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Wanda I. Lugo, Héctor L. Santiago, Rohanie Maharaj, and Wilfredo Colón

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Secretariat CFCS
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Agricultural Experiment Station
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TROPICAL FORAGES MULATO II GRASS (*BRACHIARIA* HYBRID, CIAT 36087) AND FORAGE SORGHUM (*SORGHUM BICOLOR*) FOR SILAGE CONSERVATION AND SHEEP PRODUCTION IN ST. KITTS AND NEVIS

S. Borucki[2], A.. Hosein,[1] I. Watts[3], J. Berry[3], and L.E. Phillip[2]. [1]Caribbean Agricultural Research and Development Institute (CARDI), Trinidad and Tobago Unit; [2]Animal Science Department, Faculty of Agricultural and Environmental Sciences, McGill University, Montreal Canada; [3]Department of Agriculture, Ministry of Agriculture and Marine Resources of St. Kitts and Nevis

ABSTRACT: Poor nutrition is a major factor limiting the productivity of small ruminants in St. Kitts and Nevis as well as in the wider Caribbean region. Inadequate quantity and quality of natural pastures during the dry season is a major constraint limiting the local supply of sheep and goat meat. The objectives of this study were the establishment of drought-tolerant, high-yielding crops capable of good quality forage that could also be preserved as silage for year-round feeding of small ruminants. Two hectares of Mulato II grass (*Brachiaria* hybrid CIAT 36087) were planted in the dry season during February 2012, with a re-seeded section during April 2012. Forage yield after 12 weeks of successful establishment was 4,783 kg of dry matter (DM) per ha. In July the Mulato grass was harvested and conserved as silage in 153 plastic bags of 20 kg and 550 silage bags of 11 kg, for a total yield of 10,317 kg fresh ensiled material per ha. During the wet season after 3.5 weeks of re-growth, the Mulato grass produced 10,465 kg DM/ha, 2.2 times more forage compared to the dry season. For the forage sorghum (*Sorghum bicolor)*, two cycles of Great Scott brown mid-rib were established and harvested: one in the dry season and the other in the wet season, March to May 2012 and November to January 2013, respectively. During the dry season the forage sorghum produced 1,870 kg DM/ ha with 81-day of growth, whereas in the rainy season, the forage sorghum produced 1.8 times higher, 3,429 kg DM/ha, with 53-day of growth. Successful establishment in the dry season and forage production during both the dry and wet season proved that Mulato grass and forage sorghum are valid forage options for small ruminant production under the Caribbean weather conditions, with the potential to increase farmers' income and provide year-round meat protein sources for these communities.

Keywords: mulato grass; forage sorghum; silage conservation.

Introduction

Small ruminants can help address some of the causes of food insecurity. They are considered "micro-credit" for small farmers because they could be used as sources of food, fibre or sold anytime as a source of income (Sinn *et* al., 1999). Sheep and goats utilize feeds cut and carried from a wide variety of herbage (bushes and trees), and they could readily graze on crop residues, food wastes and agricultural by-products. They are ideal in mixed grazing systems, being able to utilize a wide variety of landscapes. The investment costs are lower compared to cattle which is ideal for limited resource families of the rural sector.

In St. Kitts and Nevis, the agriculture sector was historically dominated by sugar production, but the industry experienced a continuous decline in the last three decades and the Government decided to close it in 2005. In this framework, the Ministry of Agriculture and Marine Resources of St. Kitts (MAMR) and the Inter-American Institute for Cooperation in Agriculture IICA, developed the Agricultural Development Strategy (ADS) in 2006, with three major program components: livestock, crops and fisheries (IICA 2011). The aim of the livestock program is to transform livestock into a competitive sector through increased productivity, lower costs of production and improved carcass quality.

St. Kitts and Nevis together with most CARICOM countries is a net importer of sheep and goat meat products, with a domestic production of only 12% of national consumption needs (Stanley, 2010). The trend indicates that the consumer demands for meats and meat preparations derived from small ruminants are strong and expected to expand with growing incomes and continued growth of the tourism sector. However, significant improvements in the production systems are required to improve their competitiveness and their contribution to the food supply.

In St. Kitts as in many Caribbean islands, one of the major factors limiting productivity of small ruminants is poor nutrition. Insufficient forage during the dry season is a major constraint to ruminant productivity. Natural pastures cannot support the desired productivity of sheep and goats limiting the capacity to a certain level and for a short period of time. Cultivated pasture or forage banks are required with the aim to improve forage yield and nutritive value of the native grasses. The plane of nutrition must be considered in any strategy to increase reproductive performance (conception rate, neonatal losses), growth, health (disease control) and overall productivity (milk, final weight).

Given the continued high world grain prices, the focus on forage-based feeding systems for small ruminants is imperative. Management strategies involve the selection of varieties adapted to the dry season that would increase the amount and quality of forage, together with conservation techniques and by- product supplementation strategies in period of shortages. The Caribbean Agricultural Research and Development Institute (CARDI) Research Program promotes forage species like the 'Mulato' grass (*Brachiaria spp.*) in the region (Gibson and Hosein, 2008; CARDI 2011). This forage crop is easy to sow and establish, and is well adapted to the regional weather conditions. It is attractive because it provides quality and quantity of biomass and the stools are well rooted so it helps prevent livestock overgrazing and destruction of natural pastures (erosion and biodiversity loss). Areas of abandoned sugar cane in St. Kitts and Nevis could be efficiently used. Natural legumes trees and shrubs in the area (*Leucaena leucocephala, Gliricidia sepium*) that are normally used as fences, would provide pruned branches and leaves rich in protein to supplement the small ruminants diet (Asiedu and Fearon, 1994).

Technologies aimed at transferring a high production of the forage during the wet season towards the dry season must also be developed (Asiedu et al. 1997). Harvesting for hay is difficult and sometimes not possible and the option for conserving grasses is ensilage (Titterton and Bareeba, 1999). Tropical grasses and legumes are not ideal ensilage material, largely because at cutting they have a low level of the water soluble carbohydrates which are essential for successful ensilage (Buxton and O'Kiely, 2003). Alternative crops, such as grain sorghum or forage sorghum which are drought tolerant yet high yielding, have been investigated as silage crops and found to be suitable (Bolsen et al., 2003).

Objectives

General

Increase the quantity and quality of forage production year round to meet the nutrient requirements of sheep thereby increasing the productivity and market stability of small ruminants in St. Kitts. Introduce the "drum" silage technique to conserve the forages from periods of high production (wet season) and use them in periods of low production (dry season).

Specific

To evaluate the establishment and production of both Mulato II grass and Forage Sorghum using adequate pasture management practices.

To evaluate the silage produced by both Mulato grass and Forage sorghum using the "drum silage" conservation technique.

Materials and Methods

Agronomic Practices

First Cycle. 2012 Forage Sorghum

Two has of Great Scott brown mid-rib (BMR) Forage Sorghum were seeded in March 2nd, 2012, at a rate of 22.4 kg/ha in rows separated by 0.6 m. A tractor drawn trail harrow and spring rake were used for land preparation. The land was leveled and the stones and boulders on the soil were removed to avoid breaking the harvester blades. At 52 days growth, 227 kg of NPK (15:15:15) was applied. A severe weed infestation was observed, with the majority of the plants stunted and with a degree of yellowing on the NW side of the field. About 30-40% of the weeds were Guinea grass, and local weeds as "Mussambay".

The Forage Sorghum was harvested between 80 and 90 days of growth producing 6,789 kg fresh forage/ha (1,870 kg dry matter, DM) at the milk dough stage (30% DM). A New Holland flail harvester Model 38 (Growers Equipment, Davies, FL) was used to harvest the forages; the bar holding the blades was raised to a height of approximately 30 cm to allow for clearance of any stones in the field and avoid soil contamination of the chopped forage The chop length was 5 – 16 cm with optimum DM evidenced by hand-squeezing a sample of the chopped material for 1 minute and no water was found to be dripping, and the forage sprung back quickly to its original form.

Silage Making Process

The Forage Sorghum was harvested and filled into plastic bags (drum liners) using a split drum as a "mould". The size of the bag was 0.6 m diameter of base and 1.2 m tall. The drum was filled with forage and primary packing was done by stomping the forage inside the drum by feet. The final compaction was done using a mechanical compactor (Pack-Master, S&G Enterprises Inc. Germantown, WI). Mechanical compaction was a very slow process and rendered silage bags only 2-4 lb heavier. Most of the bags were then compacted by

feet stomping. The end of the bag was twisted to tightly remove all air inside the bag and the closure secured with strong twist ties. A total of 325 bags of silage were completed with an average bag weight of 73 kg (160 lb). The process required extreme caution to avoid puncturing the silage bags. Farmers were requested to store the bags over a gravel base protected with a surrounding area of lime (calcium hydroxide) to avoid rodents. Silage bags were stacked in a pyramid shape to a height with no more than 3 layers. The bags were covered with a green tarpaulin to avoid the condensation and sunlight on the bags.

2nd Cycle. 2012-13 Forage Sorghum (Section D)

One ha was harrowed, fertilized with 110 kg/ha of urea and seeded with Great Scott BMR in November 2nd at a rate of 22.4 kg seed/ ha in rows 0.6 m apart. A spray insecticide (Newmectin, abamectin; MAI-Caribbean Ltd.) was applied to the plant (250 ml/ha) in December 11th. A post-emergent, broad-leaf herbicide was also applied at a rate of 4.4 ml/L (2,4-Dichlorophenoxyacetic acid, 2,4-D). This section was harvested during the period of January 22-23, 2013 and 1,814 kg of fresh forage material were bagged in 160 bags of 11,3 kg (25 lb).

Mulato II Grass

Establishment

Two has of Mulato II grass (Brachiaria hybrid CIAT 36087) were planted in February 3rd of 2012. The land was harrowed with a tractor drawn trail harrow and leveled. The stones and boulders on the soil were removed to avoid breaking the harvester blades. Mulato II was seeded at a rate of 11 kg/ ha in rows 0.6 m apart. Dry weather conditions and a low germination rate (35%) caused a high degree of weed infestation.

As a field demonstration exercise, 0.40 has (1 acre) of Mulato II was re-seeded at Belle Vue on April 19, 2012. The field was ploughed, fertilized with NPK 20:10:10 at a rate of 110 kg/ ha and rotovated to a fine tilth. Prowl was applied at a rate of 7.7 ml/L as a pre-emergent herbicide (pendimethalin) two weeks before seeding. The seeding rate was increased to 18kg /ha to compensate the low germination rate in rows 0.6 m apart. A beet seed plate was used and the seeder was adjusted to 3.8 cm. Moisture was ensured after two days of seeding using a fire truck as a temporary irrigation system. On June 2nd and June 13, 2012, a post-emergent, broad-leaf herbicide was applied at a rate of 4.4 ml/L (2, 4 D; 2,4-Dichlorophenoxyacetic acid). Fertilization with 110 kg/ ha of NPK (15:15:10) was applied with the rain split one month apart. A contact non-selective herbicide was applied (Paraquat; 1, 1'-dimethyl-4,4'-bipyridium-ion dichloride) between rows in July, only under no-wind conditions to avoid spray drift onto the crop.

The Mulato grass was divided into different areas and harvested or brush cut based on experimental needs. It was harvested for silage preparation between July 2012 and February 2013, following the same procedure as that for the Forage Sorghum. After the forage harvest or brush cut, the Mulato was fertilized with 110 or 224 kg/ha of NPK (15:15:15) or 67 lb to 300 kg/ ha of urea based on the conditions of each section, after rainy periods. The sections were examined for weeds and 2, 4 D (phenoxy/ phenoxyacetic acid) was applied targeting broad-leaf weeds.

Silage Preparation

The Mulato II grass harvested material was packed in a 0.76 m diameter plastic container with a height of 0.6 m, with the aim of producing smaller silage bags for easier handling.

Forage Sampling and Analysis

The sampling was based on the homogeneity of the sward, and divided by sections A'B'C' in the Mulato II, and D'E' in the Forage Sorghum. A plastic quadrat of 0.46 x 0.46 m was used for measurements and sampling for Mulato II and a quadrat of 0.90 x 0.90 m was used for Forage Sorghum. Samples were taken by walking across the field using imaginary lines joining fence posts. The quadrat was placed on the ground every 30 paces and all the plants within the quadrat were counted as well as the number of tillers in the case of the Forage Sorghum. The material was sampled cutting 15.2 cm from the ground for Mulato II and 22.8 cm for the Forage sorghum, removing any soil attached to the plant. The fresh weight was taken and the samples placed in an oven to dry for two days at 65^0 C and the dry weight recorded. The scale used was an AWS Blade digital scale. Also, measurements of height and stem diameters were taken from three randomly selected plants within the quadrat and the averages calculated. The sorghum coverage within the quadrat was estimated visually. Other observations included: plant physiological state, presence of diseases or pests, general health of the sward. Samples were taken March 01, May 21, July 10, August 22, September 05 and December 18, 2012.

Results and Discussion

Forage Establishment

The first cycle of Forage Sorghum was established in the dry season, with a higher seed planting density than recommended (25 vs. 10 kg/ ha), and with no irrigation. This caused a high degree of weed infestation and reduced the Forage Sorghum yields. The evolution of the area covered by sorghum was better in the wet season (cycle 2), but only 50% of the area was covered by Forage Sorghum plants (Table 1). The plants never achieved the height potential (2 m) for this variety (Bean et al. 2010); the maximum height was no greater than 0.90 m. This is primary because of the lack of soil moisture and the low fertility status of the soils.

The Mulato II grass first seeded in February 2012 was not successfully established and a strategic re-seeding of a 30% of this area was effective in mid-April. The evolution of establishment was slow; it took seven months from March to September to cover 98% of the soil for Mulato II grass (Figure 1, Table 2). Some of the areas still have some patches of bare soil and weeds, but in general the Mulato II grass was successfully established considering that seeding was done in the dry season.

Biomass production and conservation

Forage sorghum

The first cycle of Forage Sorghum produced 1,870 kg dry matter/ha (DM) and 6,789 kg fresh forage/ha were harvested at a milk dough stage (30% DM) with 84 days of growth during the dry season – March to May 2012 (Figure 2). For the second cycle Forage

Sorghum (2012-2013) D' section was harvested in January 22 and 23, 2013 (81 days of growth) producing an estimate of 6,299 kg DM/ ha (Figure 3), 3.6 times higher compared to the dry season cycle one. Another section E' which was seeded a month later, produced only 2,307 kg/ha DM and it was harvested at 71 d of maturity. This area was seeded with a lower density to avoid volting, following the company's advice, but suffered more pest damage by worms and monkeys. Local wild primates have apparently discovered the sweetness of the Forage Sorghum stalks and developed a taste for sorghum grains. The estimated damage was 20 to 25% of the field. Research plots for Forage Sorghum Great Scott BMR (Bean et al. 2010) show a potential yield of 26,697 kg of DM/ha, under optimal conditions with irrigation. Only 23% of this variety's production potential was achieved (Section D') in January 22, 2013.

The Forage Sorghum re-growth was analyzed for both cycles but the biomass produced was not encouraging (see Figures 2 and 3). Cycle One produced 352 kg DM/ha re-growth after 50 d of harvest, whereas the cycle two (Section D') produced 674 kg DM/ha of re-growth after 23 d of harvest. The Great Scott BMR variety was selected because of its good quality for forage conservation, disregarding any re-growth capability. The first cycle of forage sorghum was harvested with a chop length of 5 – 16 cm, and was ensiled into 325 silage bags of 73 kg (160 lb). For the second cycle only 1,814 kg of fresh harvested material was ensiled (Section D') in 160 bags of 11.3 kg (25 lb), and 1,428 kg fresh were ensiled (Section E') in 126 bags of 11.3 kg (25 lb). The silage was well prepared based on the pH measurements obtained for the first month (Table 3).

Mulato II Grass

Mulato II grass biomass production is presented in Figure 4. The establishment occurred in a harsh dry season (12 weeks April through June, 2012) were the Mulato II grass achieved a production of 4,783 kg DM/ha. After harvest in July 27, during the re-growth in 2012 wet season, the Mulato II grass produced 15,286 kg DM/ha in 6 weeks (Sections B', A') 12,771 kg DM/ha (Section C') and the maximum achieved for the wet season was 17,424 kg DM/ha growth (Section C) for a period of 12 weeks (July 27 to October 26). This biomass production is comparable and exceeds those results found in research plots for 6 weeks: 13,354 kg DM/ha, at the Sugarcane Feeds Centre (SFC) in Trinidad and Tobago (CARDI, 2008).

The total amount of silage prepared from the 2 has of Mulato II grass was 14,308 kg of fresh forage. Mulato II Section C' was harvested for silage preparation during the period July 24-27, 2012, and the forage was conserved in 153 bags of 20.4 kg (45 lb) for a total of 3,121 kg fresh conserved. Section A' was ensiled from November 1 to 15, 2012, producing 550 silage bags of 11.3 kg (25 lb) (6,215 kg conserved). In 2013, Section B' was harvested in February 10, producing 440 silage bags of 11,3 kg (25 lb), with a total of 4,972 total kg conserved. The silage was well prepared based on the pH measurements obtained for the first months (Table 4). The first ensiled harvest (July 2012) presented very good preservation characteristic based on pH measures obtained at 6 and 7 months from harvest. The second harvest (November 2012) also shows very good pH measures and signs of very good preservation. On the last harvest of Mulato II grass, however (February 2013) one of the batches is clearly spoiled based on pH measures higher than 6. This is a clear symptom that the acidic processes characteristic of normally ensiling did not happen and the forage spoiled. This case is under investigation.

Conclusions

Both Mulato II grass and Forage Sorghum forage crops were successfully established in the dry season 2012 in St. Kitts and Nevis, showing promising establishment and production potential for ruminant species in the Caribbean Region. Both forages increased their yields in the wet season producing a surplus of forage that was conserved using the silage technique.

Mulato II grass was able to cover 98% of the soil in 20 weeks, producing similar yields for the wet season comparable to results obtained at Research Stations in the Caribbean. Mulato II grass proved its potential to produce a total of 54,700 kg DM/ ha a year. Forage Sorghum seeding and growing conditions resulted in only a 50% coverage of the area, producing 3.6 times higher kg of DM biomass/ ha (6,299) when seeded in the wet season compared to the dry season (1,870). We only achieved 23% of this Forage Sorghum variety's potential, so there is still room to improve the management practices on this forage crop. Both Forage Sorghum and Mulato II grass proved to be successfully conserved using the silage technique, with optimal pH obtained after 6 months of storage.

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References

Asiedu, F. H. and L. Fearon. 1994. Biomass and nutritive value of leucaena edible forage of different stem diameters. Proceedings of the Caribbean Food and Crops Society. Vol 30: 150 – 155.

Asiedu, F. H. K., C.A. Alexander and G. Proverbs. 1997. Ensilage for low resource farmers. 1. Drum, wirebasket and pit as silos. Proceedings of the Eighteenth International Grassland Congress, Winnipeg, Canada, 8-17 June 1997. Session 14 - Post Harvest Management

Bean, B., McCollum, T., Becker, J., Blumenthal, J, Robinson, J., Brandon, R., Buttrey, E., VanMeter, R., and D. Pietsch 2010. 2010 Texas Panhandle Forage Sorghum Silage Trial. AgriLife Extension and Research Series. Available online: http://amarillo.tamu.edu/amarillo-center-programs/agronomy/forage-sorghum/

Bolsen, K. K. , K. J. Moore, W.K. Coblentz, M.K. Siefers and J.S. White.2003. Sorghum Silage. In: Silage Science and Technology. Chapter 13, pages 609 – 632.

Budhram, D., M. Edwards V.Little A. Merchant and K. Phillip. 2006. St. Kitts Agricultural Development Strategy. Inter-American Institute for Cooperation on Agriculture (IICA) Report presented to the Ministry of Housing, Agriculture, Fisheries and Cooperatives.

Buxton, D.R. , and P. O'Kiely. 2003. Preharvest plant factors affecting ensiling. In: Silage Science and Technology. Chapter 5, pages 199 – 250.

CARDI 2008. Caribbean Agricultural Research and Development Institute. Trinidad and Tobago Highlights 2007/08. Trinidad and Tobago Unit. PSC Number TT//002//09. Available Online. http://www.cardi.org/cardi-publications/virtual-library/

CARDI. 2011 Caribbean Agriculture Research and Development Institute. Small Ruminants Program http://www.cardi.org/commodities-themes/small-ruminants/

Gibson N and Hosein A. 2008 Introducing Mulato II: an improved forage for the Caribbean. CARDI Factsheet TT/008/08. St. Augustine, Trinidad and Tobago. Caribbean Agricultural Research and Development Institute. Available Online. http://www.cardi.org/cardi-publications/factsheets/livestock/

Inter-American Institute for Cooperation on Agriculture IICA. 2011. IICA Technical Cooperation Strategy for St. Kitts 2011 – 2014. Available online.
http://www.iica.int/Eng/regiones/caribe/ECS/IICADocuments/Strategies-STKITTS.pdf

NRC 2007. Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids and New World Camelids. by National Research Council (U.S.) Committee on Nutrient Requirements of Small Ruminants. National Academy Press. Washington DC.

Scott Seed Co. 2012. Brown Midrib Hybrids. Great Scott BMR Factsheet. Available Online. http://scottseed.net/index.cfm?show=10&mid=42

Singh, R.H., G. Seepersad and L.B. Rankine. 2006. The Small Ruminant Meat Industry in CARICOM. Competitiveness and Industry. Development Strategies. Executive Summary. The CARICOM regional Transformation Program for Agriculture. Available online.http://www.caricom.org/jsp/community/donor_conference_agriculture/small_ruminants_competitiveness_development_strategy.pdf

Sinn, R. J. Ketzis and T. Chen. 1999. The role of woman in the sheep and goat sector. Small Rum. Res. 34: 259 – 269

Stanley. A. 2010. 2009 Annual Review. Department of Agriculture of St. Kitts. Available online. http://www.stkittsipa.org/reports_statistics.asp

Titterton, M and F.B. Bareeba. 1999. Grass and legume silages in the tropics. In: Silage Making in the Tropics with Particular Emphasis on Smallholders. Plant Production and Protection No. 161. Food and Agriculture Organization of the United Nations. Paper 4.0. Available online.
http://www.smallstock.info/reference/FAO/005/X8486E/X8486E00.HTM#Contents

Table 1. Establishment parameters for FORAGE SORGHUM Section D from December 2012 to February 2013.

Status/ Management	DATE	Days of growth	Sample n	Height (cm)	Tillers (#)	(%) Area covered by the plant	(%) Area covered by weeds (dry or fresh)	(%) Bare soil	(%) Dry matter (DM)
vegetative	4-Dec	32	8	51 ± 12.4	0 -	25% ± 27.0	64% ± 33.0	11 ± 33.0	16 ± 2.5
initial bloom	18-Dec	46	6	81 ± 22.8	6 ± 4.3	45% ± 32.6	55% ± 32.6	0 -	19 ± 0.9
full bloom	8-Jan	67	6	127 ± 19.1	11 ± 4.2	53% ± 16.3	47% ± 16.3	0 -	28 ± 5.8
harvest	22-Jan	84	6	104 ± 8.9	16 ± 8.9	53% ± 24.0	48% ± 24.0	0 -	35 ± 1.0
re-growth	14-Feb	22	11	- -	- -	57% ± 13.5	43% ± 13.5	0 -	- -

Figure 1. Establishment evolution (% of area covered) of MULATO II GRASS Sections A,B,C from March to October 2012.

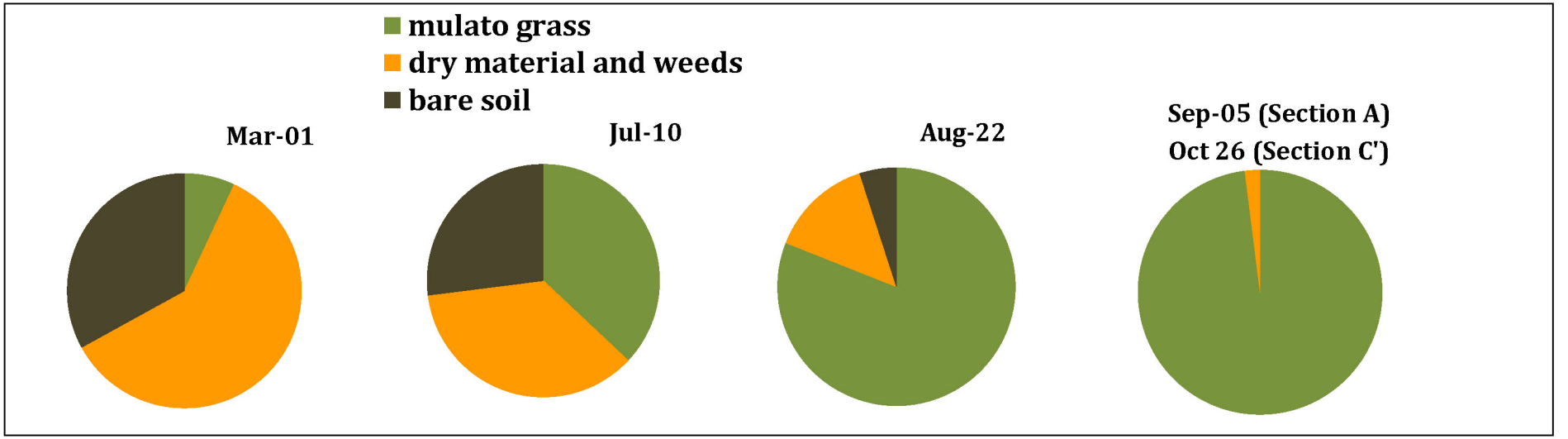

Table 2. Establishment parameters for different sections of MULATO II GRASS from July to October 2012

Date	Mulato II Grass Section	Sample n	Height (cm)	(%) Area covered by forage	(%) Area covered by weeds (dry or fresh)	(%) Bare soil
10-Jul	A	4	66 ± 32.0	30% ± 15.8	29% ± 21.7	41% ± 23.2
10-Jul	B	6	46 ± 36.6	28% ± 34.6	38% ± 30.3	35% ± 31.4
10-Jul	C	8	56 ± 45.5	52% ± 43.8	50% ± 40.1	12% ± 11.5
22-Aug	A	4	61 ± 11.4	92% ± 8.1	8% ± 8.1	0% -
22-Aug	B	6	81 ± 8.4	82% ± 14.4	13% ± 10.4	7% ± 4.5
22-Aug	C	8	86 ± 17.3	71% ± 26.7	27% ± 26.4	7% ± 5.8
5-Sep	A	4	99 ± 5.3	99% ± 2.5	5% ± 0	0% -
5-Sep	B	2	89 ± 1.8	58% ± 10.6	43% ± 10.6	0% -
26-Oct	C	4	84 ± 14.9	98% ± 5.0	3% ± 5.0	0% -

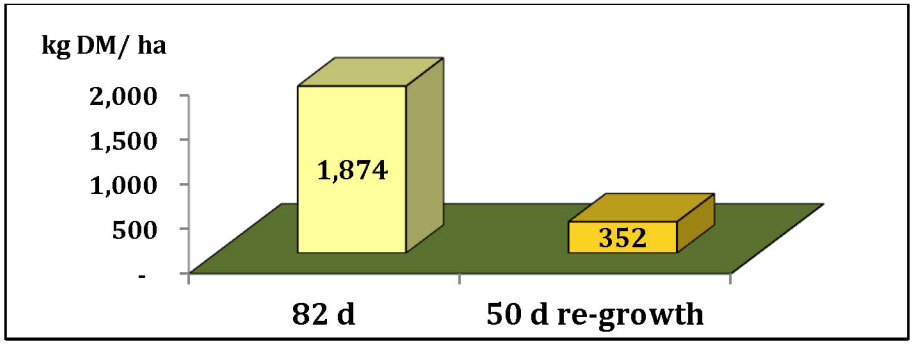

Figure 2. Biomass productio FORAGE SORGHUM Cycle One. Dry Season 2012.

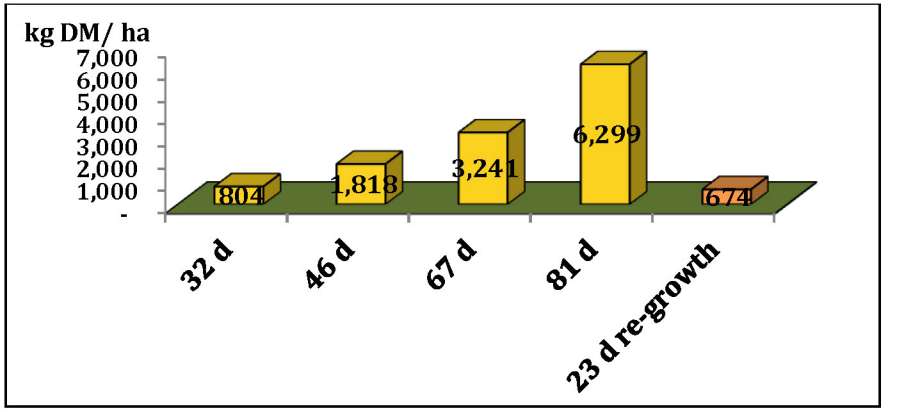

Figure 3. Biomass production FORAGE SORGHUM Cycle Two (Section D'). Wet Season 2012-13.

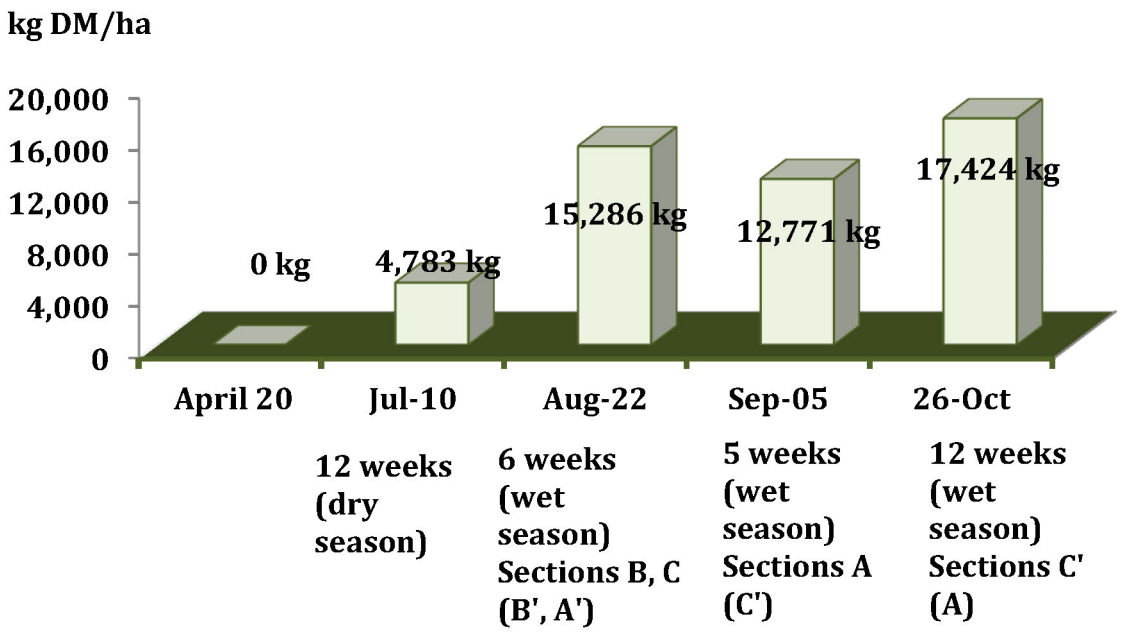

Figure 4. Biomass Production MULATO II GRASS during the dry and wet season 2012. April to October. Sections A, B, C.

Table 3. FORAGE SORGHUM Silage Conservation pH measurements.

Date of silage preparation	Date of Measurement	Days of silage conservation	Sample #	**pH**	Conditions of preservation
May 24, 2012	July 10, 2012	1 month	3	4.21	very good
January 22, 2012	February 20, 2013	1 month	5	4.33	very good

Table 4. MULATO II GRASS Silage Conservation pH measurements.

Date of silage preparation	Date of Measurement	Days of conservation	Batch (if present)	Sample #	**pH**	Conditions of preservation
July 27, 2012	Sept. 20, 2012	1 month	-	5	5.64	acceptable
July 27, 2012	Jan. 22,2013	6 months	-	5	4.47	very good
July 27, 2012	Feb. 20, 2013	7 months	-	5	4.5	very good
Nov. 10, 2012	Jan. 22,2013	2 months	1	5	4.6	good
Nov. 10, 2012	Jan. 22,2013	2 months	2	5	4.95	good
Feb. 2013	Feb. 20, 2013	3 weeks	1	5	4.32	very good
Feb. 2013	Feb. 20, 2013	3 weeks	2	5	8.32	spoiled