Resources Act No.3 of 2010. Government Printers. Dar-Es-Salaam. 32 pp.

United Republic of Tanzania, URT (2021). National Sample Census of Agriculture 2019/20 Key Findings Report, for Crops and Livestock Sectors and Fish Farming, Dar es saalam. Tanzani, nbs., pp.45. (http://www.nbs.go.tz › nbs› PDF).