Plants and Environment (2021) 3(4): 107-112
https://doi.org/10.22271/2582-3744.2021.dec.107

Research article

Forage growth, yield and nutritional characteristics of five African foxtail ecotypes grown at Magadu dairy farm in Morogoro, Tanzania

Dorice L. Lutatenekwa[1]*, Ephraim J. Mtengeti[1] and George M. Msalya[1,2]

[1]Department of Animal, Aquaculture and Range Sciences (DAARS), Sokoine University of Agriculture (SUA), PO Box 3004, Chuo Kikuu, Morogoro, Tanzania
[2]Tanzaia Dairy Board, PO Box 17029, Dodoma, Tanzania

*Corresponding Author: dorice.luta@sua.ac.tz

Abstract: This study was conducted to assess the forage growth, yield and nutritional characteristics of five ecotypes of African foxtail (*Cenchrus ciliaris*) grown under the similar environmental condition at Magadu Dairy Farm (MDF), a facility of Sokoine University of Agriculture (SUA) in Morogoro, Tanzania. The ecotypes used in the study were collected from semi-arid areas of three districts namely Kiteto (*Ologoraing'ok namelock* and *Ologoraing'ok twanga* ecotypes), Mpwapwa *(Nzingangata* and *Orupilipili* ecotypes*)*, and Kilolo *(Iramata mtandika ecotype)*. Each ecotype was planted in a 12 m^2 plot with plants interspacing of 0.5 m, 1.5 m space between plots and three replications. Then 30 tussocks were randomly sampled per ecotype and their plant height, tiller number, inflorescence length, leaf length and leaf mid-width were recorded. The dry matter yield and Nutritional characteristics were analysed from the harvested above-ground biomass in two quadrats of one square metre per plot at the age of six weeks from standardization cut. The results indicated significant variation (p-value<0.05) among ecotypes on the studied characteristics. *Orupilipili* ecotype indicated higher mean values of plant height (93.8 cm), leaf area (25.8 cm^2), inflorescence length (10.1 cm) and dry mater (10.35 $tDMha^{-1}$). *Ologoraing'ok namelock* had the lowest growth and yield characteristics except mean tiller numbers (197.3). The lowest-yielding ecotype indicated the highest percentage of Crude Protein (21.15), Acid Detergent Fibre (31.35) and ash content (16.91) but with the lowest Neutral Detergent fibre (55.89). Correlations were significant for all pairs of traits assessed. Discriminant tests suggested close relationship between *Ologoraing'ok namelock* and *Ologoraing'ok twanga*, *Nzingangata* and *Iramata mtandika* but each ecotype indicated a significant number (>46%) of unique individuals. This study recommends further study on the ecotypes when subjected to stresses such as defoliation, salinity and drought.

Keywords: Characterization, *Cenchrus ciliaris*, Dry matter, Morphological variation, Productivity.

INTRODUCTION

African foxtail (*Cenchrus ciliaris* L.) is a widely distributed tropical grass. Morphologically the grass is short to tall (20-200 cm), erect to sprawling, tussock forming, short rhizomatous with deep, course, fibrous root system of up to >2 m (Jackson, 2005; Lutatenekwa *et al.*, 2021). The seed heads are erect to nodding, straw, grey or purple coloured like foxtail (hence the name African foxtail), 2-15 cm long and 1.0-2.5 cm wide, with seed units (fascicles) carried along a zig-zag axis (Cook & Clem, 2000). Furthermore, African foxtail is distributed well in different ecological zones from semi-arid to sub-humid areas (Marshall, 2012). It is adapted to a wide range of elevations from sea level to 2000 metres above sea level (masl). The grass can be found on different soil types but perform best on a well-drained fertile and lighter-textured soils (Cook & Clem, 2000). African foxtail is one of the most important pasture species which responds more rapidly to rain than other species (Jackson, 2005; Brunao *et al.*, 2017). The ability of this grass to adapt to a range of environmental conditions triggers the formation of several ecotypes (Kannan & Priyal, 2015; Kirwa *et al.*, 2018). Ecotypes are groups of populations which are distinguished by multifaceted differences in many traits as a result of adaptation to the environmental variables that diverge in different geographical locations (Lowry, 2012).

Tanzania has about seven (7) agro-ecological zones which support a number of ecotypes of African foxtail, however, there is limited information about these ecotypes. Lutatenekwa *et al.* (manuscript submitted for publication) characterized six ecotypes based on their morphological characteristics, in natural areas of three Agro-ecological zones of Tanzania. These ecotypes were never characterized before, their naming based on local names. From each ecological zone, one district was selected and in each district two ecotypes were assessed. The districts were Kiteto, Mpwapwa and Kilolo. Ecotypes from Kiteto were *Ologoraing'ok namelock* and *Ologoraing'ok twanga,* from Mpwapwa were *Nzingangata* and *Orupilipili* and from Kilolo were *Iramata malolo* and *Iramata Mtandika* (Lutatenekwa *et al.*, 2021. Their study (Lutatenekwa *et al.*, 2021) indicated high variability in terms of plant height, tiller numbers, leaf and flower size when they were assessed in their natural areas. Conversely, there is limited information on growth characteristics,

Submitted: 17 September 2021 Accepted: 28 November 2021 Published Online: 31 December 2021

forage yield and nutritional characteristics among these ecotypes when grown under similar environmental conditions. This study was designed to assess if there would be any variability among the ecotypes of African foxtail which were collected from three districts of Tanzania (Kilolo, Mpwapwa and Kiteto). In the current study, five ecotypes of African foxtail were grown under common stress-free environmental conditions with common management practices. In particular, the study paid attention to growth, forage yield and nutritional characteristics. Information gathered becomes an important tool which can be used to support the selection and breeding of desirable traits.

MATERIALS AND METHODS

Description of the study area

The experiment was set in an unshaded area at Magadu Dairy Farm (MDF), a property of Sokoine University of Agriculture (SUA) found in Morogoro, Tanzania. The area is found at 6^o 50' 59" S and 37^o 39' 10" E (GPS coordinates), 537 metres above sea level (masl), on sandy clay, reddish-moderately acidic soil. The area is characterized by a bimodal rainfall pattern of short and long rains. Short rains start from November to December and long rains starts in March to May and sometimes extends to June. The average annual rainfall ranges from 600 up to 900 mm with mean annual temperature of 25^oC to 30^oC

Experimental design and treatments

The experiment was set in a completely randomised design (CRD) with three replications of five ecotypes. The five ecotypes were *Ologoraing'ok namelock (On), Ologoraing'ok twanga (Ot)*, *Nzingangata (Nz), Orupilipili (Op)* and *Iramata mtandika (Im*).

Source of experimental materials

African foxtail ecotypes used in this study were collected from three districts of Tanzania namely Kiteto (northern Tanzania, Manyara region), Mpwapwa (central Tanzania, Dodoma region), and Kilolo (southern highlands, Iringa region). Initially, the study planned and collected two (2) ecotypes from each district. Ecotypes from Kiteto were *On and Ot*, from Mpwapwa were *Nz* and *Op* and ecotypes from Kilolo were Iramata malolo (*Ir)* and *Im*. In this experiment the Ir ecotype which was collected from the slopes of Lukosi river was left out. This ecotype failed to give enough experimental materials in the multiplication plots thus the experiment remained with five ecotypes. Collection of the ecotypes considered variation of collection sites in terms of topographic and climatic conditions, soil types and anthropogenic factors (Lutatenekwa at el., manuscript submitted for publication)

Land preparation and establishment of grasses

Before planting of African foxtail ecotypes sprigs, the land was cleared and tilled to ensure even the seedbed ready for plots setting. Fifteen plots each measuring 3 m × 4 m (plot area of 12 m^2) were established and 35 sprigs per plot were planted with interspacing of 0.5 m to allow manual weeding. The distance between plots were 1.5 m to evade inter-ecotypic competition.

Diammonium Phosphate (DAP) was applied at the rate of 145 kg ha^{-1} during planting. Need-based irrigation was applied to ensure growth and establishment. Standardization cut was done after two months from planting at the height of 8 cm above the ground level. A top-dressing fertilizer N-P-K (15-9-20 %) was applied at the rate of 145 kg ha^{-1} after standardization cut. The application of fertilizer and irrigation was to make sure a stress-free environment is provided for the ecotypes to perform to their best.

Data collection

Parameters measured were plant height (PH), tiller number per tussock (TNT), inflorescence length (IL), leaf length (LL) and leaf mid-width (LW) and above ground fresh weight (FW).

Sampling frame and procedure used

Growth characteristics were recorded on mature plants at the age of 6 weeks from standardization cut for all ecotypes. Measurements were done on 10 randomly selected tussocks per plot, from the middle of the plot to avoid edge effects. Every single data entry for LL, LW and IL recorded was an average of three individual measurements per tussock. PH was measured from the ground surface to the tip of inflorescence and TNT were counted per tussock. LL was measured from ligule to the leaf apex, both LL and LW were measured from the leaf just below the flag leaf (penultimate leaf). PH, LL and LW were measured by using a tape measure. Leaf area (LA) was obtained by the formula below:

$$LA = LL \times LW \quad (1)$$

FW was obtained by harvesting and weighing above-ground biomass at 8 cm height from ground level in two quadrats of 1 m^2 per plot. Weighed samples from the five ecotypes were packed in bags for laboratory analysis.

Laboratory Sample analysis

Packed samples of harvested African foxtail ecotypes were taken to the laboratory, oven-dried at 70°C for 72 hours, dry weights were recorded for further calculations of DM and $tDMha^{-1}$ per ecotype. DM and $tDMha^{-1}$ were calculated as follows:

$$DM\ \% = (Wt3 - Wt1/Wt2 - Wt1) \times 100 \quad (2)$$

Where by: Wt1 = Weight of a container, Wt2 = Weight of a container and fresh sample, Wt3 = Weight of a container and dry sample (USDA NIFA, 2019)

$$(tDMha^{-1}) = [FW/\ \text{harvested area}\ (m^2)] \times DM \times 10 \quad (3)$$

To perform proximate analysis, the dry samples were milled to pass through 2 mm sieve. The content of Crude Protein (CP), Acid Detergent Fibre (ADF) and Neutral Detergent fibre (NDF) were calculated on the basis of chemical analyses. CP was analysed by Kjeldah method using AN_300; Tecator Kjeltec System procedure for block digestion and steam distillation. ADF and NDF were analysed by using Ankom technology. Ash contents was obtained by igniting the Crucibles containing the dried samples in the Muffle furnace at 550°C for three hours.

Statistical analysis

Data conception was done in excel followed by One-way analysis of variance (ANOVA) which was performed using General Linear Model (GLM) procedure of Statistical Analysis System (SAS) 2014, Duncan's Multiple Range test and Least square Means were used to separate the means

$$\text{The statistical model was: } Yij = \mu + Ei + \mathcal{E}ij \quad (4)$$

Where: Yij = Trait response, μ = General mean, Ei = ecotype effect, Ɛij = Experimental error

Correlations between traits were computed using CORR procedure of SAS to determine the interrelatedness and the strength of the relationship between assessed traits.

Discriminant analysis was performed using DISCRIM procedure of SAS to assess the variation between ecotypes. This analysis procedure calculate Mahalanobis squared distance (MSD) and the percentage of individual observations assigned to their respective ecotypes (Assignment test).

RESULTS

Variation in growth characteristics of the five ecotypes of African foxtail

It was observed that all five ecotypes started sprouting on the 3rd day after the standardization cut. There were variations in number of days to first flowering, for instance, *Im* and *Nz* started flowering in the 2nd week and reached 50% flowering in the 5th week. Conversely, *Op, On* and *Ot* started flowering in the third week and reached 50 % flowering in the 6th week.

Generally, there was considerable variability among the ecotypes with regard to all growth traits assessed as presented in table 1. It was observed that *Op* ecotype outperformed all other ecotypes with the highest mean PH, mean LA and mean IL but had the lowest TNT. The second well-performing ecotype was *Nz* followed by *Im* then *Ot*. Then again, *On* ecotype had the lowest PH and LA but presented the highest TNT compared to other ecotypes.

Table 1. Least square means of growth characteristics (n per ecotype = 30 individuals).

Ecotypes	PH	TNT	LA	IL
On	82.4^{c}	197.3^{a}	3.4^{c}	2.8^{c}
Ot	83.1^{bc}	187.0^{a}	3.7^{c}	2.8^{c}
Op	93.8^{a}	80.8^{c}	25.8^{a}	10.1^{a}
Nz	89.3^{ab}	110.1^{b}	13.8^{b}	9.9^{ab}
Im	87.7^{abc}	104.0^{b}	12.6^{b}	9.7^{b}
SEM	2.191	7.693	0.873	0.146
P-value	0.0016	< .0001	< .0001	< .0001

Note: PH = Plant height, TNT = tiller number per tussock, LA = leaf area, IL = Inflorescence length. Variable means followed by same letters along the column are not statistically significant ($p > 0.05$). SEM= standard error of the mean

Forage yield and nutritional characteristics of the five African foxtail ecotypes

The results showed a significant variability ($p < 0.05$) among the ecotypes on their DM, $tDMha^{-1}$ and nutritional characteristics which included ADF, NDF, CP and Ash (Table 2). *Op* was the highest yielder and the lowest yielder was *On* followed by *Ot* while *Nz* and *Im* had comparable forage yield results. Although On had the lowest yield, the ecotype presented highest values of ADF, CP and Ash.

Correlations among growth traits and biomass yield

The correlation growth traits and yield were assessed and results are presented in table 3. Generally, all pairs of traits assessed indicated significant positive and negative correlation coefficients. TNT had an inverse relationship (strong negative correlation coefficients) with all other traits. The highest correlation coefficient was indicated between PH and LA.

Table 2. Least square means for DM, tDMha^{-1} ADF, NDF, CP and Ash.

Ecotype	DM%	tDM ha^{-1}	ADF %	NDF %	CP %	Ash
On	18.34^{b}	5.94^{c}	31.35^{a}	55.89^{bc}	21.15^{a}	16.91^{a}
Ot	18.80^{b}	6.92^{bc}	31.15^{a}	56.53^{b}	21.10^{a}	16.01^{ab}
Op	26.32^{a}	10.35^{a}	29.94^{ab}	59.79^{a}	19.07^{b}	15.39^{b}
Nz	21.11^{ab}	8.24 ^{ab}	29.11^{b}	57.82^{b}	18.46^{bc}	15.39^{b}
Im	21.72^{ab}	8.60 ^{ab}	28.66^{b}	57.48^{b}	17.20^{d}	13.86^{c}
SEM	1.435	0.799	0.564	0.839	0.322	0.390
P-value	0.005	0.008	0.0244	0.0015	<.0001	0.0036

Note: Variable means followed by same letters along the column are not statistically significant ($p > 0.05$). SEM= standard error of the mean, tDMha^{-1} = tons of dry matter per hectare

Table 3. Correlation coefficients (r) showing relationships between pairs of studied parameters.

	PH (cm)	TNT	LA (cm^2)	IL (cm)	DM%	tDM ha^{-1}
PH (cm)	1.000					
TNT	-0.949	1.000				
LA (cm^2)	0.990	-0.920	1.000			
IL (cm)	0.894	-0.981	0.845	1.000		
DM%	0.962	-0.888	0.989	0.790	1.000	
tDM ha^{-1}	0.969	-0.948	0.969	0.869	0.971	1.000

Relationships between ecotypes

Comparison of ecotypes by using MSD

Growth characteristics of the ecotypes were compared by using the MSD technique of the discriminant procedure and the results are presented in table 4. *On* paired with *Ot* had MSD less than one but showed large MSD when the two were paired with the rest of the ecotypes. Again, a pair of *Im* with *Nz* showed MSD of less than one.

Table 4. MSD between pairs of African foxtail ecotypes.

From Treatment	*On*	*Ot*	*Op*	*Nz*	*Im*
On	0.00				
Ot	0.08	0.00			
Op	120.69	117.46	0.00		
Nz	110.96	107.75	9.85	0.00	
Im	107.95	104.74	7.72	0.17	0.00

Comparison of the ecotypes by using Assignment test results

Altogether, 60 percent of 150 assessed individuals were correctly assigned to their ecotypes while 40 percent were shared into closely related ecotypes. The highest percentage of individuals correctly assigned belonged to *Op* followed by *On*, then *Nz* and *Ot, Im* had the lowest number of individuals unique to its ecotype, majority of its individuals (43.33) shared with *Nz* ecotype. The results of an assignment test with number of individuals and their percentages for each group are presented in table 5.

Table 5. The number of individuals and percentages (in brackets) as fitted by assignment test into their corresponding groups.

From Treatment	Correctly assign	Misassigned to other Ecotypes				
		On	*Ot*	*Op*	*Nz*	*Im*
On	19 (63.33)	-	11 (37.67)	0	0	0
Ot	16 (53.33)	14(46.67)	-	0	0	0
Op	23 (76.67)	0	0	-	2 (6.67)	5(16.67)
Nz	18 (60)	0	0	0	-	12 (40)
Im	14 (46.67)	0	0	3 (10)	13 (43.33)	-
Total	90 (60)	14 (9.3)	11 (7.3)	3 (2)	15 (10)	17 (11.3)

DISCUSSION

The variation of PH, TNT, LA, and IL observed among the ecotypes when grown under similar environmental conditions, imply that there was no reduction of variability compared to the original ecotypes when they were assessed in their natural areas (Lutatenekwa *et al*., 2021). Other studies have reported a wide range of variation within this species (Bruno *et al*., 2017; Jorge *et al*., 2008). Higher-growing ecotypes were on expense of TNT while short ecotypes had the highest numbers of small tillers. These results are in line with Sibrissia *et al*. (2010) who reported that tiller population density is affected by sward height.

Grasses are the main source of animal feeds cheaply obtainable for livestock production. To attain and maintain desirable animal productivity, higher quantity and quality of the grass matters. With regard to quantity, this study observed that taller ecotypes produced the highest DM and $tDMha^{-1}$ while shorter ecotypes produced the lowest DM and $tDMha^{-1}$. Similar results were reported by Meena and Nagar (2019) that low plant height resulted to low fodder yield. The findings are contrary to Doyo *et al*. (2018) who reported high dry matter yield (2.8 ton ha^{-1}) from short-height African foxtail genotypes and low dry matter yield (1.33 ton ha^{-1}) from medium-height genotypes. PH as a result of stem elongation in addition to LA, enhances light penetration to support photosynthesis resulting to higher productivity.

A specie producing higher quantity fodder is valued if its quality is satisfactory as well. Forage quality is mainly determined by CP, fibre (ADF and NDF) and ash content (Al-Dakheel *et al*., 2015). According to Arshadullah *et al*. (2011), the production of meat, milk and associated livestock products depend on feed quality by 75% while the rest (25%) is dependent of heredity factors. The lowest-yielding ecotype depicted the highest values of nutritional characteristics of ADF, CP and Ash content while indicating the lowest NDF contrary to higher-yielding ecotypes. Higher CP as an indication of high-quality forage is important for meat, milk and animal body maintenance (Al-Dakheel *et al*., 2015). NDF, a predictor of voluntary intake, echoes the bulkiness of a forage. Low NDF (<60%) is preferred since there is a limit of bulkiness the animal can accommodate in the rumen (Belyea *et al*., 1993; Van Saun, 2013). Furthermore, ADF values are inversely related to digestibility and higher values (>35%) in a feed suggest lower-quality feed (Belyea *et al*., 1993; Van Saun, 2013). The findings of this study are with an implication that low-yielding ecotypes are of good quality compared to higher-yielding ecotypes. Comparable results were reported by Al-Dakheel *et al*. (2015). Regardless of the variation in the nutritional characteristics observed among the ecotypes, all values for CP%, ADF%, and NDF% were in acceptable ranges. The five ecotypes studied therefore, can be considered forage of good quality (Arshadullah *et al.*, 2011; Van Saun, 2013).

Concerning correlations, it was important to know the relationships among various growth characteristics because they are the potential for ecotype selection and improvement. This study observed a significant negative correlation between TNT and all other studied traits. This observation can be explained by the concept that, short forage grasses compensate the height by adopting to high bulk of small tillers with narrow and short leaves (Sbrissia *et al.*, 2010; Meena & Nagar 2019). On the other hand, taller forage grasses adopt low bulk of bigger tillers with broader leaves as an approach to make the best use of canopy light access (Assuero & Tognetti, 2010; Sbrissia *et al.*, 2010). Op with the lowest TNT recorded the highest PH and LA. *On* which has the highest TNT recorded the lowest PH and LA.

From MSD and the assignment test it was indicated that *On* and *Ot* are closely related. MSD less than one is considered an indication that these ecotypes are closely related while higher values show that the ecotypes have no relation. On the other hand, individuals with similar traits are assigned into similar groups when the assignment test is used. Therefore, the closer the ecotypes are, the more individuals will be shared among them. Contrary to On and Ot, the ecotypes from Kiteto, the ecotypes from Mpwapwa district namely *Op* and *Nz* indicated a distinct differentiation (MSD =9.85) and the fact that there were no individuals shared between them. The differentiation between *Op* and *Nz* may have been influenced by elevation, temperature and soil type of their place of origin which varied significantly and the change have become permanent. Conversely, *Nz* and *Im* (from different districts) were surprisingly less differentiated despite the difference in environmental conditions of their place of origin.

On the other hand, higher MSDs which were shown when *Op* was paired with the rest the ecotypes imply that this ecotype is far more differentiated from all other ecotypes. The phenomenon of differentiation of *Op* was further supported by the highest percentage (76.67%) of individuals correctly assigned to its group.

CONCLUSION

This study concluded that morphological variations were expressed among ecotypes when subjected to similar environmental conditions. The morphological variation observed among these ecotypes allow for the initiation of breeding programs to improve important characteristics which positively affect dry matter yield. There are possibilities that the observed morphological variations could be phenotypic and less genetic. This study, therefore, recommends further studies on the genetic characterization of the ecotypes. The study also recommends characterization of the ecotypes when subjected to stresses to find out if the ecotypes have variability in their response to stresses such as defoliation, drought and salinity. The results will be useful to farmers and breeders in selecting the best-performing ecotype for a given environmental condition.

ACKNOWLEDGEMENTS

The work is the part of Ph.D. project registered at Sokoine University of Agriculture, Morogoro, Tanzania. Authors declare that they have no conflict of interest.

REFERENCES

Al-Dakheel A.J., Hussain M.I., & Rahman A.Q.M.A. (2015). Impact of irrigation water salinity on agronomical and quality attributes of Cenchrus ciliaris L. accessions. *Agricultural Water Management*, 159: 148-154.

Arshadullah M., Malik, M. A., Rasheed, M., Jilani, G., Zahoor, F., & Kaleem, S. (2011). Seasonal and genotypic variations influence the biomass and nutritional ingredients of Cenchrus ciliaris grass forage. *International Journal of Agriculture and Biology*, 13: 1.

Assuero S.G. & Tognetti J.A. (2010). Tillering regulation by endogenous and environmental factors and its agricultural management. *The Americas Journal of Plant Science and Biotechnology*, 4: 35-48.

Belyea R.L., Steevens B.J., Garner G.B., Whittier J.C., & Sewell H.B. (1993). Using NDF and ADF to balance diets (1993). Retrieved from: https://mospace.umsystem.edu/xmlui/handle/10355/3631.

Bruno L.R.G.P, Antonio R.P, Assis J.G.D.A, Moreira J.N & Lira I.C.S.A (2017). Buffel grass morphoagronomic characterization from cenchrus germplasm active bank. *Revista Caatinga*, 30: 487-495.

Cook B.G & Clem R.L (2000). Which grass for where? *Tropical Grasslands*, 34: 156-161.

Doyo J, Nagasa B, Tuffa S, Ejo A, Eba B. Elaya, G & Yabello E. (2018) Evaluation of Cenchrus ciliaris ecotypes for dry matter yield and yield related attributes in Borana rangelands, Southern Ethiopia. In: *Regional Review Workshop on Completed Research Activities*. 192 p.

Jackson J. (2005). Is there a relationship between herbaceous species richness and buffel grass (*Cenchrus ciliaris*)? *Austral Ecology*, 30: 505-517.

Jorge M.A.B, Van de Wouw M., Hanson J & Mohammed J. (2008). Characterisation of a collection of buffel grass (*Cenchrus ciliaris*). *Tropical Grasslands*, 42: 27.

Kannan D & Priyal S.B (2015). Morphological variability potential of *Cenchrus ciliaris* L. ecotypes on their phytochemical substances and antibacterial activities. In: *Conference paper, XXIII International Rangeland Congress*. At New Delhi, India.

Kirwa E.C, Ngugi E.K, Chemining'wa G.N & Mnene W.N. (2018). Participatory identification and selection of collections of Cenchrus ciliaris in the Southern Rangelands of Kenya. *Development*, 30: 11.

Lowry D.B. (2012). Ecotypes and the controversy over stages in the formation of new species. *Biological Journal of the Linnean Society*, 106(2): 241-257.

Lutatenekwa D.L., Mtengeti E.J. & 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: 269-278.