

**THE INFLUENCE OF DESMODIUM AND MANURE ON THE AGRONOMIC
PERFORMANCE OF FODDER PLANTS IN LUSHOTO DISTRICT, TANZANIA**

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
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ABSTRACT

Animal feed scarcity and mostly the availability of high quality forage, is one of the major limiting factors to dairy productivity improvement in Lushoto District. This is a result of soil fertility losses due to soil erosion, deforestation practices and to the decrease or the abandonment of mineral fertilizer use. The present study was conducted in Ubiri Village, Lushoto District to assess the influence of desmodium and farmyard manure on the agronomic performance of fodder plants species. Two treatments used in this study were; fertility improvement options (with four levels) and fodder plant species (with three levels), which were established using RCBD with three replications. The forage agronomic data collected included counting the number of tillers per bunch, measuring the height of tillers (m), leaf area indices and biomass yield (tha^{-1}) in each treatment in their respective replications. Weather data during crop development were also collected. The results during the third harvest (28 weeks) indicated that; desmodium significantly ($P < 0.05$) increased the biomass yield (tha^{-1}) of the local napier, hybrid napier and hybrid brachiaria grasses by 28.59%, 53.63% and 68.55%, respectively. Farmyard manure during the second harvest (22 weeks) significantly ($P < 0.05$) increased the biomass yield (tha^{-1}) of the local napier, hybrid napier and hybrid brachiaria grasses by 14.16%, 39.89% and 36.5%, respectively. At the age of 28 weeks (third harvest) the combined desmodium and farmyard manure significantly ($P < 0.05$) increased the biomass yield (tha^{-1}) of the local napier, hybrid napier and hybrid brachiaria grasses by 50%, 65.16% and 82.20%, respectively. Both desmodium and farmyard manure had positive influence on the agronomic performance of both napier and hybrid brachiaria grasses. Hence, for the smallholder livestock keepers of Lushoto District to benefit sustainably from growing forage crops in their farms, the integration of either or both desmodium and farmyard manure should be promoted.

DECLARATION

I Cyril Stephano Lissu, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

Cyril Stephano Lissu
(MSc. Candidate)

Date

The above declaration is confirmed by;

Prof. L.L.L.Lulandala
(Supervisor)

Date

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DEDICATION

This work is dedicated to my beloved father Mr. Stephano Madubi and to my beloved mother, Theresia Ntui, who sacrificed their time and the little resources they had on building the foundation of my education. May the almighty God bless them abundantly, Amen!

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LIST OF ACRONYMS, ABRVIATIONS AND SYMBOLS

ADF	Acid detergent fiber
ADL	Acid detergent lignin
ANOVA	Analysis of variance
B. Yield	Biomass yield
CIAT	International Centre for Tropical Agriculture
cv	Caltivar
d.f	Degrees of freedom
DM	Dry matter
DMY	Dry matter yield
FAO	Food and Agriculture Organization of the United Nations
FYM	Farm yard manure
ha	Hectare
ICRAF	International Centre for Research in Agroforestry
ILRI	International Livestock Research Institute
kg	Kilograms
m	Metre
m.s	Mean square
mgt	Management
N	Nitrogen
N ₂	Nitrogen gas
NDF	Neutral detergent fiber
NLUPC	National Land Use Planning Commission
No.	Number
P<0.05	Significant at level 5% of significance

P>0.05	Not significant at 5% of significance
RCBD	Randomized Complete Block Design
s.s	Sum of Squares
SECAP	Soil Erosion Control and Agroforestry Project
SUA	Sokoine University of Agriculture
t	Tones
T.Max	Maximum temperature
T.Mean	Mean Temperature
T.Min	Minimum Temperature
TALIRI	Tanzania Livestock Research Institution
Tiller H.	Tiller height
URT	United Republic of Tanzania
yr	Year
⁰ C	Centigrades degree

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Declining soil fertility and low macro-nutrient levels are fundamental obstructions to agricultural development in sub-Saharan Africa (Vanlauwe and Giller, 2006). Apart from the primary effects of declining per capita food production, poor soil fertility triggers other side effects on-farm such as lack of fodder for livestock production and high deforestation rates (Foley, 2011). Ajayi *et al.* (2007) added that, there is a troublesome challenge for stakeholders and policy makers, in finding the scientific and developmental innovations that can lead to sustainable livelihoods while minimizing declines in environmental services but essential to reducing the poverty and environmental stress that characterize much of the region.

Tanzania is one of the countries which are endowed with highest densities of livestock in sub-Saharan Africa and ranks the third after Sudan and Ethiopia (FAO, 2005). Tanzania has approximately 21.3 million cattle, 15.6 million goats and 7 million sheep; other livestock include 2 million pigs and 60 million poultry (URT, 2012).

According to More and Sollenburg (2004), the animal performance including milk production and growth rates depend on the quality of feeds especially the forages available to the animal. Unfortunately, small holder livestock keepers in sub-Saharan Africa, Tanzania inclusive, rely on the native pastures and crop residues which are poor in quality and provide inadequate nutrients to grazing livestock (Franzel and Wambugu, 2007). The supply of nutrients to animals can be improved by cultivation of promising tropical forage species. Some of such forages are Napier grass (*Pennisetum purpureum*), Brachiaria

(MulatoIIhybrid)(*B. ruziziensis* x *B. decumbens* x *B. brizantha*) and various legumes including Desmodium (*Desmodium intortum*) and lablab species (*Lablab purpureus*) (Cook *et al.*, 2005).

Desmodium belongs to the family Fabaceae or Leguminosae which is one of the plant families comprising the Carbon 3 plants (C3-plants) (Ben, 2013). C3 plants are geographically adapted in temperate regions (cold environment) (Moore *et al.*, 2003). On the other hand Brachiaria and Napier grasses belong to the family Poaceae which comprises the Carbon 4 plants (C4-plants) (Ben, 2013). C4 plants geographically adapt well in the tropical and semi tropical high light intensity, high temperature and dry conditions (Simpson, 2010).

According to Massomo and Rweyemamu (1989), the animal manure output in mainland Tanzania is about 14 million tons per year. Kimbi *et al.* (2001) added that, if it is assumed that average N content of animal manure is 0.7%, the total N from manure is 98000 tons which is about four times the amount of nitrogenous fertilizers used in the country in 1980. Efficient use of animal manure could, therefore, alleviate the problem of declining land productivity in most parts of Tanzania (Kimbi *et al.*, 1992). Lamentably, the culture of fertilizing pastures is still uncommon to most smallholder farming communities in sub-Saharan Africa including Tanzania, where manure is normally used for fertilizing food crops such as maize, millet, beans and plantains (Powell *et al.*, 1996). Thus, this practice tends to accelerate soil nutrient mining and consequently reducing both growth and yield of various desirable pasture species (Turner, 2002).

Klausner and Boulding (1983) estimated that the fraction of organic N in fresh dairy cattle manure that is mineralized during the first year is about 40% where by 12% is mineralized in the second year. According to Brady (1990), about 50% N in most animal manures is

available for plant uptake during the first year of application. Poultry manure can release up to 90% of its N in the first year (Semoka and Ndunguru, 1983).

Decomposition of organic matter is optimum at the pH range of 6.5 to 7.5, where most of the nutrient elements such as N, K, Ca, and Mg are generally more available (Uriyo *et al.*, 1979). Most incubation studies suggest that the optimum temperature for organic matter decomposition and nitrogen mineralization is in the range of 25-35°C (Ross, 1989). This range of temperature influences growth and activities of most decomposers such as bacteria, fungi and actinomycetes. Temperatures that are below or above this range will slow down decomposition process (Troel and Thompson, 1993).

According to ILRI (2013), Desmodium Greenleaf acts as ground cover as it needs only 4 months to cover the soil and to prevent weeds. It was added that it has been used as ground cover on coffee plantations. Greenleaf Desmodium as a legume improves soil fertility via nitrogen-fixation. It has been reported Desmodium Greenleaf fixes 213-300 kg N ha⁻¹ year⁻¹ in the soil, but it transfers only 5% of this nitrogen to its companion grasses (Maina *et al.*, 2006). It was added that leaf fall could add an additional 1.3 kg N ha⁻¹ week⁻¹ (Skerman *et al.*, 1990). Greenleaf Desmodium can be a valuable protein supplement in ruminant diets based on fibrous by-products or low nutritive value forages (Boukila *et al.*, 2009).

1.2 Problem Statement and Justification

Feed scarcity and mostly, the availability of high quality forage is one of the major limiting factors to dairy productivity improvement (Lecomte *et al.*, 2008). The on-farm crop production and productivity are declining as a result of soil fertility losses due to soil erosion and deforestation practices and to the decrease or the abandonment of mineral fertilizer use (Vågen *et al.*, 2006). This situation is also exacerbated by the negative impacts of climatic variations and climatic change (FAO, 2006).

The components of grass/legume mixtures have the ability to utilize the limited resources more efficiently than when grown in pure stands, thus, showing resource complementarity (Atis *et al.*, 2012). Grasses and legumes are considered as important forage crops because of their nutritional value, especially protein content in legumes and crude fiber in grasses (Rakeih *et al.*, 2008). However, monocultures of legumes or grasses do not provide satisfactory results for forage production and nutritive value (Lithourgidis *et al.*, 2006).

Various studies have been conducted to document the effect of legumes on the performance of fodder plant species under different climatic conditions. For example, Muinga *et al.* (1992) reported that the inclusion of a legume in Napier grass based diet has shown to improve animal performance in terms of milk production because of their high nutrient contents in semi-arid regions. In addition, Mureithi *et al.* (1995), reported that the quantity and quality of fodder was improved in an Alley farming practice based on Napier grass intercropped with *Leucaena* in coastal lowland. No information is available about the same study in mountainous region of Lushoto District.

The application of fertilizers to improve nutrient element availability in the soil for enhanced crop yield is a major practice by farmers all over the world (Vanlauwe *et al.*, 2013). Although soil fertility can be improved with inorganic fertilizers, their high cost and inaccessibility resulting in low, erratic and unprofitable crop responses limit their use, particularly on smallholder farms in Eastern Africa (Nandwa and Bekunda, 1998).

Many studies have been conducted worldwide on the effect of fertilizers toward the performance of fodder plant species. For example, Maleko *et al.* (2014) conducted an experiment in Magadu-Morogoro-Tanzania and reported that the application of farmyard manure had increased the biomass yield of the *Brachiaria ruziziensis* by 1.3 tha^{-1} , 4.19 tha^{-1} and 4.39 tha^{-1} when manure was applied at the rate of 5 tha^{-1} , 10 tha^{-1} and 15 tha^{-1} respectively over the control (without manure).

Elsewhere, Sodeinde *et al.*(2009) working in savanna zone of Nigeria indicated that poultry manure application to *P. maximum* cv T58 harvested at six weeks of regrowth significantly enhanced leaf and stem production than the control treatment without manure. Moreover, researchers at Lunyanyangwa Agricultural Research Station (2008) in Malawi reported that the application of 4.6 t ha⁻¹ of cattle manure produced Napier dry matter yield that was more significant than the control. Furthermore, Ram and Trivedi (2014) in Central Research Farm of Indian Grassland and Fodder Research Institute reported that the application of 5 t FYM ha⁻¹ recorded significantly higher growth parameters of Guinea grass as compared to the control treatment. But little information is known about the effect of farmyard manure on the agronomic performance of fodder plants in mountainous region of Lushoto District.

Hence this study was intended to assess the effect of Desmodium and Farmyard manure on the agronomic performance of Napier and Brachiaria grasses in Lushoto District. The findings in this study will create awareness to the livestock stakeholders and policy makers on the potential of intercropping legumes with other fodder plant species for the purpose of improving agronomic performance and hence livestock productivity - a case with Napier and Brachiaria grasses.

The findings of this study will also create awareness of the livestock stakeholders and policy makers towards the influence of Desmodium and Farmyard manure on the agronomic performance of fodder plant species and hence livestock productivity.

1.3 The Objectives of the Study

1.3.1 The main objective

The main objective of the study is to assess the influence of Desmodium and Farmyard manure on the agronomic performance of Napier and Brachiaria grasses of the smallholder livestock keepers of Lushoto District.

1.3.2 Specific objectives

The specific objectives of the study were:

- i. To assess the influence of Desmodium on the agronomic performance of the local and hybrid Napier and hybrid Brachiaria grasses.
- ii. To assess the influence of Farmyard manure on the agronomic performance of the local and hybrid Napier and hybrid Brachiaria grasses.
- iii. To assess the influence of combined Desmodium and Farmyard manure on the agronomic performance of the local and hybrid Napier and hybrid Brachiaria grasses.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Influence of *Desmodium* on the Agronomic Performance of Hybrid

Napier Grass

Napier grass (*Penisetum purpurium*) is native to Africa and got introduced to all tropical and sub-tropical countries of the world (Bogdan, 1977). Sollenberger *et al.* (2014) reported that the Napier grass is an adaptable, vigorous, highly productive species and withstands considerable periods of drought. It was moreover added that the grass rapidly recovers from stagnation of growth with the onset of rains after the extended dry periods. Napier grass is palatable and could be fed fresh, as silage or directly grazed in the field (Jame *et al.* 2015). Fertile soils are a requirement to maintaining high productivity of the grass (Bogdan, 1977), and it performs well if intercropped with the climbing forage legumes (Magacale *et al.*, 1998).

Though Napier grass is mainly grown in pure stands, it can be cultivated in association with legumes such as Pueru (*Pueraria phaseoloides*), Centro (*Centrosema pubescens*), perennial Soybean (*Neonotonia wightii*) and Leucaena (*Leucaena leucocephala*) (Mannetje, 1992). Mwangi *et al.* (2004) added that, such associations have higher nutritional value than elephant grass alone and can produce higher DM yields, suppress weeds and improve soil fertility. It was further added that in central Kenya, a comparison of three legumes (*Desmodium intortum*, *Macrotyloma axillare*, *Neonotonia wightii*) associated with elephant grass concluded that *Desmodium intortum* was the best choice whereas *Neonotonia wightii* gave the lowest performance. Elephant grass is sometimes intercropped with banana and cassava in home gardens (Mannetje, 1992).

Forage crop-legume mixture can improve the nutritional level of livestock as forage legumes generally have a higher nutritive value than tropical grasses and also have the ability to fix atmospheric nitrogen through their symbiotic association with rhizobia (Giller, 2001). Legumes benefit the grass by contributing nitrogen to the soil through atmospheric N₂ fixation, decay of dead root nodules and mineralization of shed off leaves (Seresinhe *et al.*, 1994).

Several studies have been conducted on the influence of legumes on the agronomic performance of Napier grass. For example, Mwangi and Thorpe (2002) reported in Rahman *et al.* (2015) that, the DM production increased from 20 to 25 and 27 tha⁻¹yr⁻¹ by integrating Axillaris (*Macrotyloma axillare*) and Greenleaf Desmodium (*Desmodium intortum* cv Greenleaf) respectively in Napier grass systems in central Kenya. In Sri Lanka, Seresinhe and Pathirana (2000) showed enhanced yield of grass and total output of Gliricidia (*Gliricidia sepium*) and *P. maximum* cv. Guinea mixed forage systems. Also Berdahl *et al.* (2001) showed average DM yield of 8.7 and 2.71tha⁻¹ from grass and lucerne mixture and sole grass, respectively. Mureithi *et al.* (1995) also showed a beneficial effect to Napier grass when grown together with Leucaena in coastal lowland of Kenya. They recorded increased yield of Napier grass when planted adjacent to Leucaena hedgerows than sole Napier grass or Napier grass growing away from Leucaena. This contradicts results of Mwangi (1999) who found that intercropping with Desmodium depressed DM yield of Napier grass but overall total yield (grass+legumes) was higher.

Also Njunie *et al.* (2000) when intercropping Cowpea with Napier grass in coastal low land of Kenya reported that the legumes benefited the grasses more when the rainfall was relatively high. Furthermore Kabirizi *et al.* (2013) in Masaka District Central Uganda reported that, the dry matter yield of Napier-Centrosema and Brachiaria Mulato –Clitoria

intercrop were $15790\text{kg ha}^{-1}\text{2yrs}^{-1}$ and $12119\text{kg ha}^{-1}\text{2yr}^{-1}$ respectively compared to the Napier monocrop $10354\text{kg ha}^{-1}\text{2yrs}^{-1}$.

2.2 The Influence of Manure on the Agronomic Performance of Hybrid Napier Grass

Napier grass requires high levels of fertilizer and a regular water supply (Mannetje, 1992). Yields range from 20 to 80 t DMha⁻¹year⁻¹ under high fertilizer inputs (Francis, 2004; Skerman and Riveros, 1990). With no or inadequate fertilizers, yields are in the range of 2-10 t DMha⁻¹year⁻¹ (Bogdan, 1977).

Several studies have been conducted on the influence of Farmyard manure on the performance of Napier grass: Shokri (2005) reported that the organic fertilizer as either sheep manure alone or in combination with urea gave better growth performance of the Napier grass in terms of the tiller height, tiller number and leaf area index over the 6 cutting cycles of 6 weeks per cycle. The treatment with 200 kg Nha⁻¹ of sheep manure gave highest dry matter yield ($16\text{ tha}^{-1}\text{yr}^{-1}$) compared to control ($10\text{ tha}^{-1}\text{yr}^{-1}$).

Also Hasyim *et al.* (2014) working in the the warm region of Japan found that, the use of 5.05N (low), 10.08N (Medium) and 20.16N (High) of solid digested effluent of manure resulted into the yield of 800gm^{-2} , 1600gm^{-2} and 2200gm^{-2} respectively of dwarf Napier grass. Moreover Shahin *et al.* (2013) in Shalakan experimental unit in Egypt revealed that, nitrogen fertilization in Pearl millet (*Pennisetum galucum*) at the rate of 0N, 30N and 60N at 10cm cutting height resulted in annual yield of 0.81 tfed^{-1} , 1.57 tfed^{-1} and 2.6 tfed^{-1} , leaf area indices of 1.89, 3.09 and 5.63; tiller heights of 81.92 cm, 101.80 cm and 121.9 cm and tiller number of 64.75 tillm^{-2} , 74.04 tillm^{-2} and 82.5 tillm^{-2} . Hiroshi (2013) in the semi-arid tropical region of India also showed that the dry matter yield of sweet sorghum

(*Sorghum bicorlar*) increased by 16.15% and 40% when Nitrogen at the rate of 30N and 150N per year respectively over the control.

2.3 The Influence of Desmodium on the Agronomic Performance of Brachiaria Grass

Brachiaria mulato II is a perennial, tetraploid hybrid (Brachiaria ruziziensis X Brachiaria brizantha X Brachiaria decumbens) with a semi-erect growth habit, reaching a height of up to 1m. Its stems are strong, cylindrical, and pubescent, some present semi-decumbent growth habit and are capable of rooting when they come into close contact with the soil either because of the effect of animal trampling or because of mechanical compaction (CIAT, 2004). This cultivar grows well from sea level up to 1800m above sea level in the humid tropics with high precipitation, and in sub-humid conditions with 5-6 dry months and an annual precipitation of over 700mm. The cultivar adapts well to poor acid soils with high aluminium (Al) content and it is tolerant to prolonged periods of drought (up to 6 months) (CIAT, 2006).

Variuous studies have been conducted on the influence of Desmodium on the agronomic performance of Brachiaria grasses. For example Volatera *et al.* (2012) reported that, the total DM and protein digestibility in the small intestine (PDI) yields of mixture for a three years period were 93% and 9.4% respectively higher than those of the pure stand of Brachiaria.

Moreover, Lobo and Acuña (2004) in Latin America and Carribbean islands reported the 18.5% higher mean dry matter yield over three consecutive years for *Brachiaria brizantha*-*Arachis pintoii* mixture compared with pure stand of *Brachiaria brizantha*. Furthermore, in Sri Lanka, Seresinhe and Pathirana (2000) showed enhanced yield of grass and total output of *Gliricidia sepium* and *P. maximum* cv.

Guinea mixed forage systems. Elsewhere, Berdahl *et al.* (2001) showed average DM yield of 8.7 and 2.71 t ha⁻¹ from grass/lucerne mixture and sole grass, respectively.

2.4 The Influence of Manure on the Agronomic Performance of Hybrid

Brachiaria Grass

Both organic and inorganic fertilizers can be applied in the soil to add nutrients for increasing the yields of *Brachiaria grass*. It can yield up to 20 DMtha⁻¹ when fertilized with N rich inorganic fertilizers (Skerman and Riveros, 1990). However, inorganic fertilizers are too expensive for most smallholder farmers to afford purchasing (Sanchez *et al.*, 1997). Moreover, inorganic fertilizers do not last longer in the soil and require frequent re-application. In contrast, organic manures like cow manure are known to last longer in the soil whilst allowing pastures to be re-grown several times without immediate replenishment (Lund and Doss, 1980).

Several studies have been conducted on how organic or inorganic fertilizers influence the agronomic performance of forage crops. For example, Frederiksen and Kategile (1980), reported that without fertilizer application, a yield of about 3 t DMha⁻¹ of *Brachiaria brizantha* on a 10-year-old field while on fertilizer application, yields were raised to about 10 t DMha⁻¹. Also, Guiot (2005) reported that *Brachiaria mulato II* yielded 3.9 t DMha⁻¹ per harvest with an annual fertilization of 150 kg N and 50 kg Pha⁻¹. However, other literature stress that, under low temperature conditions brachiaria grasses performs poor. For example, Ndikumana and Leeuw (1996), reported that the optimal temperature for the *B. decumbens* is 30-35°C and the low temperature depresses its growth. Moreover Villela *et al.* (2008) found that, the *Brachiaria decumbens* had CP content of 11.69%, 11.08%, 9.43% and 8.93% in spring, summer, autumn and winter, respectively, showing the reduction of CP content during the winter period.

CHAPER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

The experiment was conducted in Ubiri Village; Lushoto District from mid-November 2014 to end of June 2015. The site is situated between $4^{\circ}49.44'$ and $4^{\circ}49.51'$ latitudes south of Equator and between $38^{\circ}18.99'$ and $38^{\circ}19.33'$ longitudes east of Greenwich and the mean elevation of 1199 m above sea level. The site has a total area of 1224 m² (51 m x 24 m).

Lushoto District is one of the the seven districts of Tanga Region located in the northeastern part of Tanzania. It lies between longitudes $38^{\circ} 10'$ and $38^{\circ} 36'$ East and Latitudes $4^{\circ} 24'$ and $5^{\circ} 15'$ south. The altitude ranges between 800- 2300m above sea level. It borders the republic of Kenya in the north, Kilimanjaro Region in the northwest and Korogwe District to the south and east.

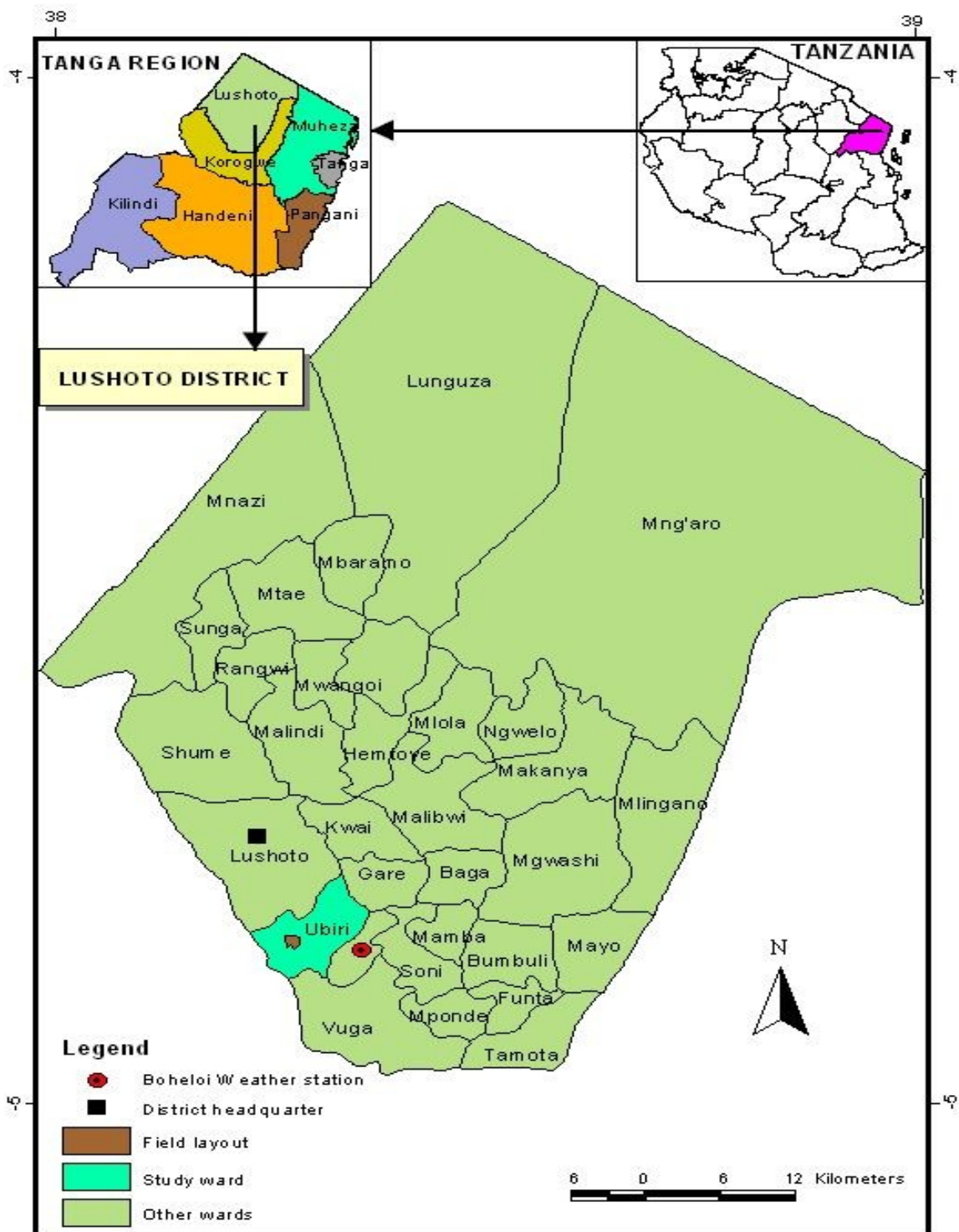


Figure 1: The location of the study area in Lushoto District, Tanzania

3.1.2 Climate

The district receives bimodal pattern of rainfall; long rains falling between March and June while short rains between October and December. The climate is highland temperate with annual temperature of 16 to 22 °C and annual rainfall of 600-1200 mm (Haruyama and Toko 2005). Generally, the mean annual temperatures vary with altitude. At 500m above sea level, the temperature ranges from 25 to 27⁰C while between altitudes 1500-1800m above sea level, the temperatures are from 16 to 18⁰C (Wiersum *et al.*, 1985). The period between the month of June to early September mark the coldest period of the year with temperature of 15 to 20⁰C and occasionally dropping to 3⁰C (SECAP, 1991).

3.1.3 Topography, geology and soils

Lushoto District, which covers most of the west Usambara Mountains in the north-eastern part of Tanzania, forms part of the Eastern Arch Mountains (Msangi, 1990). These consist of uplifted block of highly folded, metamorphosed volcanic rocks rising from the surrounding plains at approximately 600m altitudes. They have irregular eastward – sloping upper plateau at about 1300-1900m and a maximum altitude of 23000m (Wiersum *et al.*, 1985).

The main rock types are gneiss intruded by quartzite veins with varying amount of pyroxene, hornblende and biotite. The soils derived from these soils are generally latosols (highly weathered and leached soils) predominantly acidic with a pH range of 3.5 to 5.5 and poor in nutrient content. In the lower wetter areas the soils are humic ferralitic due to high precipitation and humic ferrisol in drier and cooler areas (FAO/UNESCO, 1979). The color is red to yellowish red, but the soil is darker, owing to the high organic matter of the original forest soils, which ensures high cation exchange capacity but disintegrate quickly under cultivation. The soils have high clay, and sand content, but low in silt and

freely drained and have their nutrients concentrated in the top soils, which are no more than 30cm deep (Wiesum *et al.*, 1985). The average annual rainfall ranges from 1400 mm to 1800 mm.

3.2 Methods

3.2.1 Experimental design

The experimental design was a randomized complete block design (RCBD) with three replicates (Fig.2). The plots had dimensions of 6m x 4 m. Each plot had four rows and each row had 6 plants for napier and brachiaria and 12 plants for desmodium. These treatments were:

- T1. Local napier alone
- T2. Local napier with desmodium
- T3. Local napier with manure
- T4. Local napier with desmodium and manure
- T5. Hybrid napier alone
- T6. Hybrid napier with desmodium
- T7. Hybrid napier with manure
- T8. Hybrid napier with desmodium and manure
- T9. Hybrid brachiaria alone
- T10. Hybrid brachiaria with desmodium
- T11. Hybrid brachiaria with manure
- T12. Hybrid brachiaria with desmodium and manure

The interrow and intrarow spacing for the napier and brachiaria treatments were 1m and the intrarow and interrow spacing between demodium were 0.5m and 1m, respectively. The farmyard manure (cow manure) was applied at the rate of 8.8 tonesha⁻¹

$^1(127.5 \text{ kgNha}^{-1})$. This application rating is adopted from local application practice which is below the recommended rating for cereals in sub-Saharan Africa which is between 10-15 tha^{-1} as manure is scarce in the area.

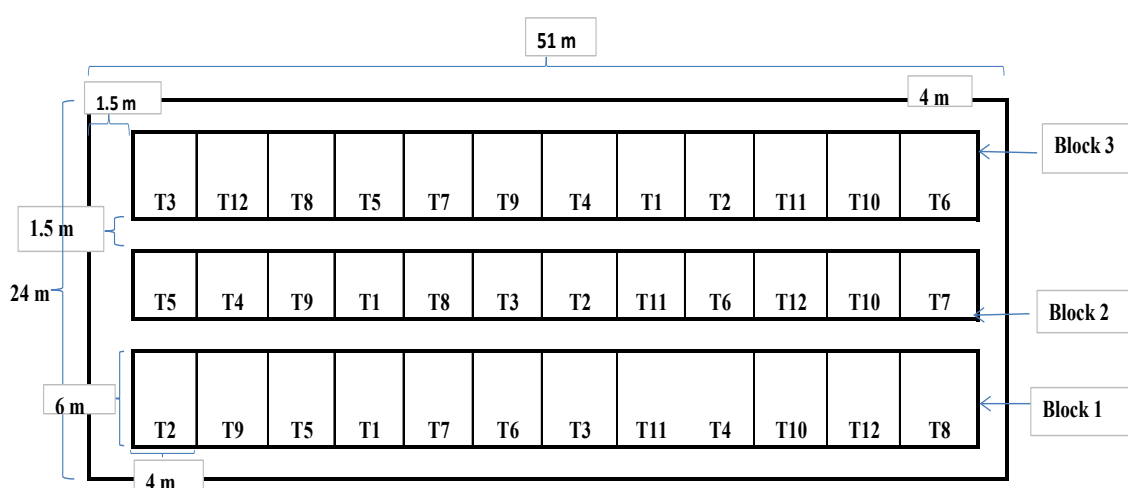


Figure 2: The trial layout

3.2.2 Management of the experiment

The land was prepared at the beginning of the month of November 2014. The land was tilled by hand hoe followed by harrowing using a forked hoe. The first weed control was done three weeks after crop emergence. More weed controls were done to ensure that the field was weed-free (Table 1).

Table 1: The experimental layout management and forage harvesting schedule

Year	2014				2015			
Month	November	December	January	February	March	April	May	June
	planting	weeding		Weeding	1 st cut	2 nd cut	Weeding	3 rd cut

3.2.3 Data collection

3.2.3.1 Forage sampling

The first harvest was done when the forage crops had the age of 16 weeks. The successive harvests were done at intervals of 6 weeks. The first harvest was done for all forage

plantsexcept for the desmodium.Desmodium plants were harvested together with other varieties during the third harvest. In all species samples were collected from the net plot (at the plot center) which consisted of eight bunches/clumps (had the area of 4m x 2 m). Also three bunches/clumps were randomly selected among the eight bunches in each plot and marked.The following agronomic data were collected in the field trial: Tiller number, tiller height, leaf area index and dry matter yield.

(i)Tiller heights

The height of the tall, medium and the short tillers in three randomly selected bunches/clumps were measured by using the ordinary tape measure (in cm).

(ii) Tiller numbers

Tiller numbers for the three randomly selected bunches in the net plot of each plot were counted.

(iii)The leaf area indices

The leaf area index parameters were measured by using an Accupar/ Ceptometer in which one above (photosynthetic active radiation) reading was measured followed by five below successive (phosynthetic active radiations) readings diagonally in the five randomly selected bunches in the net plot and thesewere repeated in every plot. All readings were taken when the sun was directly overhead (zero zenith angle).

(iv)The dry matter yield parameters

All forage crops in the net plot (8 bunches) were harvested at the height of 10 cm from the ground level and tied together by using a rope and its bulk weight was measured by using a beam balance. The forages were untied and the tillers were thoroughly mixed together

and five tillers were randomly selected, chopped and packed in the paper bags and their fresh weights measured by using electronic weigh balance. The samples were then transported to laboratory of Tanzania Livestock Research Institute (TALIRI)-Tanga which is situated at latitude 5° South of Equator and longitude 39° East of Greenwich. Its altitude is 6 metres above sea level and is about 6 km inland from the Indian Ocean. Then samples were introduced in the oven to obtain the dry weight at 65 °C in 48 hours (two days). The dry samples were removed from the oven and the weights of the dry samples in the paper bag were weighed by using the electronic weight balance.

3.2.3.2 Weather data

Weather data on monthly maximum and minimum temperature and rainfall (Table 2) during forage crop development were collected from CIAT meteorological station installed at Boheloi Village Lushoto District. The station is about 6.5kms from field trial site and is situated 1198.7 m above sea level.

Table 2: The Rainfall (mm) and Temperature (°C) data from Boheloi weather station per month

Year	2014				2015			
Month	November	December	January	February	March	April	May	June
Number of raining days	11	9	7	5	5	17	17	5
Amount of rain (mm)	142.5	94.8	136	33.4	82.5	231.6	206.5	39.5
Minimum Temperature (°C)	6.23	7.1	8.9	8.54	7.65	10.77	11.16	6.93
Maximum Temperature (°C)	25.87	26.13	27.06	27.54	27.77	23.63	20.77	21.63
Mean Temperature (°C)	15.56	16.61	17.98	18.04	17.71	17.2	15.97	14.28

3.2.4 Data analysis

3.2.4.1 Forage data preparation

Data on tiller number, tiller height and biomass yield were processed by using Microsoft excel 2010.

(i) Tiller height

The average of the three tillers was calculated to get the bunch tiller height.

$$\text{The bunch tiller height} = \frac{\text{Tall tiller} + \text{Medium tiller} + \text{Short tiller}}{3} \dots\dots\dots(1)$$

The average tiller heights (in m) were calculated as:

$$\text{Tiller height} = \frac{1^{\text{st}} \text{ bunch tiller height} + 2 \text{ bunch tiller height} + 3^{\text{rd}} \text{ bunch tiller height}}{3} \dots\dots\dots(2)$$

(ii) Tiller number

The average tiller number from three bunches was calculated to estimate the tiller number in the bunch of each forage variety.

$$\text{Tiller number} = \frac{\text{Tiller no. for the } 1^{\text{st}} \text{ bunch} + \text{Tiller no. for the } 2^{\text{nd}} \text{ bunch} + \text{Tiller for the } 3^{\text{rd}} \text{ bunch}}{3} \dots\dots\dots(4)$$

(iii) Biomass yield

Fresh sample weights and dry sample weights were obtained by subtracting the paper bag weights:

$$\text{fsw} = (\text{fsw} + \text{pbw}) - \text{pbw} \dots\dots\dots(5)$$

$$\text{dsw} = (\text{dsw} + \text{pbw}) - \text{pbw} \dots\dots\dots(5)$$

The dry matter (%) (DM) was then calculated by using the following formular

$$\text{DM} = (\text{dws}/\text{fws}) \times 100\% \dots\dots\dots(6)$$

Also the Dry matter yield (DMY) was calculated by using the formular:

$$\text{DMY} = \text{DM} \times \text{bulk fresh weight} \dots\dots\dots(7)$$

Where;

fsw = Fresh sample weight

dsw = Dry sample weight

pbw = Paper bag weight

3.2.4.2 Statistical data analysis

Data were then analyzed by using 3 x 4 factorial treatment design followed in Anova procedure of Genstat Discovery 4th-edition statistical package. Differences in means were compared by standard error of the mean (Lawes Agricultural Trust, 1997).

The following model was used;

$$Y_{ijk} = \mu + \tau_i + \alpha_j + (\alpha\tau)_{ij} + \beta_k + e_{ijk} \dots \dots \dots (8)$$

Where;

Y_{ijk} = A single observation from i^{th} level of variety, j^{th} level of fertilizer and k^{th} replications

μ = Over all mean

τ_i = Effect of i^{th} level of variety

α_j = effect of k^{th} level of fertilizer

$(\alpha\tau)_{ij}$ = Effect of i^{th} level of variety and j^{th} level of fertilizer interaction

β_k = Effect of k^{th} replications

e_{ijk} = Error

CHAPTER FOUR

4.0 RESULTS

4.1 The Agronomic Performance of the three Grasses Types due to Influence of Desmodium

The influence of Desmodium on the agronomic performance of the local and hybrid Napier and hybrid Brachiaria grasses were assessed based on tiller height, tiller number, leaf area indices and biomass yield. The results of each category are presented in the following subsections;

4.1.1 Tiller height

The results on the influence of desmodium on the tiller heights of the local and hybrid Napier and hybrid Brachiaria grasses over the three successive harvests are shown in Fig.3. The Desmodium integration had no significant ($P>0.05$) increase in tiller height for all grasses over the three successive harvests. Furthermore the performance of the grasses in terms of tiller heights reached the peak during the second harvest (22 weeks) but declined during the third harvest (28 weeks).

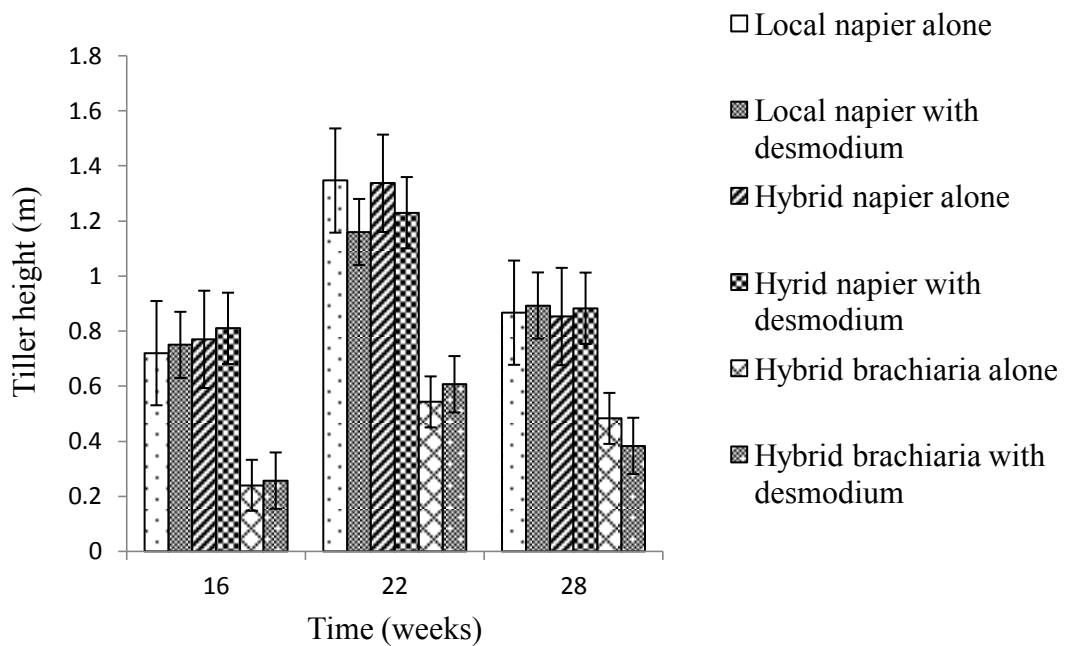


Figure 3: The performance in tiller height of the local and hybrid Napier and hybrid Brachiaria when alone or in integration with Desmodium over the three successive harvests

4.1.2 Tiller number

The results on the influence of desmodium on the tiller numbers of the local and hybrid Napier and hybrid Brachiaria grasses over the three successive harvests are shown in Fig. 4. The integration of Desmodium had no significant ($P > 0.05$) increase in tiller numbers for all grasses except for the tillers of hybrid Napier grasses which significantly ($P < 0.05$) increased by 37.63% during the third harvest. The tiller numbers of all grasses kept on increasing from the first harvest to the third harvest.

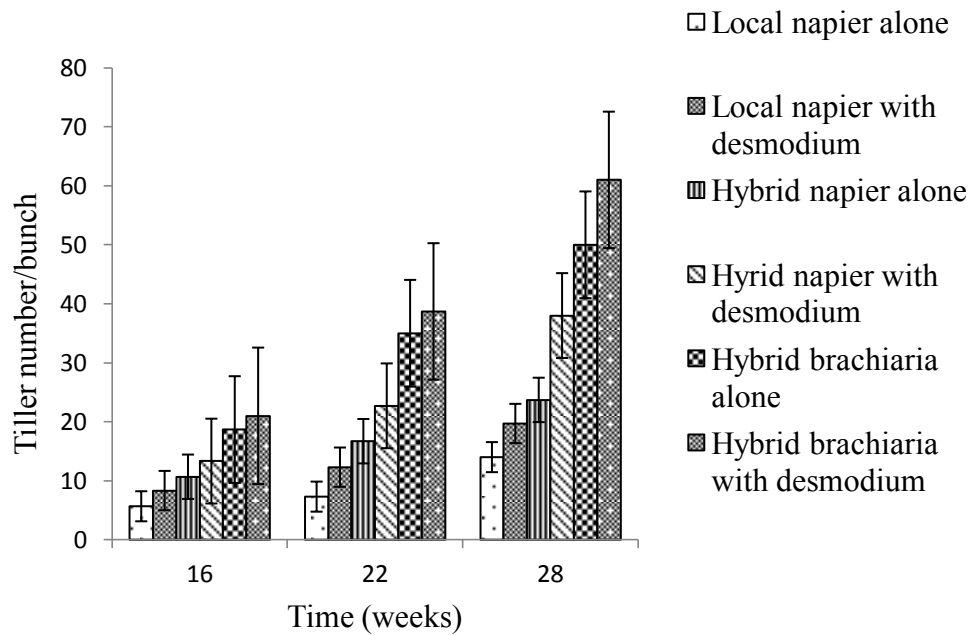


Figure 4: The performance in tiller number of the local and hybrid Napier and hybrid Brachiaria when alone or in integration with Desmodium over the three successive harvests

4.1.3 Leaf area indices

The results on the influence of Desmodium on the leaf area indices of the local and hybrid Napier and hybrid Brachiaria grasses over the three successive harvests are shown in Fig. 5. The Desmodium integration had significantly ($P < 0.05$) improved the performance of in terms of leaf area index by 68.85%, 65.23% and 64.22% for the local Napier, hybrid Napier and hybrid Brachiaria respectively during the third harvest (28 weeks). However, the integration of Desmodium had no significant increase in leaf area index for all grasses during the first (16 weeks) and second (22 weeks) harvests.

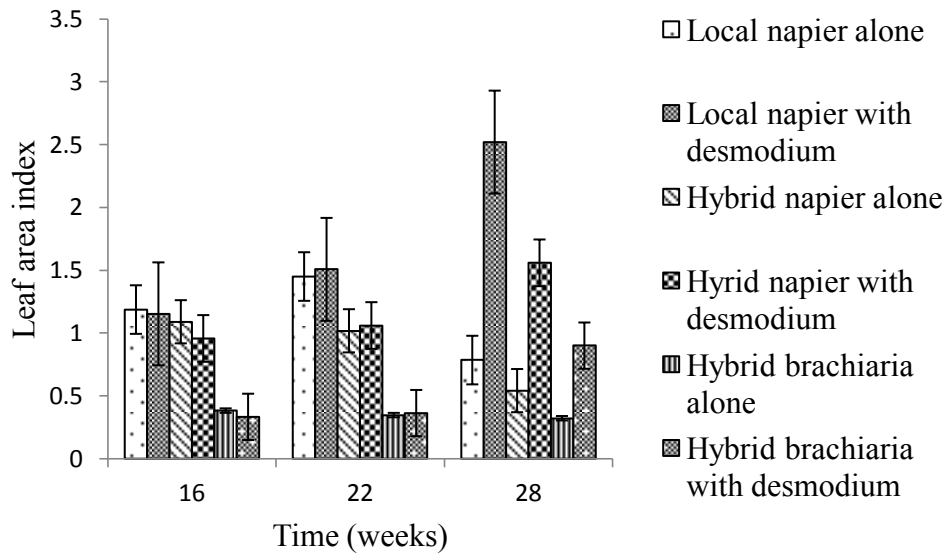


Figure 5: The performance in leaf area indices of the local and hybrid Napier and hybrid Brachiaria when alone or in integration with Desmodium over the three successive harvests

4.1.4 Biomass yield

The results on the influence of Desmodium on the biomass yield of the local and hybrid Napier and hybrid Brachiaria grasses over the three successive harvests are shown in Fig. 6. The Desmodium had significantly ($P < 0.05$) increased the biomass yield of the local Napier, hybrid Napier and hybrid Brachiaria grasses by 28.59%, 53.63% and 68.55% respectively during the third harvest. However, it was also indicated that, the biomass yield of all grasses was not affected by Desmodium integration during the first (16 weeks) and second (22 weeks) harvests. Moreover the performance of all grasses reached the peak during the second harvest and declined during the third harvests except for the hybrid Brachiaria grasses.

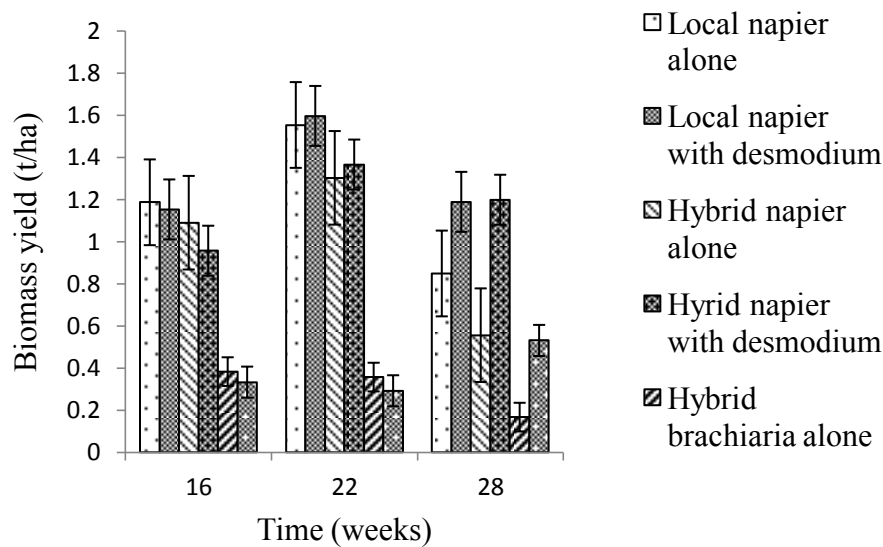


Figure 6: The performance in biomass yield of the local and hybrid Napier and hybrid Brachiria when alone or in integration with Desmodium over the three successive harvests

4.2 The Agronomic Performance of the three Grass types due to the Influence of Farmyard Manure

The influence of Farmyard manure on the agronomic performance of the local and hybrid Napier and hybrid Brachiaria grasses were assessed based on tiller height, tiller number, leaf area indices and biomass yield. The results of each category are presented in the following subsections;

4.2.1 Tiller height

The results on the influence of Farmyard manure on the tiller heights, of the local and hybrid Napier and hybrid Brachiaria grasses when alone and in combination with Farmyard manure over the three successive harvests are presented in Fig. 7. The addition of Farmyard manure on the grasses had not significantly ($P > 0.05$) increased the tiller heights over the three growth cycles. Furthermore the performance of all grasses in terms of

tiller height reached the peak during the second harvest (22 weeks) and declined during the third harvest (28 weeks).

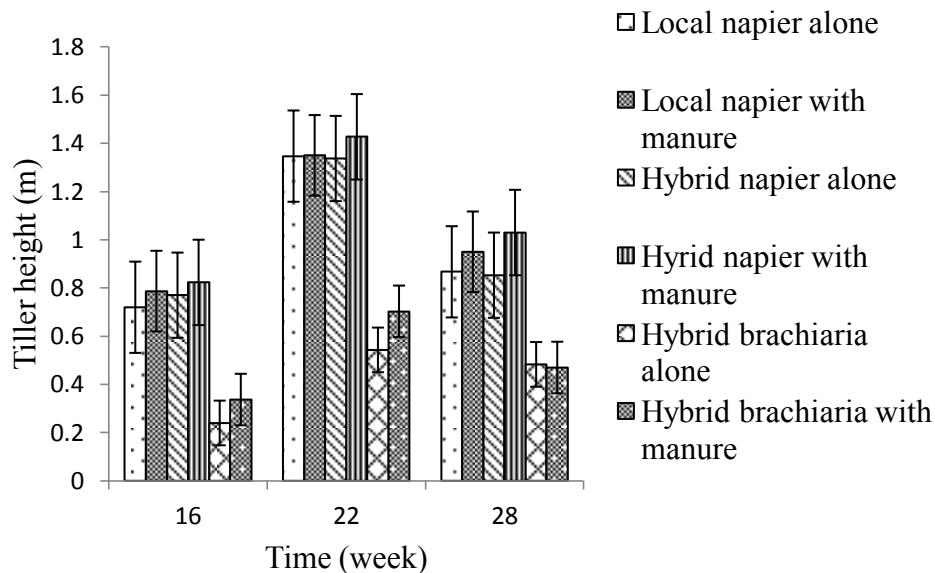


Figure 7: The performance in tiller height of the local and hybrid Napier and hybrid Brachiria when alone or in combination with Farmyard manure over the three successive harvests

4.2.2 Tiller number

The results on the influence of Farmyard manure on the tiller numbers of the local and hybrid Napier and hybrid Brachiaria grasses when alone and in combination with Farmyard manure over the three successive harvests are shown in Fig. 8. The Farmyard manure addition had significantly ($P < 0.05$) enhanced the tiller numbers of the local and hybrid Napier by 60.11% and 48.93% respectively during the second harvest (22 weeks) and by 56.66% and 48.49% respectively during the third harvest (28 weeks). However the Farmyard manure addition had no effect on the tiller numbers of the local and hybrid Napier during the first harvest (16 weeks) and on hybrid Brachiaria grasses in all the three successive harvests. Moreover the tiller numbers of all grasses kept on increasing from the first harvest (16 weeks) to the third harvest (28 weeks).

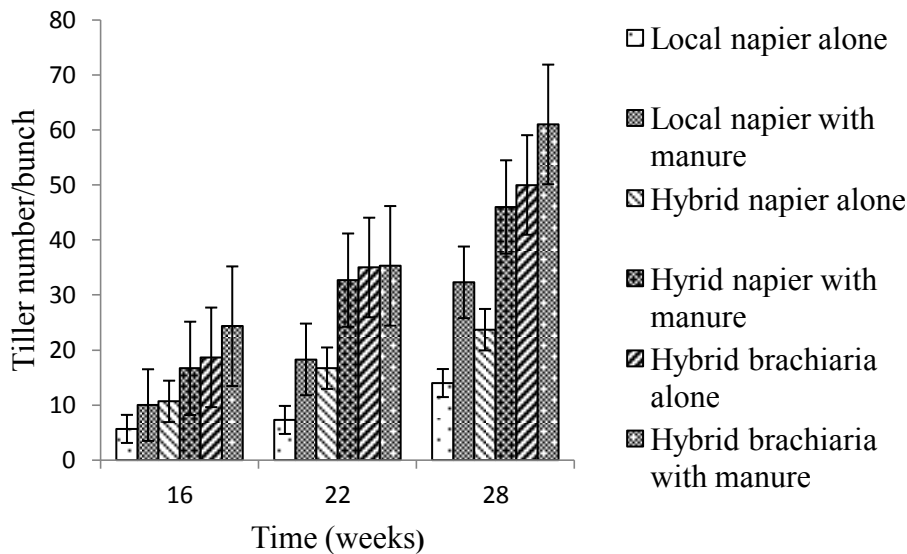


Figure 8: The performance in tiller number of the local and hybrid Napier and hybrid Brachiria when alone or in combination with Farmyard manure over the three successive harvests

4.2.3 Leaf area indices

The results on the influence of Farmyard manure on the leaf area indices of the local and hybrid Napier and hybrid Brachiaria grasses when alone and in combination with Farmyard manure over the three successive harvests are presented in Fig. 9. The farmyard manure addition had significantly ($P < 0.05$) increased the leaf area indices of all local Napier, hybrid Napier and hybrid Brachiaria grasses by 53.94%, 37.70% and 21.27% respectively during the second harvest (22 weeks). Notwithstanding Farmyard manure had no significant effect on the increase in leaf area indices of all the grasses during the first (16 weeks) and third (28 weeks) growth cycles. Furthermore the leaf area indices reached the optimum point during the second harvest (22 weeks) and dropped during the third harvest (28 weeks).

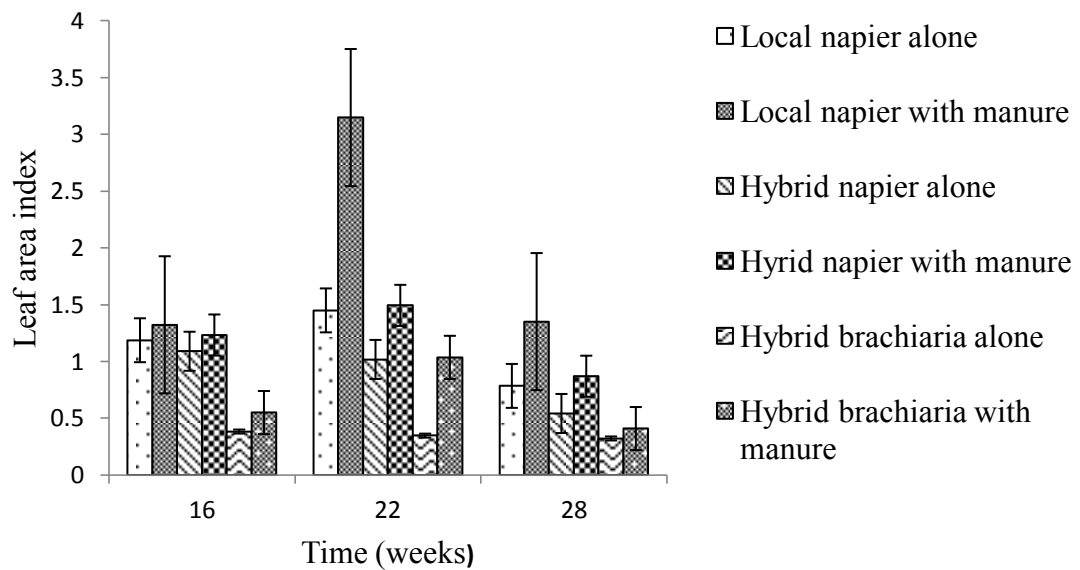


Figure 9: The performance in leaf area index of the local and hybrid Napier and hybrid Brachiria when alone or in combination with Farmyard manure over the three successive harvests

4.2.4 Biomass yield

The results on the influence of Farmyard manure on the biomass yield of the local Napier, hybrid Napier and hybrid Brachiaria grasses when alone and in combination with Farmyard manure over the three successive harvests are presented in Fig. 10. The Farmyard manure addition had significantly ($P < 0.05$) improved the performance of the local Napier, hybrid Napier and hybrid Brachiaria grasses by 14.16%, 39.89% and 36.50% respectively in terms of biomass yield during the second growth cycle (22 weeks). Nonetheless the Farmyard manure had no significant effect on the biomass yield of all grasses during the first (16 weeks) and third (28 weeks) growth cycles. Furthermore the performance of all grasses in terms of biomass yield had reached the peak during the second harvest (22 weeks) and then declined during the third harvest (28 weeks).

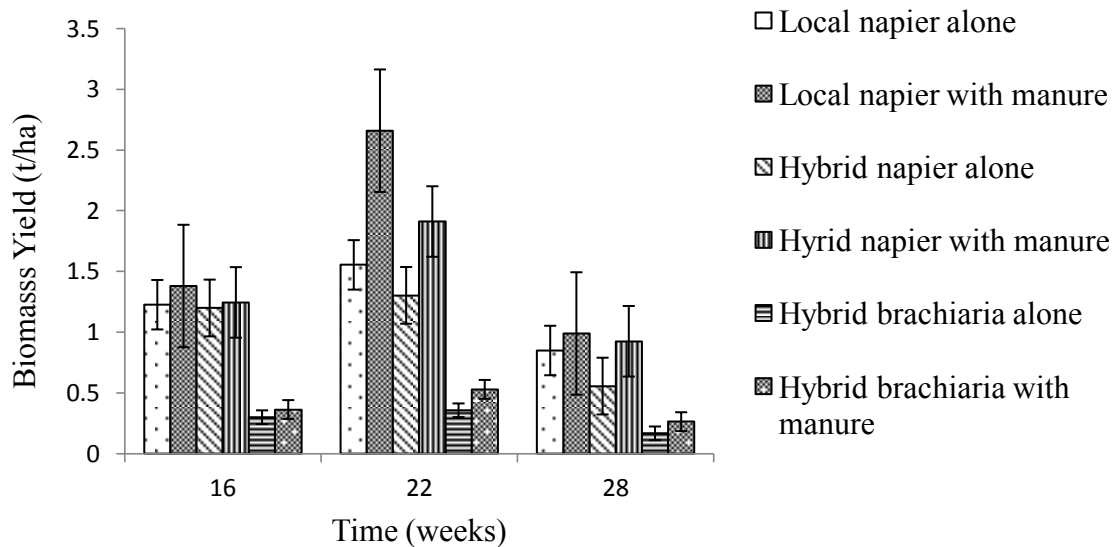


Figure 10: The performance in biomass yield of the local and hybrid Napier and hybrid Brachiaria when alone or in combination with Farmyard manure over the three successive harvests

4.3 The Agronomic Performance of the three Grasses types due to the Influence of Combined Desmodium and Farmyard Manure

The influence of combined Desmodium and Farmyard manure on the agronomic performance of the local and hybrid Napier and hybrid Brachiaria grasses were assessed based on tiller height, tiller number, leaf area indices and biomass yield. The results of each category are presented in the following subsections.

4.3.1 Tiller height

The results on the influence of the combined Desmodium and Farmyard manure on the tiller heights of the local and hybrid Napier and hybrid Brachiaria grasses over the three successive harvests are indicated in Fig. 11. The combined Desmodium and Farmyard manure had no significant ($P > 0.05$) effect on the performance of all grasses in terms of tiller height over the all successive harvests. Furthermore shows that the performance of all

the grasses in terms of tiller height had reached the peak during the second harvest (22 weeks) and declined during the third harvest (28 weeks).

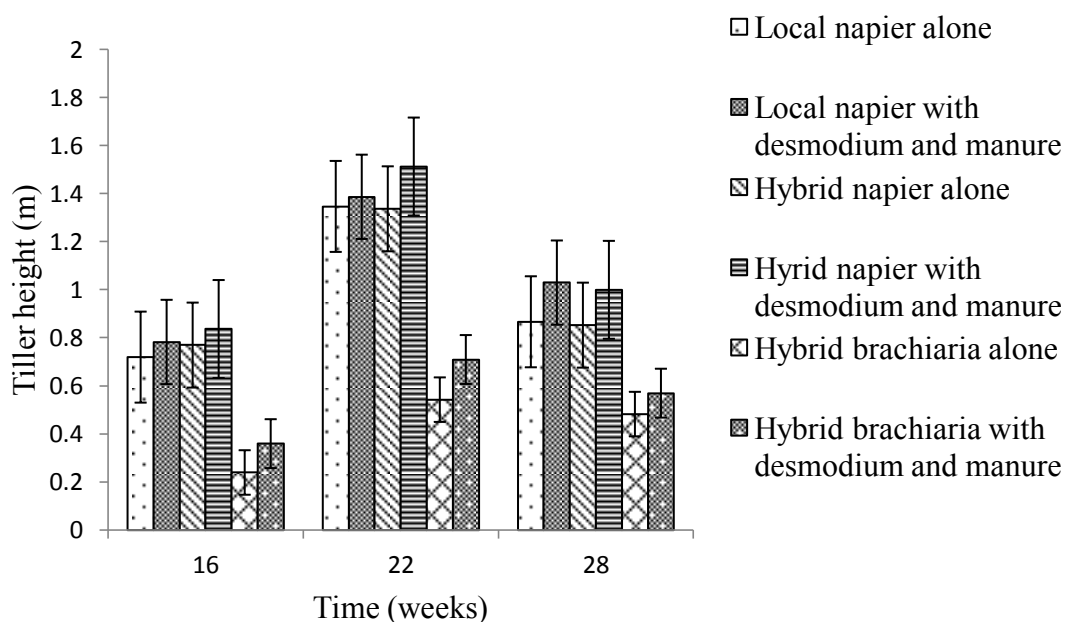


Figure 11: The performance in tiller number of the local and hybrid Napier and hybrid Brachiaria when alone or in combination of both Desmodium and Farmyard manure over the three successive harvests

4.3.2 Tiller number

The results on the influence of combined Desmodium and Farmyard manure on the tiller numbers of the local and hybrid Napier and hybrid Brachiaria grasses over the three successive harvests are shown in Fig. 12. The combined Desmodium and Farmyard manure had significantly ($P < 0.05$) increased the tiller numbers of the local and hybrid Napier grasses by 41.67% and 34.17% respectively during the third harvest (28 weeks). However, the Farmyard manure had no influence on the tiller numbers hybrid Brachiaria in all harvests and on hybrid and local Napier grasses during the first (16 weeks) and second (28 weeks) harvests. Furthermore the number of tillers kept on increasing from the first harvest (16 weeks) to the third harvest (28 weeks).

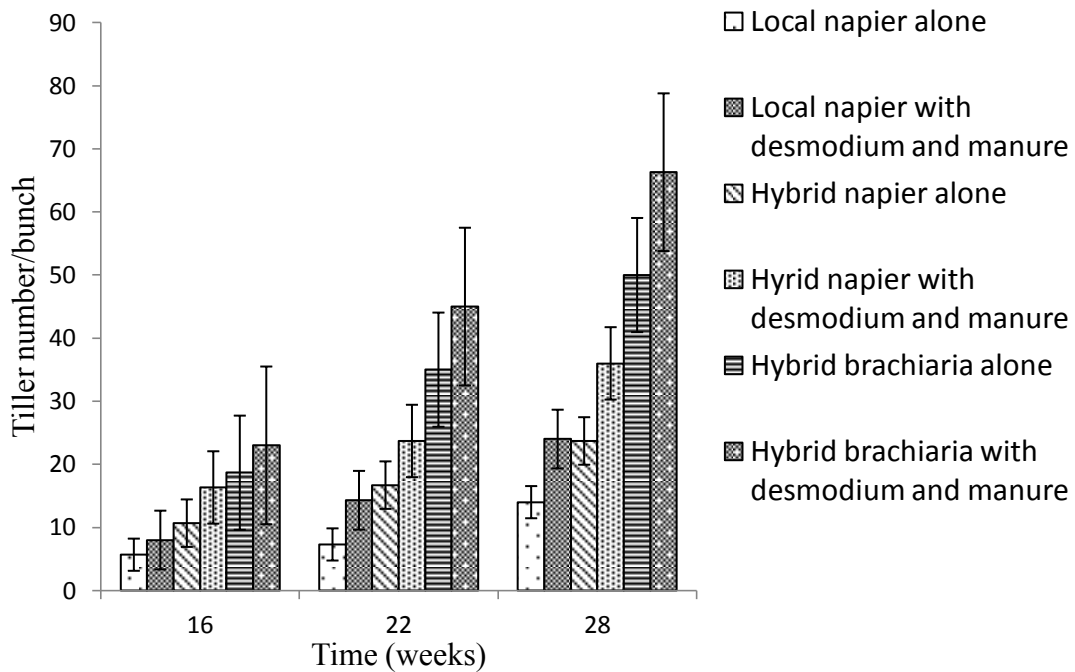


Figure 12: The performance in tiller number of the local and hybrid Napier and hybrid Brachiria when alone or in combination of both Desmodium and Farmyard manure over the three successive harvests

4.3.3 Leaf area indices

The results on the influence of combined Desmodium and Farmyard manure on the leaf area indices of the local Napier, hybrid Napier and hybrid Brachiariagrasses over the three successive harvests are indicated in Fig. 13. The combined Desmodium and Farmyard manure had significantly ($P < 0.05$) increased the leaf area indices of the local Napier, hybrid Napier and hybrid Brachiaria grasses by 76.27%, 80.84% and 78.39% respectively during the third harvest (28 weeks). Nonetheless the combined Desmodium and Farmyard manure had no effect on the leaf area indices of the local and hybrid Napier grasses during the first (16 weeks) and second (22 weeks) harvests.

Moreover the leaf area indices of all the grasses in intergration with the combined Desmodium and Farmyard manure kept on increasing from the first harvest (16 weeks) to

the third (28 weeks) harvest. Nevertheless the leaf area indices of the all grasses when alone reached the peak during the second harvest (22 weeks) and declined during the third harvest (28 weeks).

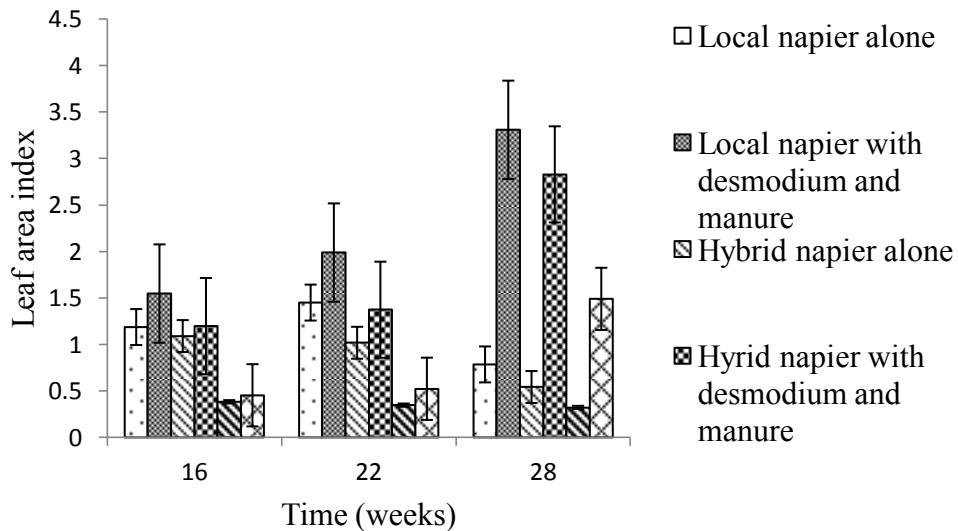


Figure 13: The performance in leaf area indices of the local and hybrid Napier and hybrid Brachiria when alone or in combination of both Desmodium and Farmyard manure over the three successive harvests

4.3.4 Biomass yield

The results on the influence of combined Desmodium and Farmyard manure on the biomass yield of the local and hybrid Napier and hybrid Brachiariagrasses over the three successive harvests are presented in Fig. 14. The combined Desmodium and Farmyard manure had significantly ($P < 0.05$) increased by biomass yield of the local Napier, hybrid Napier and hybrid Brachiaria by 50%, 64.16% and 83.20% respectively during the third harvest (28 weeks). Nevertheless no significant difference was noted for the biomass yield of all grasses during the first (16 weeks) and second (22 weeks) harvest.

Furthermore the performance of all grasses when alone and in integration of the combined Desmodium and Farmyard manure reached the peak during the second harvest (22 weeks)

and declined during the third harvest (28 weeks) except for the hybrid Brachiaria in integration with the combined Desmodium and Farmyard manure.

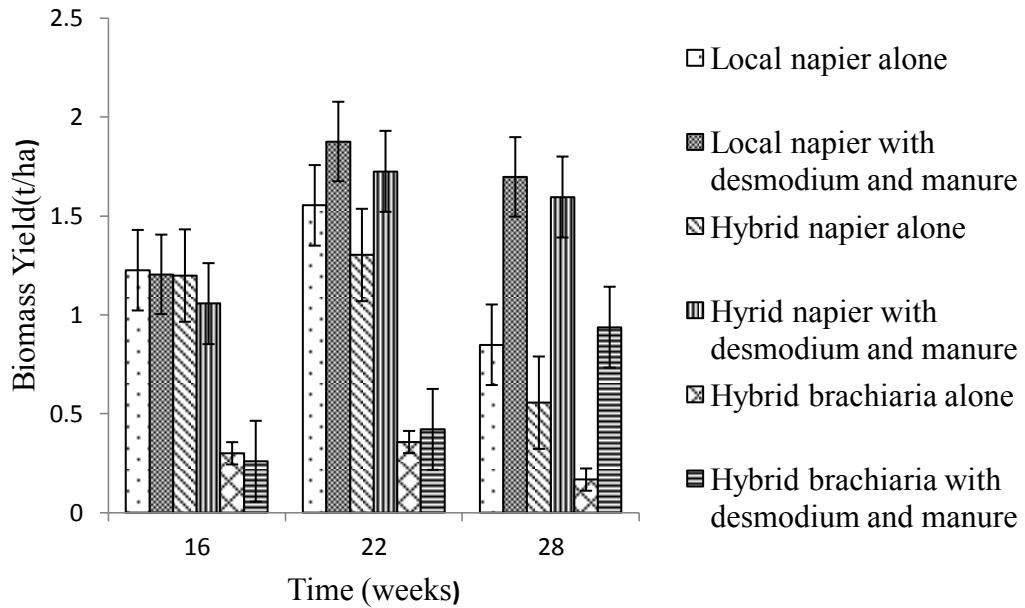


Figure 14: The performance in biomass yield of the local and hybrid Napier and hybrid Brachiria when alone or in combination of both Desmodium and Farmyard manure over the three successive harvests

CHAPTER FIVE

5.0 DISCUSSION

5.1 The Agronomic Performance of the Three Grasses due to Influence of

Desmodium

The influence of Desmodium on the agronomic performance of the all grasses was not significant during the first (16 weeks) and second (22 weeks) harvests. However, during the third harvest (28 weeks) the Desmodium significantly improved the performance of all grasses in terms of leaf area index and dry matter yield (Fig. 5 and 6). The delay of Desmodium to influence the performance of the grasses might have been attributed to low soil moisture content which probably reduced the Desmodium root nodulation during the short rain season and hence inadequate biological nitrogen fixation and the harvesting of grasses alone as desmodium was not yet matured could have reduced the biomass yield of the grasses. On the other hand, the significant influence of Desmodium on all grasses (Fig. 5 and 6) during the third harvest (28 weeks) was probably due to sufficient soil moisture content which enhanced Desmodium root nodules exudation, nutrient release from dead roots, shade off plant leaves and the additive effect of the Desmodium biomass. These findings are in line with those of Njunie *et al.* (2000) who reported that, when intercropping Cowpea with Napier grass in a coastal low land area of Kenya and found that the legumes benefited the grasses more when the rainfall was relatively high. Mwangi and Thorpe (2002) cited in Rahman *et al.* (2015) reported that the DM production increased from 20 to 25 and 27 $\text{tha}^{-1}\text{yr}^{-1}$ by integrating Axillaris (*Macrotyloma axillare*) and Greenleaf Desmodium (*Desmodium intortum* cv Greenleaf) respectively in Napier grass system in central Kenya. In Sri Lanka, Seresinhe and Pathirana (2000) showed enhanced yield of grass and total output of Gliricidia (*Gliricidia sepium*) and *P. maximum* cv. Guinea mixed forage systems. Further more, these findings are in agreement

with those reported by Lobo and Acuña (2004) in Latin America and Caribbean Islands which showed 18.5% higher mean dry matter yields over the three consecutive years for *Brachiaria brizantha* and *Arachis pintoii* mixture compared with pure stand of *Brachiaria brizantha*.

The performance of the grasses during the third harvest (28weeks) was observed to fall and this was more pronounced in the separate grasses alone. This is probably due to unfavourably low temperature for the better agronomic performance of the grasses (C4 plants) as shown in (Table 2). FAO (2015) reported that, the optimal temperatures for Napier growth are in the range 25 to 40°C with annual rainfall of over 1500mm. Duke (1983) on the other hand, reported that Napier grass stops growing below the temperature of 15 °C and is sensitive to frost, though it can regrow from the stolons if the soil is not frozen (Duke, 1983). The tall varieties cannot withstand frost, in contrast to the dwarf type which is frost tolerant (Legel, 1990). Ndikumana and Leeuw (1996) reported that the optimal temperature for the *B. decumbens* is 30-35°C and the low temperature depresses its growth.

5.2 The Agronomic Performance of the Three Grasses due to Influence of Farmyard Manure

The performance of all grasses was not significantly influenced by Farmyard manure during the first harvest (16 weeks). However the Farmyard manure was observed to significantly increase the tiller numbers, leaf area indices and biomass yield of the local and hybrid Napier grasses (Fig. 8, 9 and 10) during the second (22 weeks) harvest and the tiller numbers of the local napier grass alone during the third (28 weeks) harvest and the (Fig.9 and 10) during the second harvest (22 weeks).

The insignificant results during the first harvest might be attributed to the slow release of nutrients from the Farmyard manure which was aggravated by low moisture content especially during the short rain season. Mannelje (1992) reported that the Napier grasses require high levels of fertilizer and a regular water supply. The significant results during the second harvest (22 weeks) might be due to enough moisture content during the long rain season which created a conducive environment for soil microorganisms to mineralize the nutrients from soil organic matter and Farmyard manure and make them available for grasses uptake. Also manure could have raised the soil pH and created the favorable condition for optimum decomposition of Farmyard manure and soil organic matter and hence become available for forage plants uptake. These findings concur with those of Shokri (2005) who reported that the treatment with 200 kg N ha⁻¹ of sheep manure gave the highest dry matter yield (16 t ha⁻¹yr⁻¹) compared to the control (10 t ha⁻¹yr⁻¹). It was further reported that, the organic fertilizer either as sheep manure alone or as a combination with urea gave better growth performance of the Napier grass in terms of the tiller height, tiller number and leaf area index over 6 cycles of 6 weeks per cycle.

Moreover these findings harmonize with those of Frederiksen and Kategile (1980) who reported that without fertilizer application, a yield of about 3 t DMha⁻¹ of *Brachiaria brizantha* on a 10-year-old field while on fertilizer application, was raised to about 10 t DMha⁻¹. Also these findings correspond with those of Guiot and Meléndez (2005) who reported that, *Brachiaria mulato II* yielded 3.9 t DMha⁻¹ per harvest with an annual fertilization of 150 kg N and 50 kg P ha⁻¹.

Also the performance of all grasses alone and in combination with Farmyard manure reached the peak during the second harvest (22 weeks) and declined during the third harvest (28 weeks). The performance of grasses reached the peak probably due to favorable weather conditions of rainfall and temperature during the crop development

(Table 2). However, the grasses declined in performance during the third harvest probably due to unfavourable weather conditions which influence the growth and activities of decomposers which facilitate the mineralization processes from manure and soil organic matter (Table 2). Also low temperature (winter season) could have been the limiting factor as the C4 plants and are not adapted to such environment. These findings are in line with most incubation studies which suggest that, the optimum temperature for organic matter decomposition and nitrogen mineralization is in the range of 25-35°C (Ross, 1989). This range of temperature influences growth and activities of most decomposers such as bacteria, fungi and actinomycetes. Temperatures that are below or above this range will slow down decomposition processes (Troel and Thompson, 1993). The decline in yield could, also, had been due to low mean temperature (<15⁰C) (Table 2). These findings match with those of Simpson (2010) who reported that C4 plants geographically adapted well in the tropical and semi tropical high light intensity, high temperature and drought conditions.

5.3 Agronomic Performance of the three Grasses due to Influence of the Combined

Desmodium and Farmyard Manure

The combined Desmodium and Farmyard manure significantly increased the leaf area indices and the biomass yield of all grasses (Fig. 13 and 14) during the third harvest (28 weeks). This is probably due to the ability of Desmodium to fix atmospheric nitrogen which later became available to the companion plants due to root nodules exudation, decomposed shade off leaves and the additive effect of the Desmodium biomass as they reached maturity and harvested together with grasses. Also rising of soil pH level due to application of Farmyard manure which could have created the conducive environment for soil microorganism to survive and mineralize both Farmyard manure and the soil organic matter might have intensified the performance of the grasses. These

findings are parallel with the findings of Berdahl *et al.* (2001) who obtained the average DM yield of 8.7 and 2.71 t ha⁻¹ from the grass/lucerne mixture and sole grass treatments respectively. Similarly, Mureithi *et al.* (1995) reported a beneficial effect to Napier grass when grown together with *Leucaena* in the coastal lowland of Kenya. They recorded increased yield of Napier grass when planted adjacent to *Leucaena* hedgerows than sole Napier grass or napier grass growing away from *Leucaena*.

Moreover, these results are in agreement with the findings of Volatsara *et al.* (2012) who reported that the total DM and Protein digestibility in the small intestine (PDI) yields of mixture for a three years period were 93 and 9.4% respectively higher than those of the pure stand of *Brachiaria*. Furthermore, these findings are in line with FAO (2014) from Gulaca Panama which reported that where the mean annual rainfall is 3997 mm, *Brachiaria ruziziensis* grass's yielded 11.1 t DM ha⁻¹ without fertilizer and 27.0 t DM ha⁻¹ when fertilized with 600 kg N ha⁻¹ year⁻¹. Moreover, these results are in line with those of Hasyim *et al.* (2014) in the warm region of Japan who found that, the use of 5.05N (low), 10.08N (Medium) and 20.16N (High) of solid digested effluent of manure resulted into the yield of 800 gm⁻², 1600 gm⁻² and 2200 gm⁻² respectively of dwarf Napier grass. Also these outcomes are in agreement with those of Shahin *et al.* (2013) who revealed that nitrogen fertilization in pearl Millet at the rate of 0N, 30N and 60N at 10 cm cutting height resulted in annual yield of 0.81 t fed⁻¹, 1.57 t fed⁻¹ and 2.6 t fed⁻¹, leaf area indices of 1.89, 3.09 and 5.63 and tiller heights of 81.92 cm, 101.80 cm and 121.9 cm and tiller number of 64.75 till m⁻², 74.04 till m⁻² and 82.5 till m⁻².

Elsewhere, these findings concur with Hiroshi (2013) in the semi-arid tropical region of India who showed that the dry matter yield of sweet Sorghum (*Sorghum bicorlar*) increased by 16.15% and 40% when Nitrogen was applied at the rate of 30N and 150N per year respectively over the control.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the study results and subsequent discussion, the following conclusions are made on the influence of Desmodium and Farmyard manure on the agronomic performance of napier and brachiaria forage crops at Ubiri Village in Lushoto District.

- i. Local and hybrid napier and hybrid Brachiariagrasses performed better when in integration with Desmodium than when alone. Therefore, the integration with Desmodium improves the agronomic performance of grasses.
- ii. The supplementation with Farmyard manure significantly improved the agronomic performance of the local and hybrid Napier and hybrid Brachiaria forages.
- iii. The local and hybrid Napier and hybrid Brachiaria grasses performed best agronomically when under the combination of interactive influence of Desmodium and with the supplementation of Farmyard manure. Thus the interactive effects of the combined Desmodium and Farmyard manure become the best option to improve the agronomic performance of the grasses.
- iv. The biomass yields of the local and hybrid Napier and hybrid Brachiaria grasses declined (particularly when alone or with Farmyard manure) with decrease in temperature below 15⁰C. Therefore, both grasses are not tolerant to low temperature which is the common characteristic of most C4 plants.

6.2 Recommendations

Based on the preceding discussion and conclusions the following recommendations are made for the improvement of smallholder livestock keepers.

- i. The integrating of either or both of the Desmodium and Farmyard manure on local and hybrid Napier and hybrid Brachiaria grasses by the smallholder livestock keepers of Lushoto District should be encouraged so as to maximize the production of the forages and therefore, the proper solution of animal feed shortage.
- ii. The new hybrid Napier cultivars should be introduced in Lushoto District in order to solve the problem of animal feed shortage as the already introduced hybrid appeared to underperform in contrast to the local Napier.
- iii. The hybrid Brachiaria grass appeared to be more prone to soil moisture stress particularly during establishment phase. Hence planting of the hybrid Brachiaria grasses should be done during the long rain seasons which are more reliable than the short rain seasons. Nevertheless for the optimum establishment during the short rain season irrigation of seedlings/ cuttings/splits should be done for two or three weeks.
- iv. New forage cultivars which are tolerant to low temperature condition for example dwarf Napier grass should be introduced so as to supplement animal feed shortage during cold weather condition.
- v. Hay or silage making technology should be emphasized to the small holder farmers in order to ensure animal food security particularly during the adverse weather condition.

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APPENDIX

Appendix 1: Anova tables for first, second and third harvest at Ubiri village in

Lushoto District

(a) Anova table for first harvest

(i) Dependent variable: Tiller height (m)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	0.06145	0.030726	7.02	
Fertilizer	3	0.0403	0.013434	3.07	0.049
Variety	2	1.90865	0.954326	218	<.001
Fertilizer.Variety	6	0.0071	0.001182	0.27	0.945
Residual	22	0.09631	0.004378		
Total	35	2.11381			

(ii) Dependent variable: Tiller number

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	129.5	64.75	5.13	
Fertilizer	3	142.89	47.63	3.77	0.025
Variety	2	1137.5	568.75	45.04	<.001
Fertilizer.Variety	6	12.28	2.05	0.16	0.984
Residual	22	277.83	12.63		
Total	35	1700			

(iii) Dependent variable: Leaf area index

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.04904	0.02452	0.64	
Variety	2	5.07927	2.53964	66.48	<.001
Fertilizer	3	0.38752	0.12917	3.38	0.036
Variety.Fertilizer	6	0.11793	0.01965	0.51	0.791
Residual	22	0.84043	0.0382		
Total	35	6.47419			

(iv) Dependent variable: Biomass yield (t/ha)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	0.01707	0.00854	0.73	
Fertilizer	3	0.12897	0.04299	3.69	0.027
Variety	2	6.56425	3.28212	281.49	<.001
Fertilizer.Variety	6	0.03704	0.00617	0.53	0.78
Residual	22	0.25651	0.01166		
Total	35	7.00385			

(b) Anova table for second harvest**(i) Dependent variable: Tiller height (m)**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	0.28467	0.14234	4.65	
Fertilizer	3	0.22268	0.07423	2.43	0.093
Variety	2	3.97874	1.98937	65.01	<.001
Fertilizer.Variety	6	0.06224	0.01037	0.34	0.909
Residual	22	0.67326	0.0306		
Total	35	5.22159			

(ii) Dependent variable: Tiller number

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	270.5	135.25	1.92	
Fertilizer	3	449.22	149.74	2.12	0.126
Variety	2	3904.17	1952.08	27.67	<.001
Fertilizer.Variety	6	324.94	54.16	0.77	0.603
Total	35	6501			

(iii) Dependent variable: Leaf area index

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	1.028	0.514	3.23	
Variety	2	12.7418	6.3709	39.98	<.001
Fertilizer	3	5.2575	1.7525	11	<.001
Variety.Fertilizer	6	1.7531	0.2922	1.83	0.139
Residual	22	3.5061	0.1594		
Total	35	24.2865			

(iv) Dependent variable: Biomass yield (t/ha)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	0.144	0.072	4.73	
Fertilizer	3	2.34224	0.78075	51.33	<.001
Variety	2	15.28335	7.64168	502.4	<.001
Fertilizer.Variety	6	0.87104	0.14517	9.54	<.001
Residual	22	0.33463	0.01521		
Total	35	18.97526			

(c) Anova table for third harvest**(i) Dependent variable: Tiller height (m)**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	0.05341	0.0267	2.64	
Fertilizer	3	0.13007	0.04336	4.29	0.016
Variety	2	1.70536	0.85268	84.35	<.001
Fertilizer.Variety	6	0.03667	0.00611	0.6	0.724
Residual	22	0.22239	0.01011		
Total	35	2.14789			

(ii) Dependent variable: Tiller number

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	952.7	476.3	2.83	
Fertilizer	3	1445.1	481.7	2.86	0.06
Variety	2	8461.2	4230.6	25.11	<.001
Fertilizer.Variety	6	285.1	47.5	0.28	0.939
Residual	22	3706	168.5		
Total	35	14850			

(iii) Dependent variable: Leaf area index

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	0.2912	0.1456	0.48	
Fertilizer	3	20.7913	6.9304	22.95	<.001
Variety	2	8.8856	4.4428	14.71	<.001
Fertilizer.Variety	6	2.127	0.3545	1.17	0.356
Residual	22	6.6442	0.302		
Total	35	38.7393			

(iv) Dependent variable: Biomass yield (t/ha)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications	2	0.23217	0.11608	2.72	
Fertilizer	3	3.93706	1.31235	30.79	<.001
Variety	2	3.46325	1.73162	40.63	<.001
Fertilizer.Variety	6	0.11217	0.01869	0.44	0.845
Residual	22	0.93773	0.04262		
Total	35	8.68236			