Morphological Characterization of Selected Ecotypes of African Foxtail Grass *(Cenchrus ciliaris)* from Selected Areas of Tanzania

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Abstract

This study was conducted to assess morphological variation of African foxtail grass (Cenchrus ciliaris) ecotypes in natural habitats from three selected districts namely; Kilolo, Mpwapwa and Kiteto in Tanzania. In each district two villages were selected and assessment of morphological traits was done at one site for each village. Three plots of 10 m diameter, 40 m apart were made in each site. Ten tussocks of African foxtail grass were randomly selected from each plot to assess height, tiller number, leaf number, leaf length and inflorescence length. Environmental characteristics like altitude, vegetation and soil types were also assessed because they affect morphological traits of African foxtail grass. The lowest altitude was in Kilolo (Malolo village) at 528 masl and the highest was at 1613 masl in Kiteto (Twanga village). The soil texture was primarily sandy clay, with pH ranging from moderate acidic of 5.6 to moderate alkaline of 8.3. The recorded average annual rainfall and temperature ranged from 643 – 1157 mm and 19.4 to 24oC respectively in study areas. The vegetation was influenced by anthropogenic activities mainly grazing and farming. The study found a significant variation for all morphological traits assessed across the selected ecotypes. Ecotypes from Kilolo and Mpwapwa districts had relatively higher mean values for all traits assessed except tiller numbers while ecotypes from Kiteto district had low mean values for all traits except tiller numbers. The study concludes that African foxtail grass is morphologically variant among and within ecotypes. Further assessment of these ecotypes when grown under similar environmental conditions is recommended to reaffirm the morphological variation.

Keywords: Ecotype variation, Environmental condition, Habitat, morphological traits.

Introduction

Tanzania depends mainly on natural pastures in communal rangelands to feed ruminant species such as cattle, sheep and goats. On the other hand, low pasture biomass production and fodder scarcity are major challenges affecting livestock production (Maleko *et al.* 2019). In addition, negative effects of climatic variability including unpredicted floods, prolonged drought periods as well as salt accumulation in the soils in arid and semi-arid lands are threats to productive rangelands (Scott 2014). To disentangle these challenges, it has been recommended to select and breed pasture species with high productivity and potential to withstand different stresses or at least have the capacity to adjust to certain ecological and environmental situations (Arshad *et al.* 2007). Successful selection, breeding, commercialization and easy adoption of species by farmers depend on available information about desirable traits generated through species characterization (Govindaraj *et al.* 2015; Lutatenekwa *et al.* 2020). Plant Characterization is one of priority areas expected to contribute in ensuring adaptive and productive traits are identified and appropriately utilised to enhance plant productivity (Lutatenekwa *et al.* 2020). Nevertheless, characterization of forage species has so far been a neglected area of study in Tanzania. Before the study at hand there was limited information on the extent of morphological variation among and within African foxtail ecotypes in the country. Ecotypes are groups of populations which are distinguished by a complex variation in many traits as a result of adaptation to the environmental variables that differ in different geographical locations (Lowry 2012). This study therefore characterised the habitat and morphological traits of African foxtail ecotypes in the selected three districts of Tanzania.

Specifically, the study assessed the abundance of African foxtail grass in selected areas, the morphological traits of African foxtail grass and the characteristics of the habitats that support the species under study. Districts were selected based on differences in climatic and ecological conditions and geographical distances between them with expectations of population differentiation. Population differentiation led to trait diversity of a given species (Zhou *et al.* 2003). According to Jorge *et al.* (2008), among 68 accessions of African foxtail grass maintained in field gene bank and seed stores of the International Livestock Research Institute (ILRI) in Ethiopia, 33 accessions were collected from Africa and were never evaluated before. Furthermore, underutilization of forage species is a result of inadequate characterization and evaluation data (Shantharaja *et al.* 2015). On the other hand, the results of characterization are important to make desirable traits of species known, so that they can be promoted for production and utilisation among the livestock farmers in the country.

African foxtail grass is one among the widely established forage grasses in various parts of the tropics because of its desirable traits. The grass is deep rooted and tufted-rhizomatous characteristics which make the grass fairly adaptive to heavy grazing pressure and tolerant to drought conditions (Jackson, 2005; Burson *et al.* 2012). Furthermore, it grows well in a wide range of soil types and altitudes from sea level to 2000 m above sea level (masl) in different ecological zones from semi-arid to sub-humid climatic areas (Marshall *et al.* 2012). Adaptability of African foxtail grass to tropical climate including that of Tanzania has resulted into a wealth of natural ecotypes which are morphological diverse (Burson *et al.* 2012; Marshall *et al.* 2012). Ecotypic diversity is a potential characteristic for productivity and tolerance to environmental challenges. Therefore, African foxtail grass is a potential species to bring economic benefits to pastoral communities where pasture production is widely practised.

Materials and methods

Description of study areas

The study was conducted in three districts of Tanzania namely Kiteto, Mpwapwa and Kilolo which are located in three administrative regions of the country, Manyara (northern Tanzania), Dodoma (central Tanzania), and Iringa (Southern highlands) respectively. The three districts were purposely selected based on prior information with respect to the availability of African foxtail grass and easy accessibility. Moreover, the districts show variation in ecological, topographical, climatic conditions and anthropogenic activities which in different ways can contribute to the morphological diversity of the grasses. In each district two villages (smallest administrative units) were selected making a total of six study sites. In each site sampling of African foxtail grass for morphological traits assessment was carried out around grid points and altitude as shown in Table 1.

The climate of studied areas ranged from semi-arid to sub-humid with average annual rainfall ranging from 643–1157 mm and temperature range of 19.4 to 24°C. Studied areas had different land uses, including grazing and farming. Table 2 presents the average annual temperature, rainfall and land uses of each studied site.

Sampling procedure and data collection

A Cross–sectional study on Morphological characterization of African foxtail ecotypes involved assessment of this selected species from six sites in the study areas. In each site a

Table 1: Location and altitude of study sites

District	Village	Geo-Position		Altitude (masl)
Kiteto	Twanga	5° 24' 15" S	36° 30' 37" E	1608 - 1613
	Namelock	5° 24' 40 S	36° 29' 51" E	1555 - 1557
Mpwapwa	Ipera	7° 7' 58" S	36° 29' 28" E	1226 - 1248
	Mazae	6° 21' 21" S	36° 27' 20" E	982 – 984
Kilolo	Mtandika	7° 32' 46" S	36° 25' 30" E	585 – 588
	Malolo	7° 28' 11" S	36° 30' 39" E	528

Table 2: Climatic and land use (anthropogenic activities) of the study site

Parameter	Namelock	Twanga	Ipera	Mazae	Mtandika	Malolo
Average Annual Precipitation (mm)	643	643	758	644	1137	1157
Average Annual Temperature °C	19.4	19.4	20.1	23	23.9	24
Anthropogenic Activities	Grazing	Grazing	Farming	Farming	Fallowed land	Reserved pasture land

transect was made on which three plots of 10 m diameter 40 m apart were made. In every plot ten tussocks of the grass were randomly selected for morphological traits assessment. A total of 180 randomly selected tussocks of African foxtail grass from the six sites were assessed. Quantitative traits assessed included tussock height, tiller number, leaf number, penultimate leaf length and flower length. All height and length were measured in centimetres (cm) by using a tape measure. Tussock height was measured from the base of the tussock to the base of the inflorescence. Tillers and leaves of every selected tussock were counted and recorded in the data sheet immediately. Penultimate Leaf length was measured from the ligule to the tip of the leaf blade and the flower length was measured from its base to the tip. Each data of the leaf and flower length was recorded as an average of three measurements. All tussocks of African foxtail grass and associated plant species in each plot were counted in order to establish the African foxtail grass index of dominance (ID). ID is a measure of distribution of individuals among other species in the community. The value of ID ranges between 0 and 1, the greater the value of ID the lower is the species diversity in the community implying the higher dominance of the species under study and vice versa. This index was calculated using Simpson’s Index formula as described by Whittaker (1972).

$$ID = 1 - \left(\sum \frac{n(n-1)}{N(N-1)} \right) \quad (1)$$

Where:

ID is the Index of dominance

n is the number of individuals of African foxtail grass in the sample;

N is the total number of individuals (all species) in the sample and

∑ is the summation sign

Soil samples were collected using soil auger from each study site at a depth of 0–20 cm and 20-40 cm. Homogeneous soil sample of 500 g was made by mixing soils from randomly selected three points in each plot at respective depths. The samples were then packed in plastic bags, carried to the laboratory at the Soil and Geological Science Department of Sokoine University of Agriculture for analysis. Physical properties assessed include silt, sandy and clay ratio. Soil chemical properties assessed were, pH and Electrical conductivity (EC) which is a numerical expression of total salt concentration in an aqueous soil solution (Kashenge-Killenga *et al.,* 2016). EC and pH was measured using digital pH and EC metre in the supernatant suspension in water at the ratio of 1:2 and 1:2.5 respectively (Kashenge-Killenga *et al.,* 2016).

Data analysis

Data were summarised in excel and exported to Statistical Analysis System (SAS) for One-way Analysis of Variance (ANOVA), to find out if there were significant differences in mean values. The Duncan's Multiple Range test (DMRT) was used to measure specific differences between pairs of means. In order to determine the interrelatedness among the assessed traits, a correlation analysis was performed.

Statistical model used was a general linear model:

$Y = \mu + E_i + \varepsilon_{ij}$ …………………….............. (2)

Where: Y = Trait response, μ = General mean, E_i = ecotype effect, ε_{ij} = Experimental error.

Results and discussion

Six ecotypes of African foxtail grass were assessed in selected study sites of the three districts. Since the ecotypes have not been studied before, their names were derived from local names as used by the people of that area. In case of similar local names, a village name was added at the end of the local name. Ecotypes from Kiteto district were Ologoraing'ok namelock (On) from Namelock village and Ologoraing'ok twanga (Ot) from Twanga village, In Mpwapwa district ecotypes were Nzingangata (Nz) from Ipera village and Orupilipili (Op) from Mazae village and in Kilolo districts ecotypes were Iramata malolo (Ir) from Malolo village and Iramata Mtandika (Im) from Mtandika village.

The first ecotype assessed was Ologoraing'ok (On) found in Namelock village in Kiteto District. The landscape of the studied area was a water logging valley with scattered yellow acacia trees (*Acacia xanthophloea*), few forbs and sedges. The index of dominance of On was 0.52, this was contrary to Friedel *et al.* (2006) who reported that the African foxtail grass does not tolerate water logging. On expressed high tiller population despite the establishment on greyish cracking clay soils of moderately alkaline pH and grazing pressure, as the site was close to the watering point (Table 4). The observation was contrary to Cox *et al.* (1988) who reported that African foxtail grass loses vigour and eventually die when established on cracking clay soil. The findings of this study collaborate with Marshall *et al.* (2012) that African foxtail grass adapt well to a wide range of soil types. The tussock height of this ecotype ranged from 38 to 59 cm with a number of leafless tillers due to grazing. The leaves of this ecotype were short grey green with maximum leaf length of 13 cm and minimum of 5 cm. The observation concurs with Sbrissia *et al.* (2010) that leaf length is determined by the severity of defoliation. The grass had relatively short inflorescences.

Ologoraing'ok' (Ot) is the second ecotype which was found in Twanga village, Kiteto district. The site where Ot was sighted is gentle sloping area along the hill, dominated by woodland with scattered short acacia trees and few forbs and shrubs, a reserved grazing land for young animals in dry season. Tussock height of Ot were relatively short ranging from 39 to 65 cm with relatively high number of aerial tillers. The leaves of this ecotype were glabrous, short grey green with maximum leaf length of 16 cm and minimum of 7 cm. The inflorescences were relatively short green with length ranging from 1 to 2.5 cm. The area had high diversity of grasses and forbs, the ID of 'Ologoraing'ok twanga' was found to be 0.33. Less dominancy of Ot was influenced by the landscape of the area as it has been pointed out earlier that African foxtail grass is less common in gentle sloping areas and other slopes (Van Devender and Dimmitt, 2006).

The third ecotype, Nzingangata (Nz) was found and assessed in the slopy- hilly landscape of Ipera village located in Mpwapwa district. The site is located close to Ipera primary school and the natives suspect that African foxtail grass was brought at this site by pupils who come from different areas as it was not seen in other places except around the school. Light and fluffy nature of the seeds increases its ability to spread and occupy new areas (Friedel *et al.,* 2006) Soil of this area was reddish brown sandy clay with moderately alkaline pH which supported the establishment of Nz ecotype. The place was surrounded by trees with scattered shrubs and forbs. The landscape and vegetation type of Ipera limited the abundance of Nz as it was found with ID of 0.27(Table 3). African foxtail grass grows in abundancy in open and plain areas (Marshall *et al.,* 2012). The height of Nz ranged from 59 to 92 cm with moderately robust tussock of mainly basal tillers which ranged from 32 to 97. The lower the index of dominance the lower the abundance of a species under study.

Orupilipili (Op) is the fourth ecotype discovered at Mazae village in Mpwapwa district. Op was traced in a plain area with altitude ranging from 982 to 984 masl. The place is used for crop production and has red sandy clay with pH ranging from neutral to moderately acidic at (Table 4). Closer to the sampled area was a big gully indicating massive soil erosion by water. Soil erosion may be a possible cause of acidic soil. As water passes through soils leaches basic nutrients like magnesium, phosphorus and calcium, these are replaced by acidic elements like aluminium, iron and boron (USDA-NRCS, 2014). Despite the soils being moderately acidic (5.58) African foxtail grass established well and dominated the place (ID = 0.64) than other species of grasses and forbs (Table 3). This is an indication that African foxtail grass grow well in a wide range of soil types with varying chemical composition. In addition, like any other C4 grasses African foxtail grass grow and dominate open plain areas as compared to sloping landscape and closed systems (Marshall, 2012). Two growing habits of the grass were observed at Mazae. The first was the erect and robust with maximum tussock height of 114 cm. The other was semi-erect or decumbent with maximum height of 36 cm. Both the erect-robust and decumbent grass had purple inflorescence.

Iramata (Im) ecotype was discovered at Mtandika villages in Kilolo district. The Im was sighted in open plain area with reddish-brown sandy clay loam soils which were moderately alkaline. Im ecotype is robust green grass with plant height ranging from 51 to 98 cm, dominated by basal tillers with few branching. The ecotype had purple closed inflorescence. Im fairly dominated other species (ID = 0.52) as it was supported by an open and plain landscape (Marshall *et al.,* 2012; Van Devender and Dimmitt, 2006.) Learning from the local community member the place was fallowed for one year, previously used for horticultural crops cultivation. The condition minimises anthropogenic disturbances on African foxtail grass establishment.

Iramata Malolo (Ir) is the sixth ecotype sighted and assessed at Malolo village in Kilolo district. Ir was found in few clumps (ID = 0.16) under shade of trees and thorny shrubs at a slope area near the Lukosi River. The soils of this area were moderately alkaline blackish brown sandy clay loam. Despite the common phenomenon that low lands have high EC due to accumulation of salts (USDA-NRCS, 2014), low EC was recorded. The low amount of EC recorded perhaps is due to high average annual rainfall of 1157 mm received in the area per year. There were no signs of the place being grazed perhaps due to sloping landscape of the area and closed shrubs and trees. The ecotype recorded highest tussock height. The cause of stem elongation in addition to absence of grazing is to place leaves in upper strata so as to increasing the range of leaf area index traversed for the light interception. According to Da Silveira Pontes *et al.* (2015) this kind of elongation goes at the expense tillers. The observation by Da Silveira Pontes *et al.* (2015) concurs with what was observed in Malolo where the ecotype recorded low number of tillers with dispersed leaves.

Landforms, vegetation and dominance of African foxtail grass in studied area

The studied areas had a range of vegetation types on a varying land form as presented in Table 3, which are among the environmental factors thought to influence adaptability and dominancy of African foxtail grass in the area. The findings suggest that African foxtail grass is less common in sloping areas and hardly dominate closed woodlands. This condition was observed on Ir ecotype in the slopes of Malolo near Lukosi river area and Nz ecotype in the hills of Ipera. In the two villages trees and shrubs dominated the area thus, African foxtail grass was sighted in few clumps with ID of 0.16 for Ir and 0.27 for Nz Ot ecotype which was in the hills of Twanga also had lower index of dominancy

(ID = 33) next to Ir and Nz (See Table 3). The findings collaborate with Van Devender and Dimmitt (2006) observation that African Foxtail less common in slopes and usually scatter in patches when found. Conversely, Im and Op which were found in open plain grassland areas flourished well and dominated other species. The observation agrees with Marshall *et al.* (2012) that like any other C4 grasses, African foxtail grass flourish in open areas with ample light.

Table 3: Landforms, vegetation and level of dominance of African foxtail ecotypes

District	Village	Ecotype	Landform	Vegetation	ID
Kiteto	Namelock	On	Valley	woodland	0.52
	Twanga	Ot	Hill	woodland	0.33
Mpwapwa	Mazae	Op	Plain	grassland	0.64
	Ipera	Nz	Hill	woodland	0.27
Kilolo	Malolo	Ir	Slope	closed woodland	0.16
	Mtandika	Im	Plain	grassland	0.52

Soil characteristics of studied sites

Soil is an important component of the habitat which directly dictate what kind of vegetation will successfully establish. According to Mangosongo *et al.* (2019), soil physical and chemical properties are among the environmental factors that influence plant growth. The ability of a plant to access water and other nutrients depend on the soil texture (physical characteristics). The findings presented in Table 4 show that the soil texture of the studied sites was primarily sandy clay and African foxtail grass adapted well in these soils. The soil pH (chemical characteristic) in these areas were ranging from moderate acidic of 5.6 to moderate alkaline of 8.3. The optimum soil pH for most of plants ranges between 5.5 to 7.5 but African foxtail grass among other grasses have adapted to thrive beyond the optimum range. Principally soil pH affects availability of nutrients to plants by controlling their chemical forms and influencing their chemical reactions (Kabata-Pendias 2004).

Table 4 also shows the other soil chemical characteristic considered in this study was soil electrical conductivity (EC) or soil salinity. It is a measure of the amount of salt in the soil and is likely to contribute to morphological variation of the ecotypes. EC affects plant nutrient

Table 4: Selected soil characteristics of the studied areas (USDA-NRCS system)

District	Village	Depth (cm)	Texture	pH	pH Class	EC (dS/m)
Kiteto	Namelock	0 – 40	Clay	8.07-8.34	Moderately alkaline	3.15-4.79
	Twanga	0 - 40	Sandy clay	6.62-7.07	Slightly acid to neutral	1.42-1.56
Mpwapwa	Ipera	0 – 40	Sandy clay	8.12-8.31	Moderately alkaline	2.31-2.49
	Mazae	0 - 40	Sandy clay loam	5.58-6.74	Moderately acid to Neutral	0.83-1.31
Kilolo	Mtandika	0 - 40	Sandy clay loam	8.17-8.26	Moderately alkaline	2.34-2.41
	Malolo	0 – 40	Sandy clay loam	8.06-8.30	Moderately alkaline	1.53-2.52

pH classification as per United States Department of Agriculture Natural Resources Conservation services (USDA- NRCS 2014) classification system.

availability, activities of soil microorganisms and in turn affect plant growth characteristics (Physical and morphological). Excess salts (more than 4 dS/m of the saturation extract in the root zone) restrict plant growth by affecting soil-water balance (Shrivastava and Kumar 2015; Kashenge-Killenga *et al.* 2016). EC of the soils in the studied sites were in normal range with exception of Namelock which was saline with EC of 4.79 dS/m. Despite the higher EC in Namelock, On established well with higher number tussocks in the area (ID = 0.52) comprised of strong short tillers showing its ability to adapt to high salinity levels. These findings are in agreement with Castelli *et al.* (2010) that African foxtail grass is tolerant to salinity.

values for all traits assessed except tiller numbers while On and Ot ecotypes had low mean values for all traits except tiller numbers (Table 5). The observed variations were not by chance as high SD and F-values presented in Table 5 affirm. The high SD (standard deviation) and F-values suggest that the six assessed African foxtail ecotypes contained distinct outliers which imply more variation in nature within ecotypes (Jorge *et al.* 2008). According to Da Silveira Pontes *et al.* (2015) trait variation signifies a high level of plasticity which allow species to adapt to a wide range of environments. This phenomenon was also reported by Crispo (2008) that effects of phenotypic plasticity on interactions allows species differentiation; the contextual that African foxtail grass can still be explained.

Table 5: Morphological traits of African foxtail Ecotypes (LS Mean ± SD) n = 180

District	Ecotypes	Traits				
		Tussock height (cm)	Tiller number	Leaf number	Mean leaf length (cm)	Mean f. l* (cm)
Kiteto	On	$47.8^{c} \pm 7.1$	$93.8^{a} \pm 20.8$	$22^{e} \pm 8.4$	$9.6^{d} \pm 6.9$	$1.4^{d} \pm 0.5$
	Ot	$54.8^{c} \pm 5.1$	$67.2^{b} \pm 20.5$	$74.8^{d} \pm 17.6$	$11.8^{d} \pm 5.5$	$1.83^{d} \pm 0.7$
Mpwapwa	Op	$76.5^{b} \pm 12.9$	$66^{b} \pm 17.3$	$125^{a} \pm 15.5$	$45^{a} \pm 6.2$	$9.8^{ab} \pm 1.7$
	Nz	$75.1^{b} \pm 32.4$	$65.6^{b} \pm 20.8$	$86.5^{c} \pm 11.2$	$41.7^{b} \pm 3$	$10.1^{a} \pm 0.9$
Kilolo	Im	$84.8^{b} \pm 14.5$	$53^{c} \pm 13$	$107.1^{b} \pm 17.1$	$35.7^{c} \pm 5.2$	$9.3^{c} \pm 0.7$
	Ir	$132.8^{a} \pm 20.7$	$35.4^{d} \pm 15.8$	$78.1^{d} \pm 5.7$	$35.8^{c} \pm 8$	$9.4^{bc} \pm 1.2$
	SEM	3.56	3.30	2.58	0.86	0.18
	p- value	< .0001	< .0001	< .0001	< .0001	< .0001
	F-value	71.01	33.70	185.15	107.05	523.38

Note:(i) f. l = flower length (ii) different letters indicate that means along the columns differ significantly while those with similar letters have no significant difference*

Morphological traits of the studied African foxtail ecotypes

The findings reveal that morphological traits of the six ecotypes assessed had a significant variation (p-value<0.0001). Trait variations, for example, tussock heights ranged from 36 – 160 cm. The wide range variation of African foxtail tussock height was also observed by Marshall *et al.* (2012) who reported the height range of 20 to 150 cm. Other traits such as tiller numbers ranged from 11 – 122 cm, leaf numbers ranged from 13 – 153 cm, leaf length ranging from 12 – 56 cm and flower length from 1 –12 cm. Ir, Im, Nz and Op ecotypes had relatively high mean

In order to understand how the studied variables are linearly related to each other, a correlation analysis was performed and the correlation coefficients results are as presented in Table 6. Correlation coefficient greater than zero indicates a positive relationship while the value less than zero shows a negative relationship. From the results it was shown that tussock height for all ecotypes expressed a strong negative correlation (r = - 0.910) with tiller numbers (Table 6) The observation has an implication that the taller the grass grows the less tillers it will make. Ir ecotype which recorded the highest tussock height of all ecotypes had the lowest tiller numbers while On ecotype which recorded shortest height had higher tiller numbers of all.

Table 6: Correlations of morphological traits of African foxtail ecotypes from six study sites

Morphological traits	Tussock height (cm)	Tiller number	Leaf number	Leaf length (cm)	Flower length (cm)
Tussock height (cm)	1				
Tiller number	-0.910	1			
Leaf number	0.352	-0.558	1		
Leaf length (cm)	0.582	-0.575	0.807	1	
Flower length (cm)	0.677	-0.668	0.761	0.983	1

The findings of this study concur with Sbrissia *et al.* (2010) observations that tiller numbers were affected by sward height. In their study, the sward maintained at 10 cm had higher tiller density (1,044 tillers m^{-2}) while low tiller density (665 tillers m^{-2}) was recorded on those maintained at 40 cm. Furthermore, the study observed negative correlations of tiller numbers with all other traits studied. Expectedly, while other parts of the grass are reduced by grazing, stems are less grazed due to its hard culm which is tough for the animals to digest, a reason for high numbers of leafless tillers in frequently grazed areas. According to Sbrissia *et al.* (2001), the restoration of sward area after severe grazing or cutting occurs through recruitment of new tillers from the plant base as a compensation mechanism. However, the rate of tillering depends on soil nutrient availability and climatic conditions (Caminha *et al.* 2010).

Moreover, there was a considerable variation with leaf length., On ecotype recorded fewer and shortest while the longest leaves were of Op ecotype. Few and short leaves of On was an adaptation to grazing pressure because the study site was close to the watering point. Fewer leaves have an implication on canopy light interception which result into low herbage production.

The variation of morphological traits observed in this study is not surprising given the difference in growing conditions. Additionally, there were long geographical distances between the study sites which is likely to favour morphological variability. According to Zhou *et al.* (2003), differentiation between populations increase with the increase in geographical distances with implication that isolation by distance increase morphological differentiation.

Conclusion and Recommendations

The study ascertains the presence of six ecotypes of African foxtail grass in the study area. The findings on the abundance of species in the area lead to the conclusion that African foxtail grass colonization of the area is influenced by the physiognomy of the landscape. The study revealed that six ecotypes of African foxtail grass in studied areas exhibit a wide range of morphological variation among the ecotypes. It was observed that African foxtail grass can successfully adapt to different habitats in the rangelands of Tanzania therefore, a potential species for pasture and rangeland improvement. Morphological variation observed among the six ecotypes are likely to influence growth and productivity. This calls for a study on ecotypes performance in terms of growth characteristics and productivity when grown on similar environmental conditions. Another study of molecular characterization is recommended on these ecotypes to find out if observed morphological difference will be expressed genetically. Furthermore, this study recommends another study on characterization of the six ecotypes on growth and productivity when subjected to stresses like defoliation, drought and salinity. The results will aid farmers and breeder to select the best productive ecotype for a given environmental condition.

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