Is There an Alternative to Napier Grass? Matching Genetic Resources to Meet the Demands of Smallholder Farmers



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Civilization as it is known today could not have evolved, nor can it survive, without an adequate food supply. –Norman Borlaug

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Acknowledgements

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Introduction

Pennisetum purpureum, more commonly known as Napier grass, is an important forage due to its high yields, ease of propagation, and broad ecological adaptation. It originated from central Africa and is commonly used by many farmers today because of its growth rate, drought tolerance, and most importantly, its yield. It is highly popular with smallholder farmers, and therefore they devote their cropland to this tropical grass, and while most raise the grass for their cattle, it is also becoming common to find farmers selling the herbage on the open market. With an average crude protein content of 9% and fresh weights close to 40 tons per hectare, it is an easy favorite for many farming systems in Africa. It serves as a main feed for dairy systems and a survey by Lekasi (2000) in Kenya reported that farmers commit 21-28% of their land to Napier grass production.

There is a problem currently affecting many smallholder dairy farms throughout Eastern Africa, two diseases, Napier Stunt and Smut. For this reason, when a disease strikes farmers may lose everything. There are currently studies going on to find disease-resistant Napier grass accessions; however, the farmer's land is suffering poor yields at harvest today. Our objective is to look at the productivity and nutritional quality of eight different tropical grass species to see if any compare in yield/nutrition, and could be accessible to farmers where disease is widespread. Our hypothesis is that none of the grasses will come anywhere close to being an adequate alternative in yield to Napier grass; there will be some grasses with high nutritional value anf reasonable yield, but farmers will care mostly about what can make them the most money, whether it be through nutritional value or the biomass of the grasses.

Tropical Grass Productivity and Nutritional Quality

The yield of tropical grasses is measured by fresh weight and dry weight. In most cases you use dry weight for calculations involving nutrition for animosity when comparing results from different environmental conditions and moisture in other regions around the world. The yields of tropical grasses depend on many factors; most importantly, soil fertility and environmental conditions. While there may be a grass in Australia that yields 50 DM t/ha, in Kenya that same grass may yield around 12 DM t/ha. It not only depends on the season grown, but also the soil type and pH, planting methods, cutting intervals, leaf/stem ratio, spread and bushiness, and genetics in general. There are also ways to improve yield involving irrigation, fertilization, and pest control. These systems have not only become popular, but are a vital part of agricultural systems in many developed countries. For the developing countries, however, these advancements are out of reach due to high costs and little accessibility by the rural poor.

"The amount of energy forage contributes to a ruminant diet is arguably the single most important factor in predicting animal performance" Hoffman!!!! (1). There are many factors involving nutritional analysis that help estimate the energy content of grasses, ranging from Total Digestible Nutrients to Acid Detergent Fiber. The values we considered when analyzing the nutritional quality of tropical grasses were as follows: Dry Matter (DM), Ash (ASH), Crude Protein (CP), Acid Detergent Fiber (ADF), lignin (ADL), and Neutral Detergent Fiber (NDF). As stated earlier, Dry Matter is the total weight of the feed without the weight of water and this value is expressed as a percentage. Ash represents the minerals that are vital for an animal's survival and function; the minerals it represents include: calcium, phosphorus, sodium, magnesium, potassium, sulphur, and chlorine. By finding the total amount of nitrogen present, we can also find the CP, however if there is a high amount of urea or ammonia present, that can alter the results because they are a non-protein nitrogen. Next is ADF, which is "the fibrous, least-digestible portion of roughage. . . consisting of indigestible parts of forages" such as lignin and cellulose. As ADF values increase, digestible energy levels decrease (Government of Alberta 1). Lastly, the NDF gives an estimate of the fiber measuring the values of cellulose, silica, lignin, tannins, and cutins. Animals are unable to consume forages with high NDF values.

Getting to Know the Grasses

The first step in my project was to understand more about tropical grasses and forages. Appendix 1 shows the nine tropical grass species I studied in a compiled table with expected yield, nutritional data, morphology, and environmental conditions they prefer. I also got to see the grasses in the field to see why some grasses had a much higher yield than others, and it was clearly visible when visiting the test plots in Zwai. The photos on page 25 show the different grass species and how they differ.

The grasses that were used in the study were selected by their usage by smallholder farmers in this region, they were grown in the Zwai test plot, and had high nutritional quality and yields. Most of the grasses perform well in the area, and were selected because of their performance. *Andropogon gayanus* along with *Pennisetum purpureum* are known to have excellent drought tolerance, while *Brachiaria decumbens, Brachiaria ruziziensis, Chloris gayana,* and *Setaria sphacelata* perform fairly well. *Brachiaria mutica* grows best in waterlogged areas, and are seldom seen in the lowlands in Ethiopia. With an average yield of 10-40 fresh weight t/ha, *Pennisetum purpureum* is known for its high yield because while it grows significantly well in areas with high rainfall, it still produces a reasonable yield during the drier months. The amount of protein in each grass is also important, but in most cases, it begins to decrease after a certain age. So while some grasses such as *Panicum maximum, Setaria sphacelata, Brachiaria mutica,* and *Brachiaria decumbens,* may have values up near 20%, it is highly unlikely to achieve those levels without good soil, water supply, and fertilizer. Some grasses may need fertile soil and/or good fertilizer to perform well. For example: *Brachiaria ruziziensis, Panicum maximum, Pennisetum purpureum,* and *Setaria sphacelata* all need soil with good drainage and that is fertile, while *Andropogon gayanus, Brachiaria brizantha, Brachiaria decumbens, Brachiaria mutica,* and *Chloris gayana* do well on a different range of soils, some even on the loam and clay found in the area.

With this data, I was also able to edit the informative leaflet drafts for six of the grasses and finish them for publishing. These leaflets will be passed out to farmers when they are deciding which grass seeds to plant, and provide valuable information on the planting process, expected yield/nutrition, and preferable environmental conditions, so they know which grass is best for that area. They can also be found attached as Appendix 3**.**

Gathering Yield Data

I then was introduced to my research project. Recently, Evans Basweti, a post-doctorate and past employee of ILRI, began a research project to find out whether there were any alternatives to *Pennisetum purpureum* or *Brachiaria mutica* and whether or not the yield of these grasses was higher after one or two cuttings. He collected the data, and took samples for nutritional analysis from the experiment. It was my job to analyze and compile the productivity data and then run nutritional analysis on the different species in the laboratory. As stated earlier, the project goal was to see whether or not there is an alternative to Napier grass, and in addition, find what farmers demand and meet their needs. Our hypothesis was that Napier grass would have a significantly higher yield than any of the others, both after one or two cuts.

The methodology for the productivity analysis is detailed in the Experimental Protocol, Appendix 2, written by Evans Basweti. From this information, I was able to analyze the data making charts and diagrams to portray the results. While viewing these charts, you can easily see if any of the variables compare to the control, Napier grass, in yield.

Chart 1

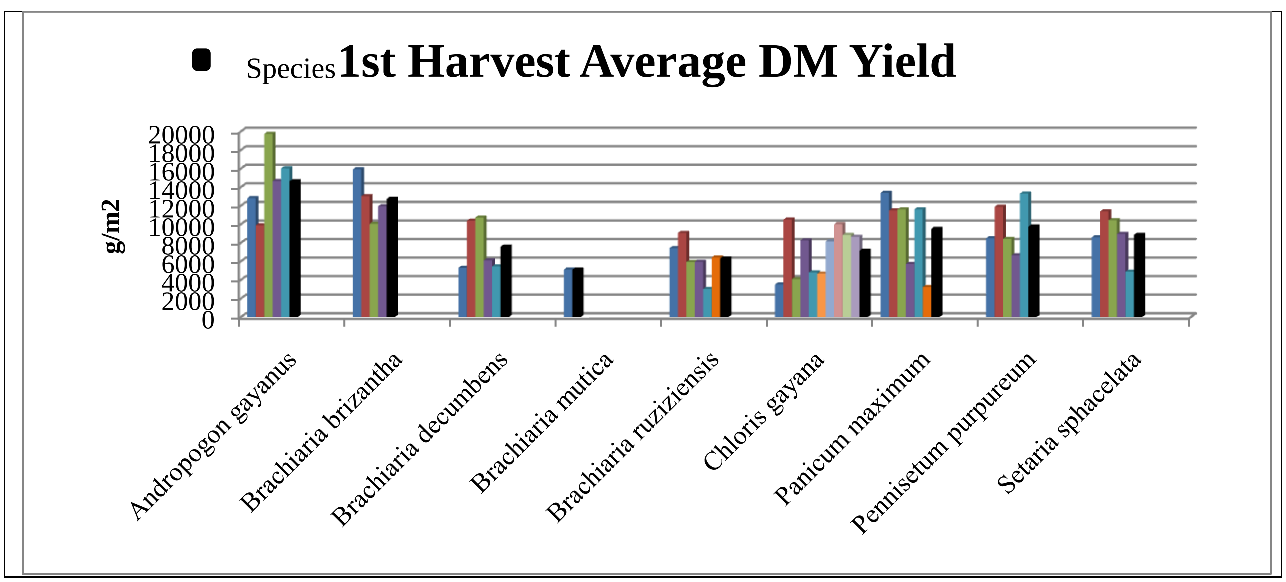
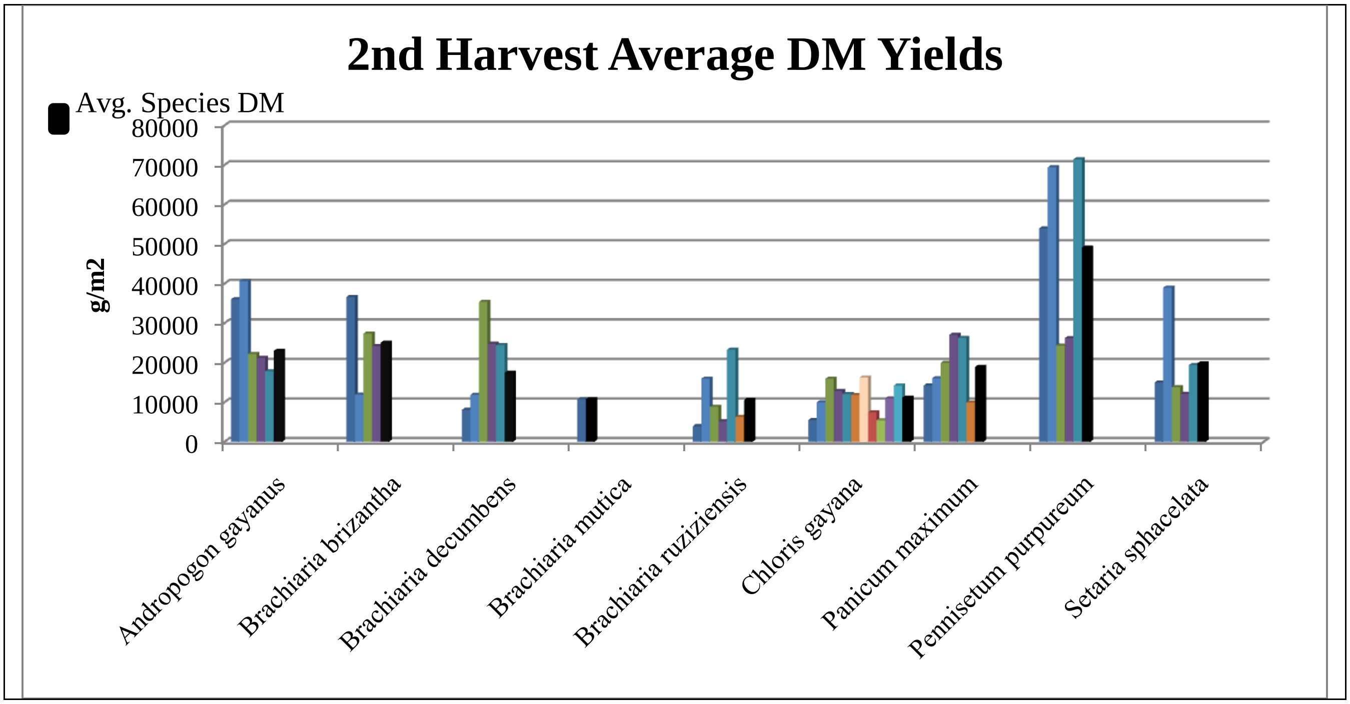


Chart 2



In Charts 1 and 2 you see the average yields for each accession in the first harvest and the second harvest. We are comparing the grasses that were cut twice in 16 weeks and seeing how their first cutting compares to their second cutting. The black bar at the end of each species cluster represents the species average, and you can clearly see which grass performs the best at each cutting. This yield data is measured in g/m2 because we were dealing with small plots. For example let's say you collect a small amount of a grass sample from the plot in grams, but you happen to make a small error when recording the weight, and when multiplied up to kilograms or tons that small error turns in to a big one and can create in significant differences. That is why for these first two charts, it was simply measured in g/m2 and in the next three it was converted to kg/m2.

In Charts 3 and 4 we are looking at the yields between the two groups of grasses; the first group of grasses which were cut twice, both at 8 and 16 weeks, and the second group which was cut once at 16 weeks. The bar chart shows the grass species in alphabetical order and each accession has one bar representing one cut in 16 weeks and one representing two cuts in 16 weeks. The scatter plot shows the same data, but in the context where you can clearly see which accessions and species stand out. Chart 5 shows the species average between all accessions shown in Appendix 2, clearly showing which species is the best.

Chart 3

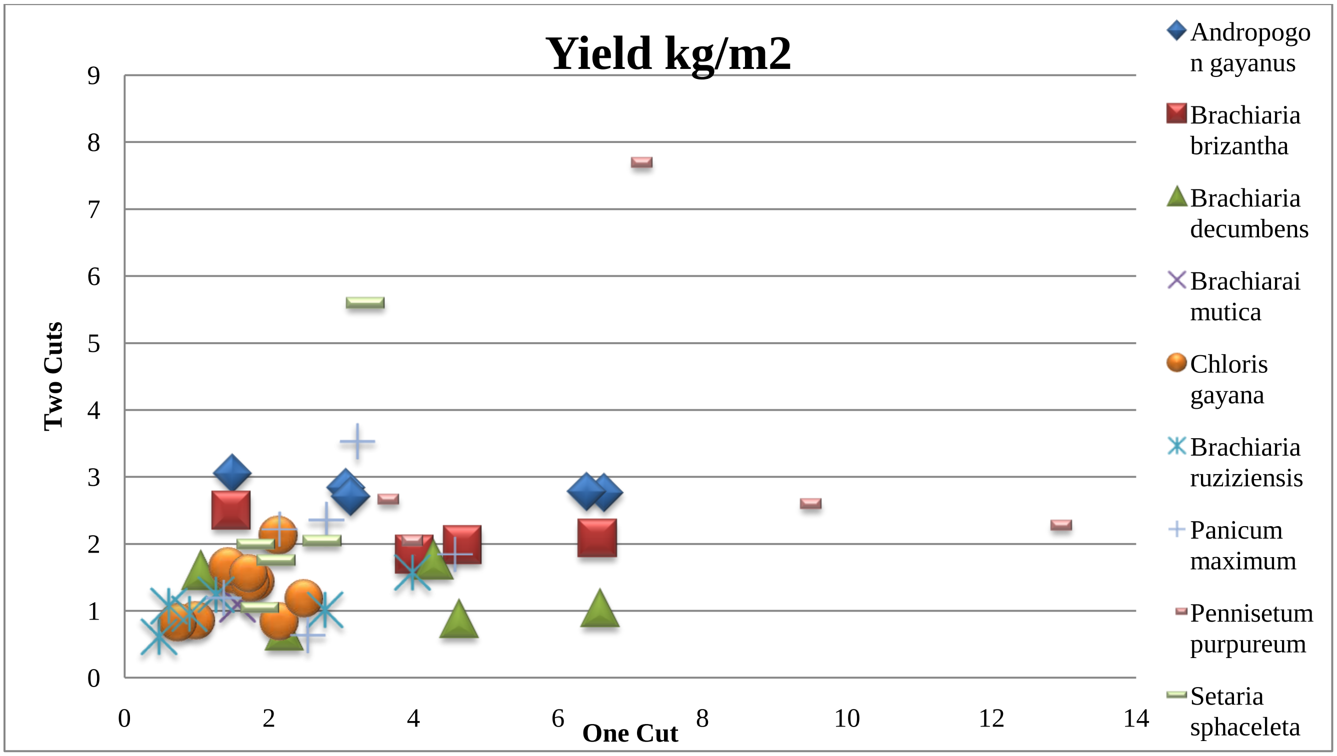


Chart 4

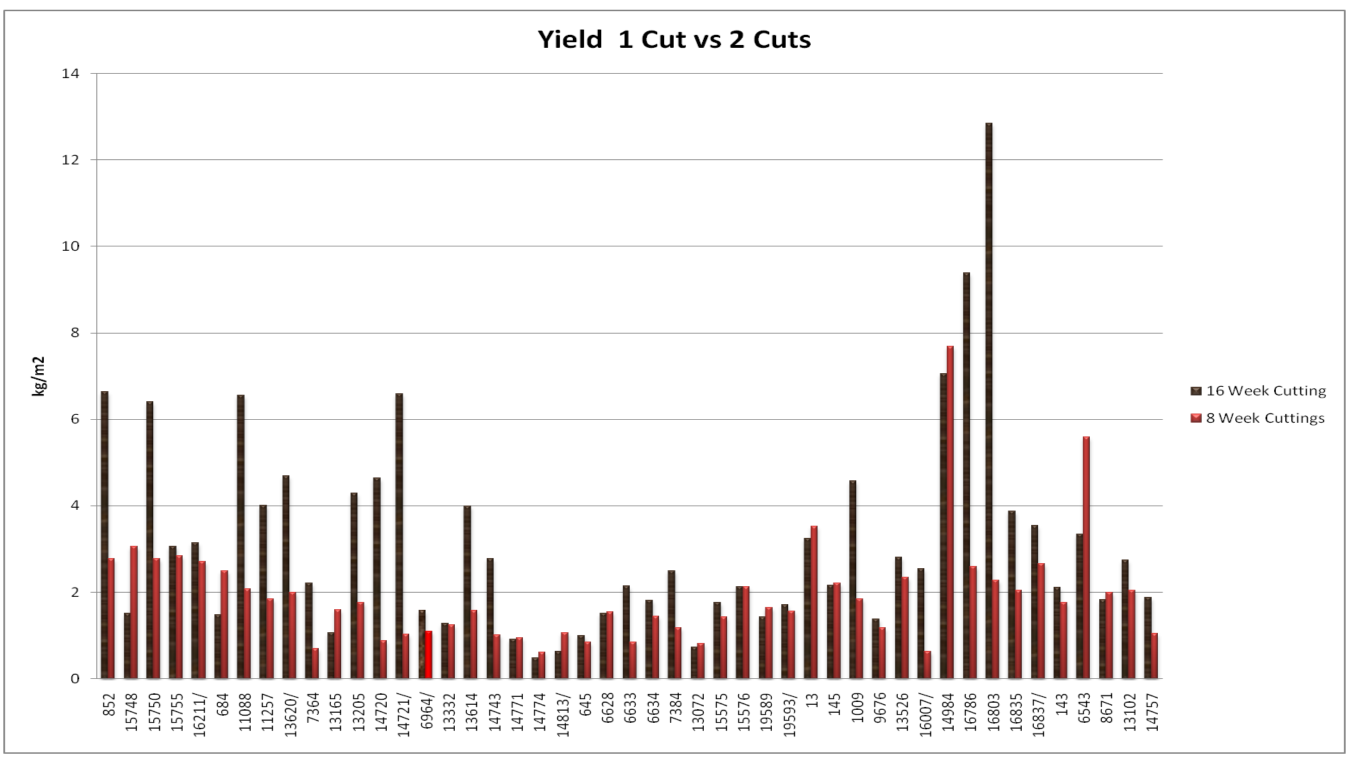
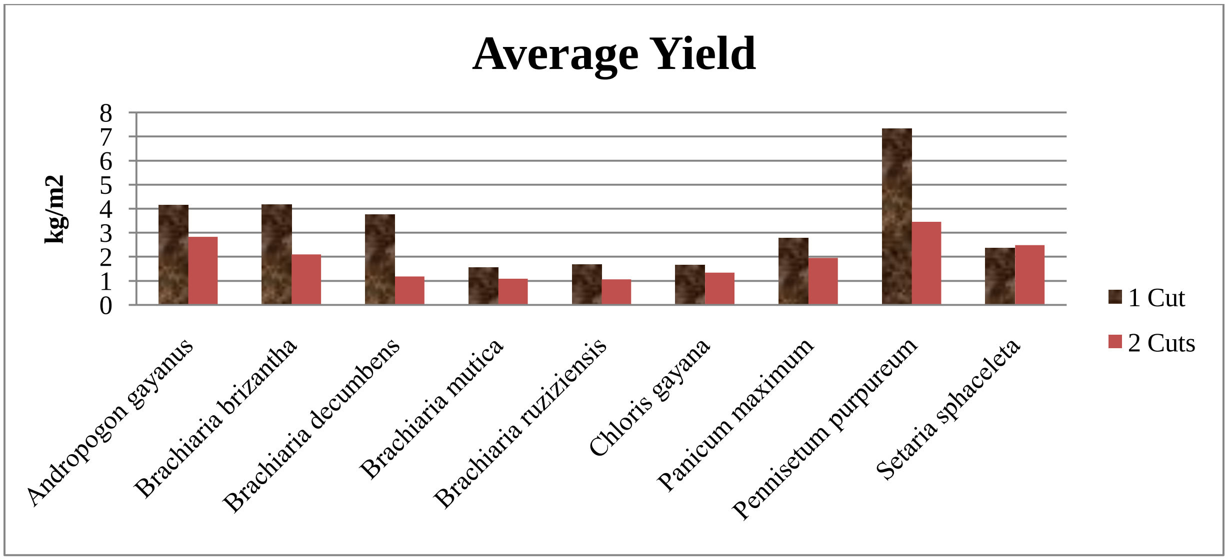


Chart 5



Nutritional Quality Data

The nutritional analysis process had two steps: NIRS Scanning and Wet Chemistry. With NIRS scanning we followed the guidelines set by the ILRI-Ethiopia Nutrition Laboratory in *Analytical Methods for Feeds, Animal Excrements, and Animal Tissues,* compiled by Mebrahtu Ogbai and Tenaye Sereke Berhan. This consisted mainly of grinding, packaging, and scanning the samples using the Near Infrared Spectroscope (NIRS). The NIRS machine uses wavelengths and the electromagnetic spectrum. The spectra are then compared to spectra from samples in the known laboratory analysis results using an equation and nutritive values are then predicted. In simple terms the molecular vibrations and reflections give wavelengths and number on the spectra every two wavelengths. The NIRS machine is useful because it provides quick, cheap, and accurate results, without the expense and time of chemistry in the laboratory. However, the results are only as accurate as the standard equation being used. NIRS scanning can be applied towards animal nutrition and forage diet and quality. Nutritive values can also be a key factor in management decisions when it comes to forages to grow.

With the data given from scanning, the RSQ values can be viewed as Chart 6, where we used the Mixed Grass 2010 equation**.** And from these values, we selected outliers that had a GH number ranging from 3.039 to 4.849, and there were 38 total samples selected for wet chemistry. With these samples we ran Dry Matter, Ash, Crude Protein, NDF, ADF, and lignin tests on them using

Analytical Methods for Feeds, Animal Excrements, and Animal Tissues, by the ILRI-Ethiopia Nutrition Laboratory and compiled by Mebrahtu Ogbai and Tenaye Sereke Berhan.

Chart 6 Old Equation

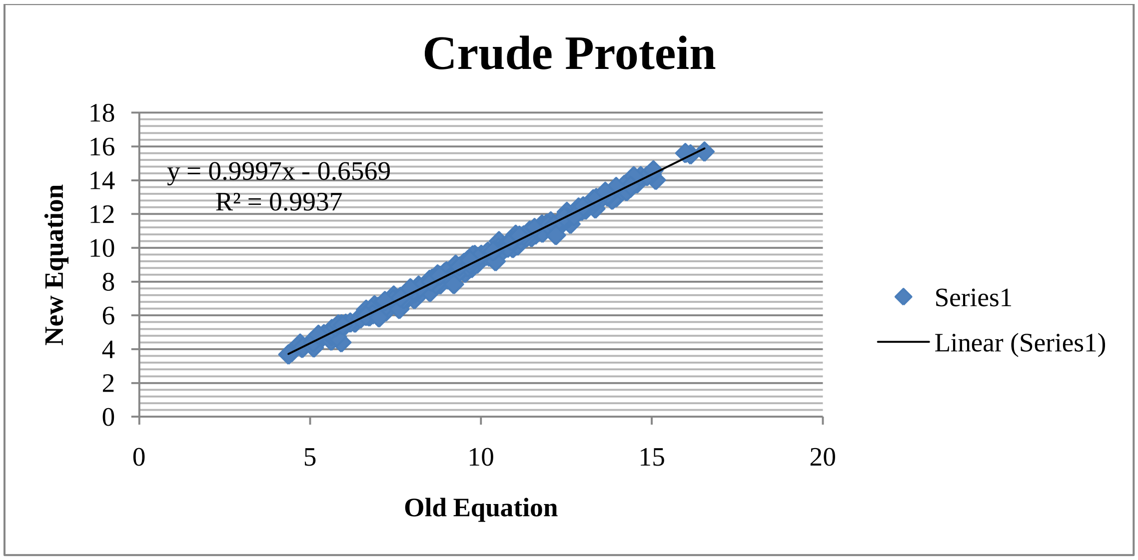
Constituent	RSQ
DM	0.8554
ASH	0.9408
CP	0.9792
NDF	0.7761
ADF	0.838
ADL	0.818

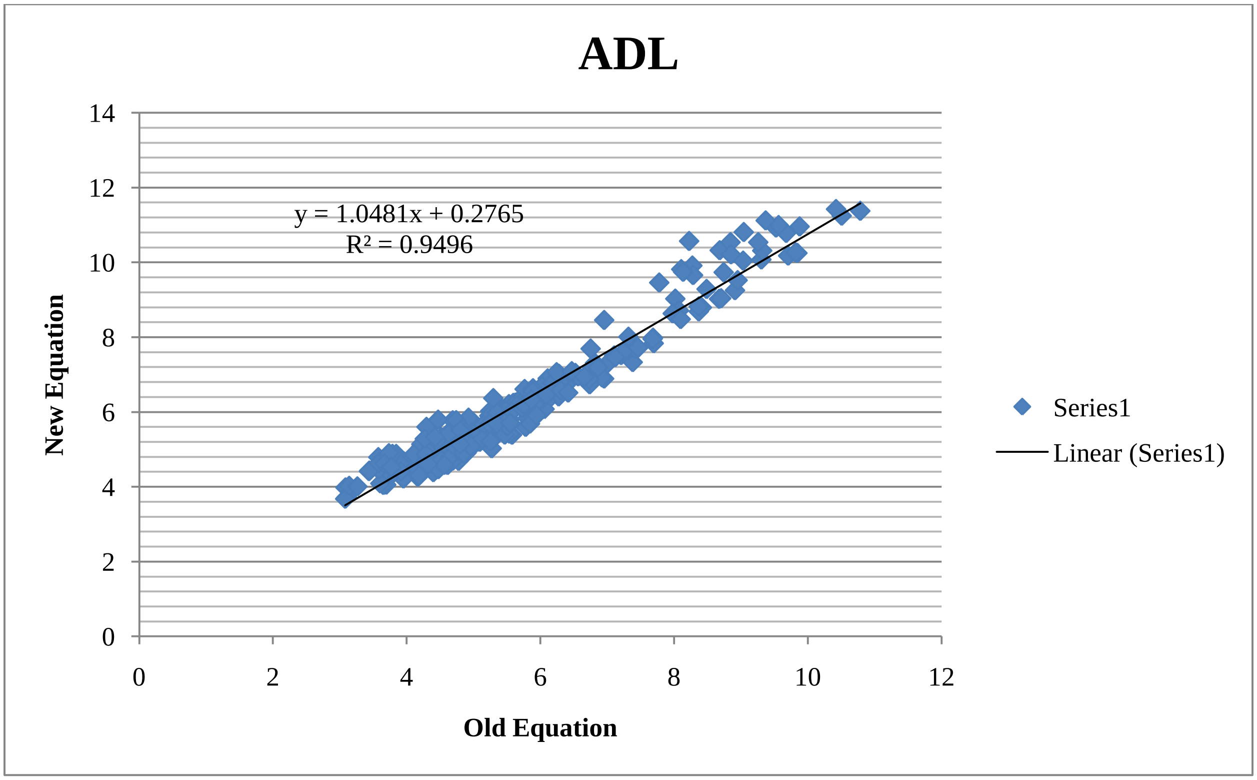
Chart 7 New Equation

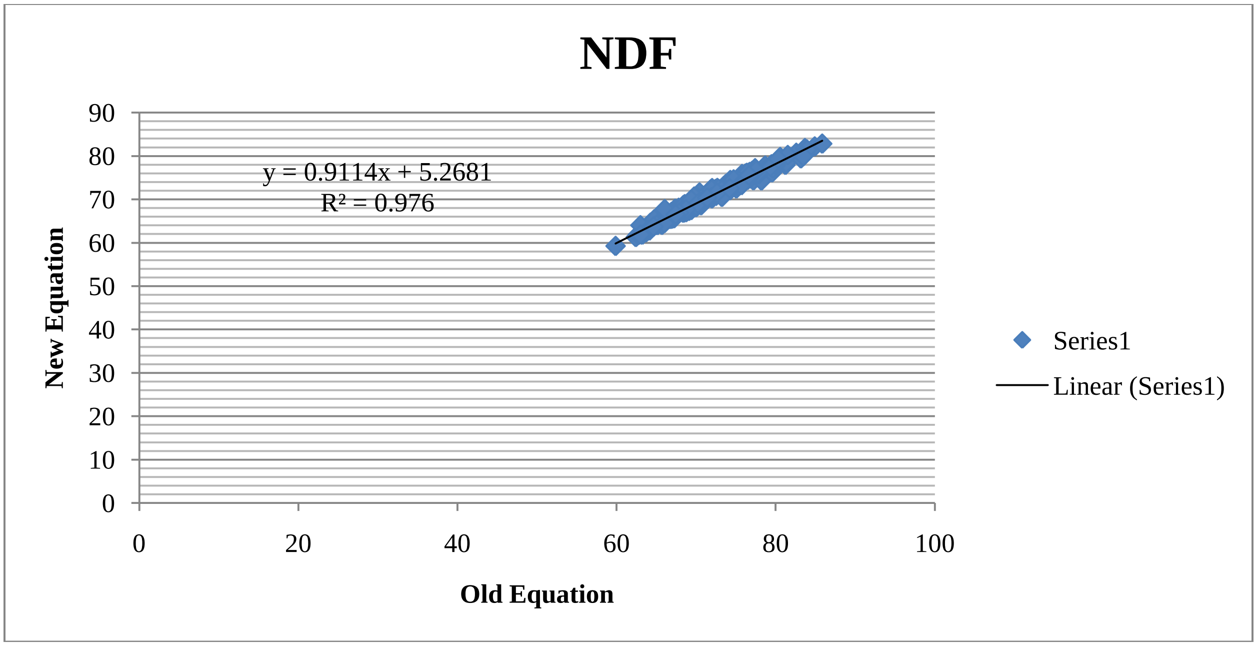
Constituent	RSQ
DM	0.8579
ASH	0.9315
CP	0.9771
NDF	0.7756
ADF	0.843
ADL	0.8367

While there is room for error in the scanning, there is also a larger room for error in the laboratory. To control for these errors, duplicates are analyzed for each sample (laboratory) number scanned, and laboratory methods are performed with precision, recording any problems that may affect the data, and then the results are calculated with a small margin of error. For example, one of the most important procedures was recording the correct hot weight of each sample and crucible they were put into. By recording their hot weight, you also control for the amount of moisture in the room, and on the scale. They would have to be in the oven for at least an hour before weighing, at 105 degrees Celsius. This is just one example of the meticulous procedures done in the lab. A more in-depth view of the methodical procedures done in the laboratory can be found in the lab manual, *Analytical Methods for Feeds, Animal Excrements, and Animal Tissues.* From this data created by wet chemistry, we compared the results to their predicted values on the NIRS machine and then inserted the data into the program to strengthen the mixed grass equation. We were now able to re-predict the scanned data and receive stronger results for each of the grasses scanned in the original equation. There was a stronger correlation between the outliers which now had more precise values. The new R-squared values under this new equation can be viewed as Chart 7**.** Charts 8-11 show correlations with the new equation are extremely strong. We now have a stronger equation which will produce more accurate results for scanning grass samples in the future. With the newly strengthened equation, we now have accurate nutritional quality data that will be used to compare with yield data, to not only see which grass had the highest nutrition, but if nutrition decreases after cuttings and which grass is the best based upon a high nutritional value and a high yield.

Chart 8-11






NDF
y = 0.9114x + 5.2681
R² = 0.976
New Equation
Old Equation
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80
100
Series1
Linear (Series1)

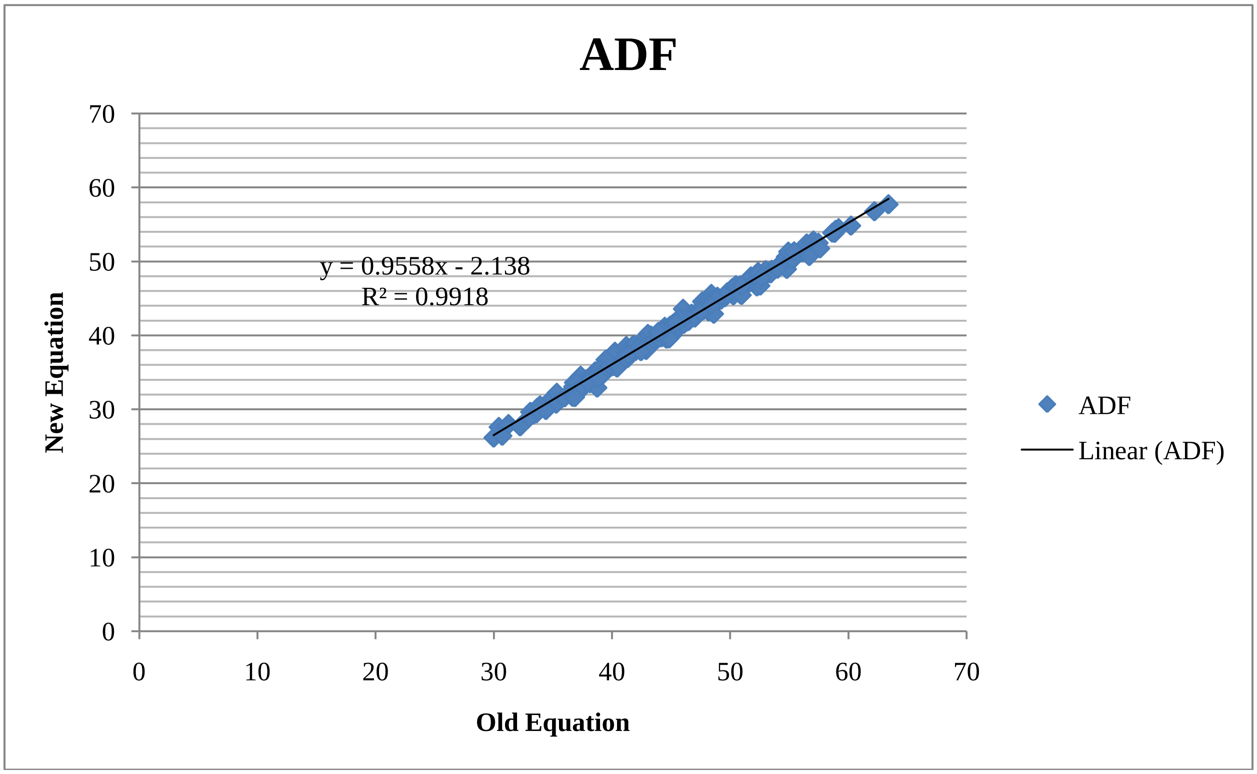

ADF
y = 0.9558x - 2.138
R² = 0.9918
New Equation
Old Equation
0
10
20
30
40
50
60
70
0
10
20
30
40
50
60
70
ADF
Linear (ADF)

Chart 12

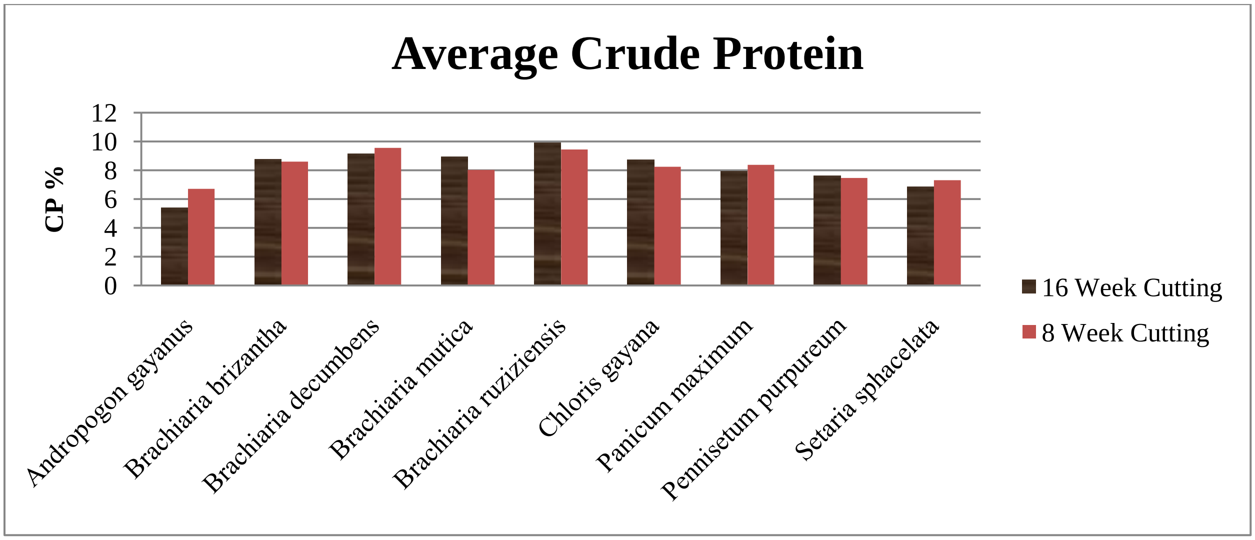


Chart 13

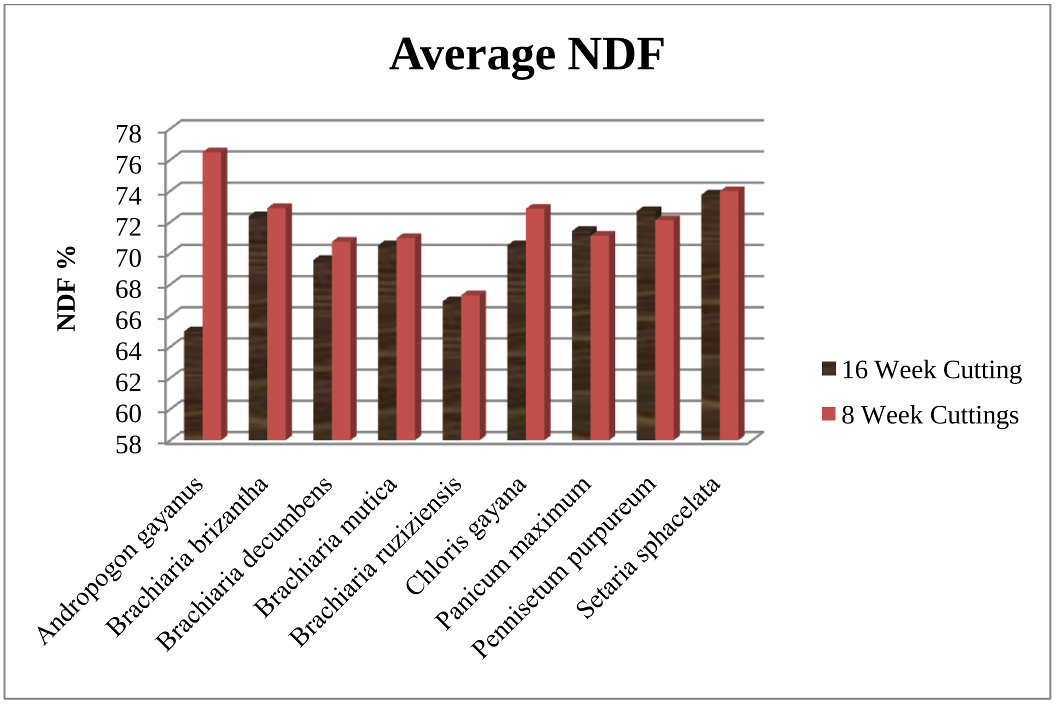


Chart 14

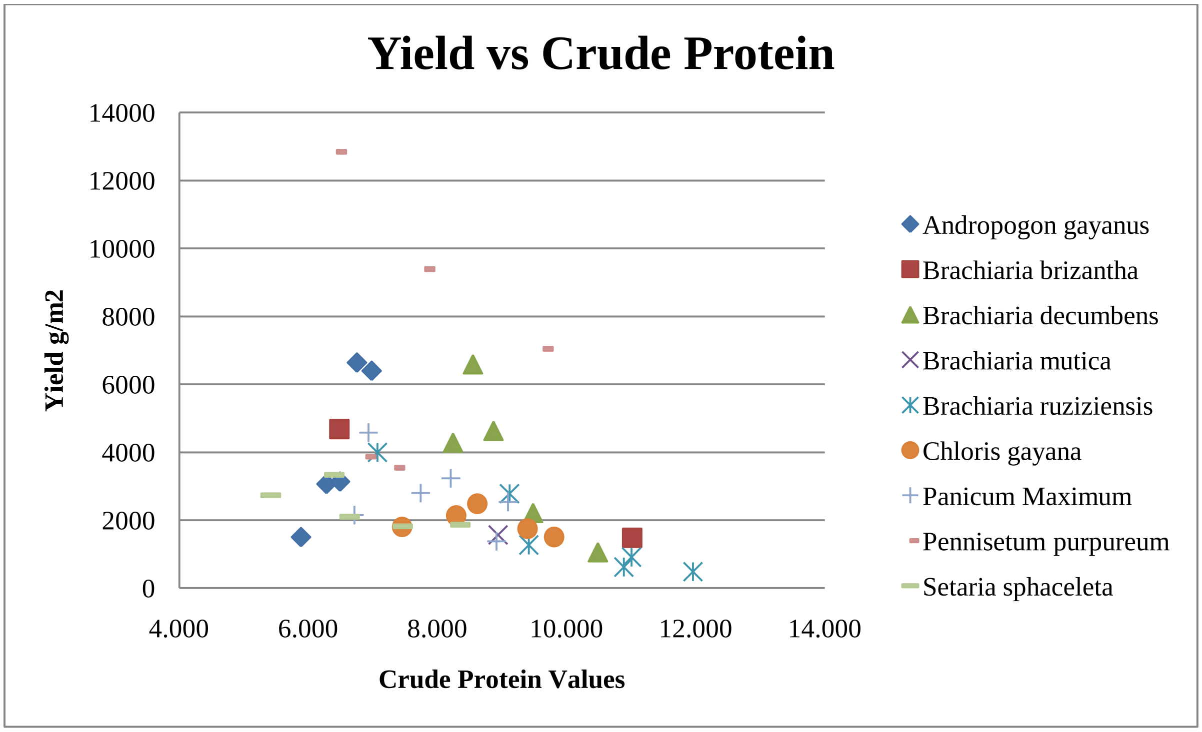
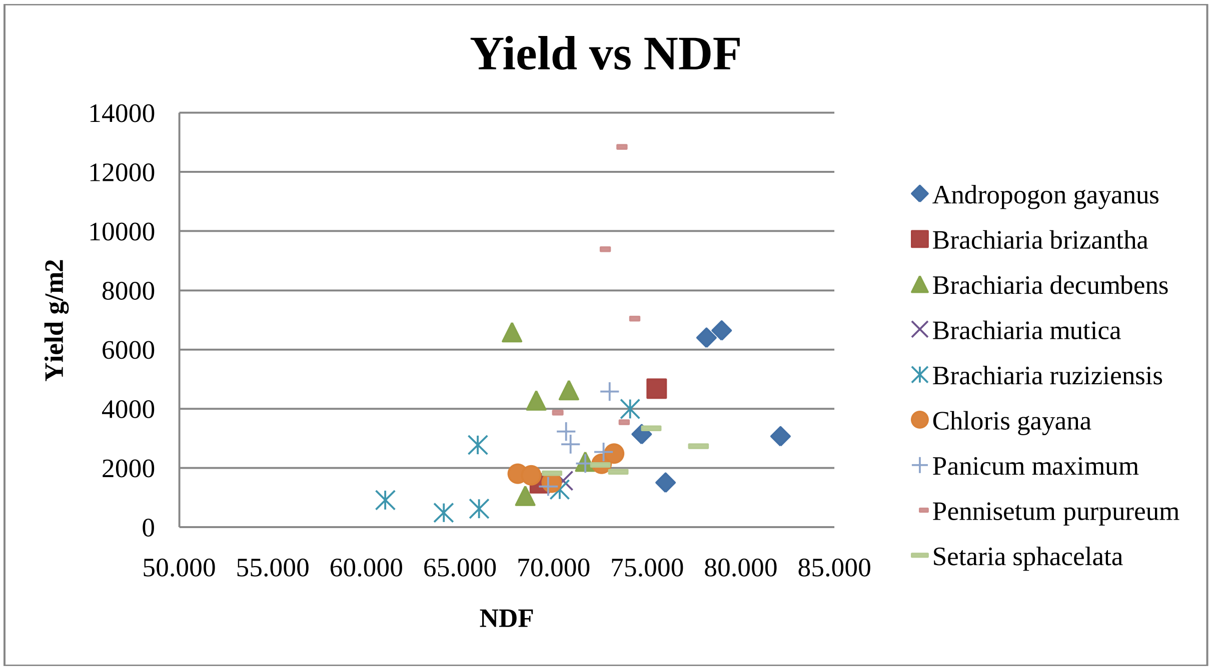


Chart 15



Charts 12 and 13 show the two most important values when looking at nutritional quality, crude protein and NDF. These bar graphs represent the average values for each species between the samples that were cut at 8 and 16 weeks. In Charts 14 and 15 we then compared the CP and NDF values of all the accessions against their yield, hoping to find the grass that had both high nutrition and yield. These values were all taken from the one cutting of the sample in the harvest at 16 weeks. Then we calculated the Relative Feed Value and Metabolizable Energy using the following equations taken from the Alberta Government Ag-Info Centre, "Know Your Feed Terms."

Relative Feed Value RFV = (%DDM X %DMI)/ 1.29
%DDM Digestible dry Matter = 88.9 - (0.779 * % ADF)
DMI as % of body weight = 120/NDF%

Metabolizable Energy ME = 3.62*TDN
Legumes and grasses TDN = 88.9 - (.79*ADF%)

The Relative Feed Value is, "a way to compare the potential of two or more like forages for energy intake" and the higher the RFV, the higher quality of the grass, while the Metabolizable Energy represents just how much energy is available from the feed (Government of Alberta 5). After the calculation, the values for each accession average were plotted against their yield and the charts looked very similar and can be seen in Chart 16 and 17. This shows ME and RFV values are similar when plotted against yield. The graphs show the same accessions in the same association to the other accessions displayed.

Chart 16

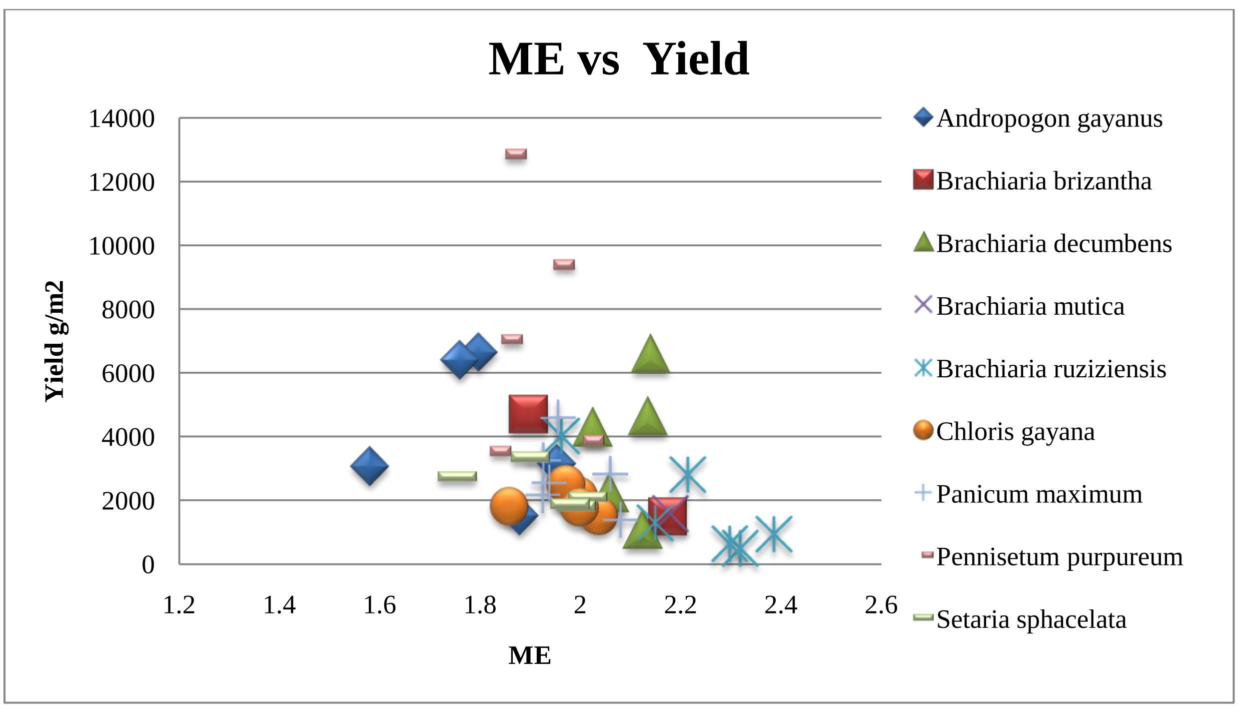
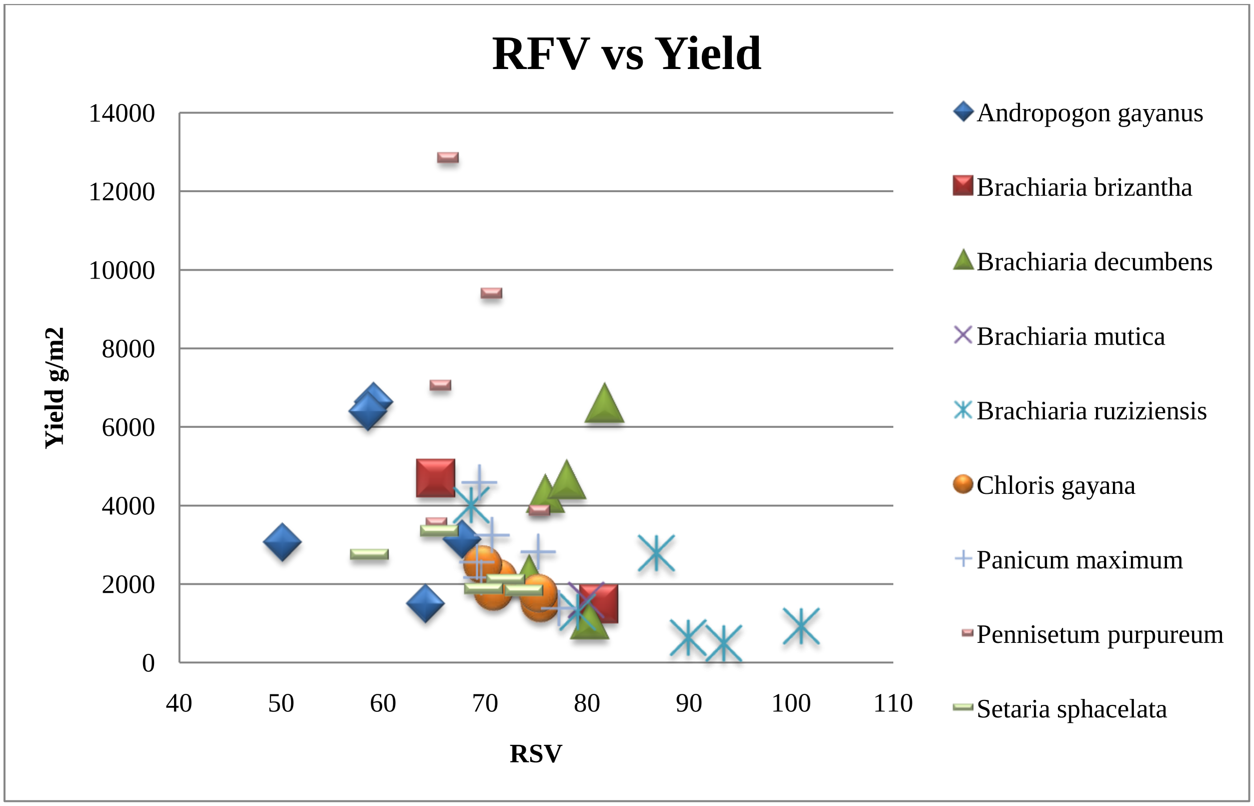


Chart 17



Finding What Farmers Need

I spent a day in the field interviewing eight farmers, four women and four men, to find out more about the typical smallholder farmer in the area and what they look for when selecting crops and forages to grow. We went to the Ada'a Liben region, southeast of Addis and near the larger city, Debre Zeit. A map of this area can be found on Appendix 4.

Ada'a Liben is one of the 12 woredas in East Shoa zone located about 45 kms south-east of Addis Ababa, and it covers an area of 1750 km2 (IPMS 6). According to CACC (Central Agricultural Census Commission, 2003), total agricultural population of the woreda is estimated at 202,276. There are 60 PAs (45 in rural and 15 urban) in Ada'a-Liben woreda. About 78 % of the household population who are over 10 years of age are engaged in full agricultural activities, 19.5 % in partial and 2.6 % in non-agricultural activities. This area is also known nationally for its Teff production, and they also produce wheat in medium to high altitudes, barley, maize, and sorgum, pulse in moist areas, lentils, honey, and horticulture. Livestock are very important as well, the most common being cattle, sheep, goat, and poultry. Dairy farming is on the rise with over 800 smallholder dairy farmers who are involved in the cooperatives for marketing milk production. (IPMS 6). "There are two cropping seasons. . . Belg (short rainy season) from March to April and meher (main rainy season) from June to September" (IPMS 8). "Total cultivated land account for 64,412 ha. Out of this 64,088 ha is rural and 324 ha is urban" (IPMS 11).

There are also programs for agricultural extension, serviced mostly by the government. There are both the Development Agents (DA) and a new program called Farmer Training Centers (FTC). Both of these programs work to train employees who then teach better farming practices to the farmers in their area. Anything from selecting which crop is suitable to grow in that area to how to prevent soil erosion is taught when they meet. Smallholder farmers then have the opportunities to improve their practices and also share advice and ideas with other farmers in the area. There are problems that arise with extension centers as well including: "insufficient number of DAs, lack of demonstration materials, lack of practical and applicable knowledge by DAs, and involvement of DAs in non-extension activities such as input distribution and credit collection" (IPMS 18).

We selected the famers to be interviewed based on who ILRI had previously given forage seed to, staying within the Peasant's Association of Babogaya, randomly selecting both women and men, and they had to be dairy farmers with either local or cross-bred cattle. They were asked a serious of ten questions based on their farm size and operation, forages grown, and even extension services used. None of these results provide good statistical data because we did not interview a large quantity of farmers, but it served as more of an informative survey to find out what small holder farms are like and to compare the farms of males and females. Our main objective was to find out what farmers look for when they select a forage to grow on their land, and as stated earlier the hypothesis was that farmers will look for what can bring them the highest yield and in turn, the most money in the market system. A copy of the questions can be found on Appendix 5 and you can see the answers compiled in three charts in Appendix 6, with a compressed chart comparing the differences between the head of households being males or females as Appendix 7. When comparing males and females, males not only have more owned land, but in most cases own more livestock as well. Charts 17 and 18 show the number of animals found on each farm as well as the most popular feed used by farmers. These values were given by taking the most popular by each farmer as 1,2,3 and so on. Those values were then multiplied by a weighted value of …3,2,1 to find out which was most popular. Crop residue was most commonly used and each farmer, because they had a cross bred dairy cow, used concentrates as well.

Chart 18

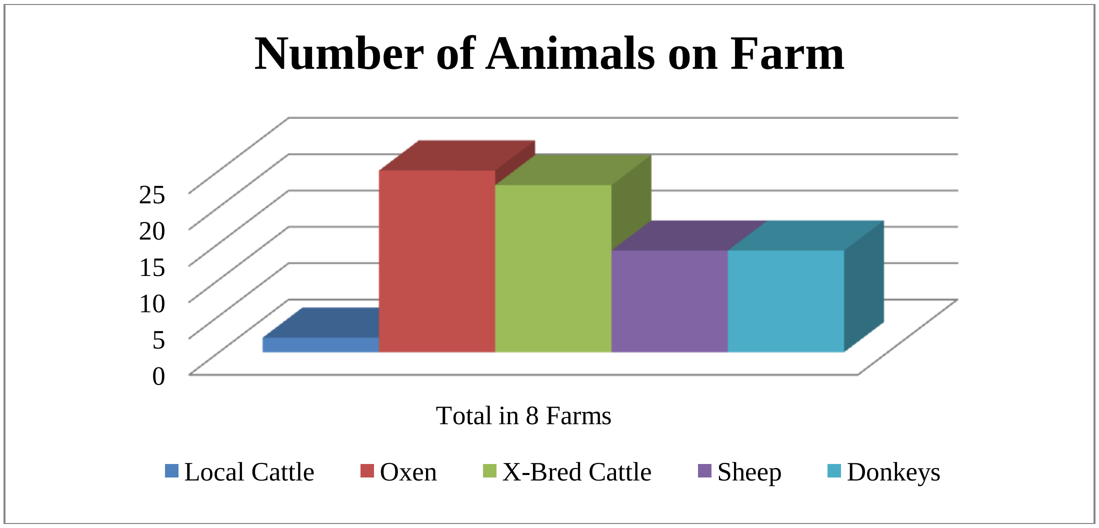


Chart 19

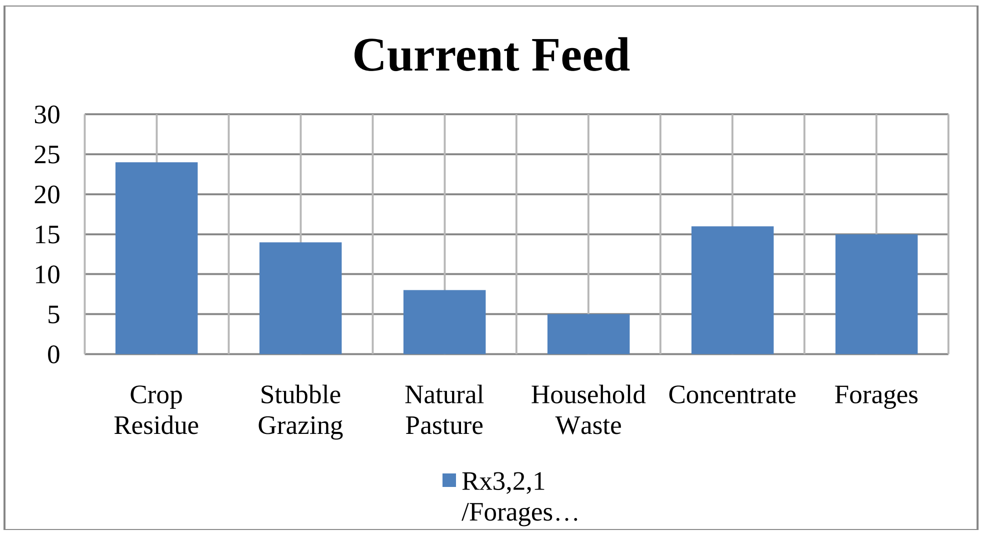


Chart 20

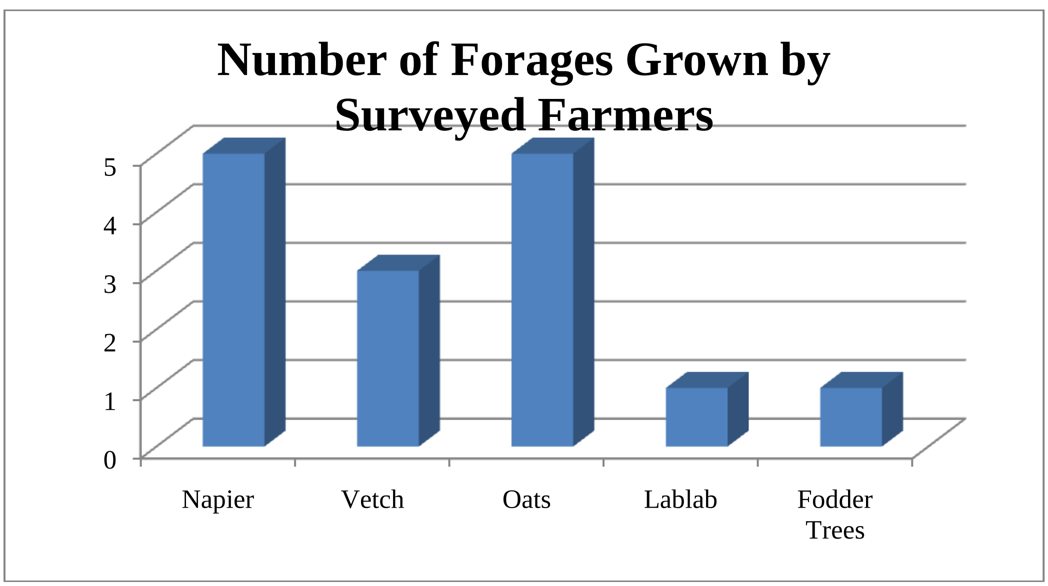
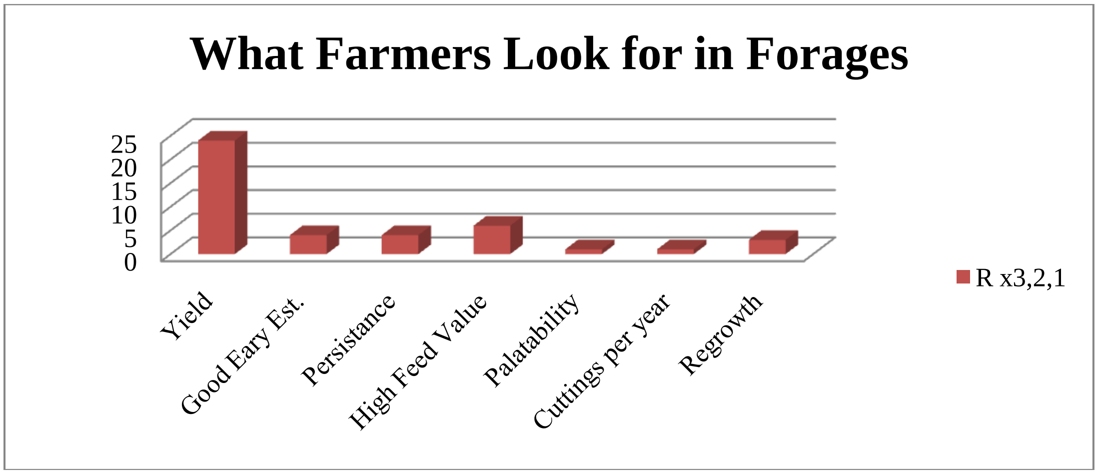


Chart 21



Charts 20 and 21 portray just what it is that farmers look for in a forage and which ones they grow; the only grasses being Napier and Oats, while Vetch and Lablab are legumes. You can also see that although I only interviewed eight farmers, all of them preferred forages with high yields.

From the answers to their questions I was able to see how the farmers used the seeds ILRI has provided in their backyards, plots, and fields. When asked what they look for in a forage, the number one answer for all eight farmers was yield, and second nutritional quality, ease of propagation, or what is best for their land area. Most farmers also encounter feed shortages constantly throughout the year and purchase the feed and concentrates for their cross bred cattle. These cross bred cattle however, produce a lot more milk than the local cattle, and for that reason require more nutrition and feed then the local cattle and oxen. It is now important to take what we have learned and match our resources to meet their demands.

Chart 22

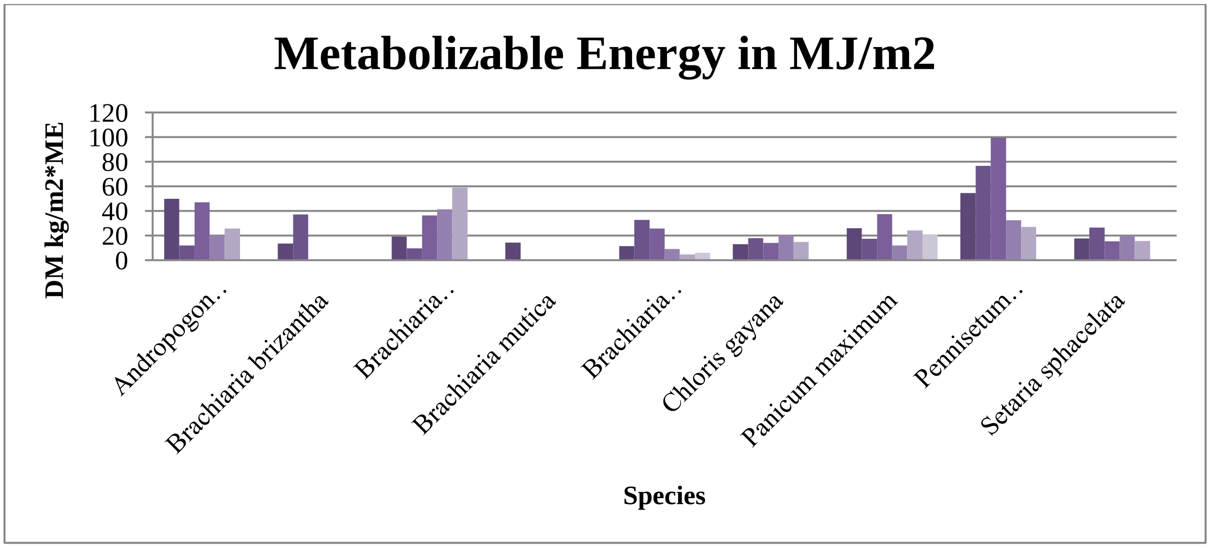


Chart 22 shows the Metabolizable energy values in megajoules per m2, this was calculated by the following equation:

MJ/m2=ME*Yield (kg/m2)*4.18

Chart 23

Farmer's Needs	A. gayanus	B. brizantha	B. decumbens	B. mutica	B. ruziziensis	C. gayana	P. maximum	P. purpureum	S. sphacelata
Yield	4-25	8-20	10-30	8-30	11-27	10-25	20-30	40	10-15
Feed Value	M	H	H	H	H	H	H	H	M
Establishment	M	G	G	G	G	G	G	G	M
Persistence	H	H	H	M	M	VH	VH	VH	H
Re-growth	F	F	F	F	F	F	F	VF	F
Palatability	M	H	H	H	VH	M	VH	H	M
Cutting Intervals	4-6	4	6	6	4	4-7	4	6-8	3-4

Chart 22 shows the highest performing grasses found in our study. This was found by multiplying the ME values with the DM yield and shown in a column chart. Chart 23 is a compiled chart created from the literature found online and in the informative leaflets regarding what farmers look for in forages. Their preferences are ranked in order going down the right side of the chart, and a letter or number is given for each grass; the best being VH or VF, followed by H or F, G, and M. If a grass performed well under a category it is marked by a dark yellow, followed by light yellow and pale, consecutively. From this chart it is seen that *Pennisetum purpureum*, *Panicum maximum*, and *Brachiaria ruziziensis* outperform the others when it comes to meeting the needs of farmers. While in Chart 22 the highest performing grasses found in our study were *Pennisetum purpureum, Andropogon gayanus*, and *Brachiaria decumbens* .

Conclusion: Meeting the Needs of Farmers

From these compiled charts and diagrams it is clear that none of the grasses tested in this experiment compare to Napier grass in yield nor Metabolizable Energy available for livestock feed under the conditions of this experiment. The species average's differences in nutritional quality were very small although they did vary at the accession level. That small difference goes unnoticed with the average small holder dairy farmers today. So if farmers care mostly about yield, how can we persuade them to grow an alternative that comes nowhere close to the yields of Napier? It was discussed quite often that we should be looking for alternative grasses at the ASARECA Napier grass smut and stunt disease workshop back in June; alternatives such as *Panicum maximum*, *Brachiaria*, and crop residues were suggested (ASARECA). But if farmers prefer grasses with high yields and are not adapted to change, should we be looking for alternative grasses? There is a solution to this issue that does not lie within exploring alternative grasses, but finding and utilizing the disease resistant strains of Napier grass. The results of scientific studies lack value until they are shared with those who need them most, which is why outreach to the smallholder farmers is important.

This study also opens up many doors for possible experiments in the future. One issue that could be explored would be to repeat this experiment in different locations to confirm results in a wider range of soil, rainfall, and temperature combinations. Another would be to change the cutting intervals and species. This study had cutting intervals that were longer than recommended in literature, so it would be good to repeat this study using the same intervals as farmers. It would also be good to explore different species because as stated earlier, some grasses perform better in different areas. Regarding the surveys, we found interesting results and it was good to see the two traits used for selection in research are yield and nutritional quality, which were the top preferences for forage selection by farmers. It would also be useful to do a large scale interview with farmers in different areas to get a more precise definition of what farmers look for in forages; providing genebank staff with the information needed to make better selections for research and evaluation.

"Farm animals are an ancient, vital and renewable natural resource. Throughout the developing world, they are means for hundreds of millions of people to escape absolute poverty" (ILRI). This study has not only shown the value of Napier grass in livestock systems, but highlighted the issues to test in possible experiments in the future. Now is the time to match the resources we have available in the genebank to meet the needs of smallholder farmers today.

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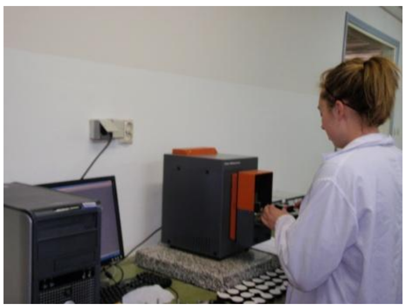
Pictures through Project

Welcome to ILRI

At Zwai Test Plot


Assessing Yield Traits in Zwai

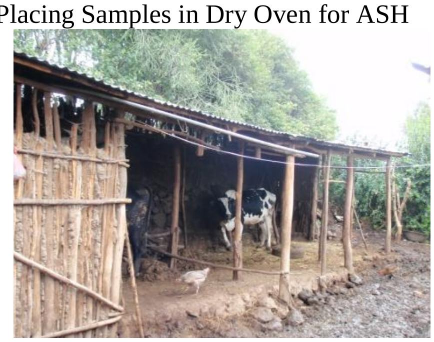

NIRS Scanning Samples


Hot Weighing Samples


Placing Samples in Dry Oven for ASH


Mixing Acid with Samples for Boiling


Rinsing Samples for ADF


One X-bred Dairy at Poor Farm


Interviewing Farmer in Ada'a Liben


Seven X-Bred Dairy at Larger Farm


Interviewing Farmer in Ada'a Liben

The Grasses

Brachiaria brizantha

Andropogon gayanus

Brachiaria decumbens

Brachiaria mutica

Brachiaria ruziziensis

Chloris gayana

Panicum maximum

Pennisetum purpureum

Setaria sphacelata

Appendix 1

Species	**Andropogon gayanus**
Com. Name	Gamba grass
Morphology	Perennial, fibrous roots close to the surface, short rhizomes
Height	2-4 m. high
Prop. Method	Seed, Sown in beds
Drought Tol.	Excellent Drought Tolerance
Flood Tol.	Grow in Seasonal Floodplains
Frost/Fire	No Frost, Fire Tolerant
Soil Quality	Different Soils (-1,000 m)
Yield	4-25 DM t/ha
Nut. Quality	Maturity causes coarseness, LWGs up to 250 kg/ha/yr,m, CP 7-10%, 30-60% IVDM
Species	**Brachiaria brizantha**
Com. Name	Signal grass
Morphology	Tufted Perennial
Height	60–150 cm
Prop. Method	vegetatively by sods, seeds, root pieces and stems, with legumes,
Drought Tol.	Fair tolerance to drought
Flood Tol.	No
Frost/Fire	No Fire, Survive frost
Soil Quality	Different Soils
Yield	Varies, (dry) 7 850 kg DM/ha to (green matter) 10 368 to 17 377 kg/ha, DM 8–20 t/ha/yr.
Nut. Quality	Crude Protein Tropical- 7–16% and digestibility 51–75%, IVDMD 75-55% with age
Species	**Brachiaria decumbens**
Com. Name	Surinam Grass
Morphology	Low-growing rhizomatous and stoloniferous bright green moderately hairy leaves, 2 rows rachis
Height	10 cm axis
Prop. Method	vegetative material, seeds stored or scarified before planting
Drought Tol.	facilitating water infiltration and preventing erosion
Flood Tol.	Bad in waterlogged areas
Frost/Fire	Poor performance in frost
Soil Quality	Poor soils, sea lvl- +1750
Yield	4-10 T DM/ha
Nut. Quality	high digestability, LWG x2 w/ fert., legumes needed, 9-20% CP, Dig. 50-80%
Species	**Brachiaria mutica**

Com. Name	Para grass
Morphology	Creeping, hairy, leaves 30 cm, semi-aquatic, short-culmed, high with long, hairy leaf-blades spikelets 3-3.5 mm long,stolon branches
Height	200 cm
Prop. Method	Hand plant, or disc, Sprigs in ashes of rainforest or swampy land, helps prevent erosion
Drought Tol.	Fair in Drought (Swampy Environment)
Flood Tol.	high-rainfall or in areas with 900 mm per year
Frost/Fire	frost sensitive and severely affected by it, but persists well
Soil Quality	Different Soils Sea-level to 1 000 m.
Yield	Up to 31 kg/ha.
Nut. Quality	14–20% CP IVDMD 65–80% for leafy regrowth, 55–65% top
Species	**Brachiaria ruziziensis**
Com. Name	Ruzi grass
Morphology	Perennial, softer leaves than Bb, short rhizomes, spikelike racemes over 3 mm wide,
Height	
Prop. Method	Drill seed in seedbed
Drought Tol.	Good drought tolerance
Flood Tol.	
Frost/Fire	Killed by frost and fire
Soil Quality	Fertile Soil, good drainage
Yield	21 159 kg DM/ha, 16 807-25 585 kg DM/ha, and 31 352- 21 468 GM/ha, (11-27,000 DM kg/ha)
Nut. Quality	CP 7-13%, Dig. 55-75%
Species	**Chloris gayana**
Com. Name	Rhodes Grass
Morphology	Tufted Perennial, stolon stems, Inflorescence 15 spikes, two whorls,
Height	90 cm (varies) (1.5 m)
Prop. Method	Sown into ashes, drill
Drought Tol.	Roots make good drought toleranc, 691- 1 597 mm rain
Flood Tol.	Tolerates Seasonal Waterlogging
Frost/Fire	Can survive fire and sub-zero temp, doesn't grow in shade
Soil Quality	Different Soils, prefers loams and clays
Yield	10-25 t/ha
Nut. Quality	LWG range 160 kg/head and 850 kg/ha , CP vary with age and N+ 17%-3% IVDMD 40-80%, Na 300-3,100 ppm
Species	**Panicum Maximum**
Com. Name	Guinea Grass
Morphology	Tufted perennial, creeping rhizome, leaf blades, open spikelets, purple red, 12-40 cm

	long,
Height	1.5-3.5 m tall, with stems to about 10 mm diameter
Prop. Method	Drill, transplant over root cuttings
Drought Tol.	Not really,
Flood Tol.	No
Frost/Fire	Does survive shading (variable) Not frost, Fire doesn't harm long
Soil Quality	Diff soils w/ good fert
Yield	(10-) 20-30 (-60) t/ha DM
Nut. Quality	N & soil fert. increases LWG, IVDMD 64-50% CP 6-25%, even 5-10% Ca from 0.6-0.8% and Na from 0.07-0.12%
Species	**Pennisetum purpureum**
Com. Name	Napier/ Elephant Grass
Morphology	Perennial, rig. Roots, leaf sheaths 20-40 mm wide, spike yellow-brown color,, 3 nodes,
Height	180-360 cm
Prop. Method	Root cuttings or stem pieces
Drought Tol.	Excellent Drought Resistance (Roots)
Flood Tol.	No, grows best in high rainfall
Frost/Fire	No frost resistance,
Soil Quality	Fertile soil/loams, yields decline without fertilizer
Yield	10-30 t/ha/yr common Up to 80 w/ fert., 2-10 if bad
Nut. Quality	CP < w/ age 10-7.6%, CP and IVDMD leaf range from 9.5-19.7%, and 68-74% LWG of 1 kg per day
Species	**Setaria sphacelata**
Com. Name	Setaria
Morphology	Leaves bluish grey-green, leaf blades soft, basal leaf sheaths, spike has bristles and spikelets, stigmata purple or white
Height	45-180 cm high or 2 m tall tussock
Prop. Method	rooted cuttings or divided root-stocks, stored seeds drilling seed is better
Drought Tol.	Fair Drought Tolerance, Mod. Shade
Flood Tol.	Tolerates waterlogging short periods
Frost/Fire	Fair fire and frost tolerance
Soil Quality	Fertile soils pH 5.5-6.5 (NPK app)
Yield	10,000-15,000 kg/ha (26,000 w/ irrigation) LWG 500-800 kg/ha
Nut. Quality	CP 6-20% digestibility 50-65% (<w/age)

Appendix 2

EXPERIMENTAL PROTOCOL

Theme:	People Livestock and the Environment
Operating Project:	Forage Diversity
Experiment no.:	PL04/09/01
Lead scientist(s):	Evans Basweti and Jean Hanson
Collaborators:	PLE1
Research assistant:	Asebe Abdena
Experiment title:	Evaluation of productivity and nutritional quality of a range of tropical grasses
Location:	Zwai, Ethiopia
Date:	2009

Justification

Smallholder dairy farming in Sub Saharan Africa relies mainly on availability of sufficient high quality feed to supplement available crop residues and natural pasture. *Pennisetum purpureum,* also known as Napier grass, is the most important forage for smallholder dairy in East Africa due to high yields, ease of propagation, and a broad ecological range. Recently however, Napier grass is being threatened by Napier head smut, a fungal disease caused by *Ustilago kamerunensis*, which results in drastically decreased biomass as well as Napier stunt, a disease caused by a phytoplasma, which causes severe stunting and yield reduction.

Resource-poor and landless farmers are particularly affected by these yield reductions to the extent that they cannot produce sufficient feed for their cows or sale to others. Farmers have to sell animals because they do not have enough feed and cannot afford to buy it at current prices. With fewer animals, the farmers have less milk so the nutrition of children suffers. Similarly without surplus milk to sell their income decreases and school fees and other expenses cannot be met. Unless resistance to these diseases or alternative grasses are identified, the smallholder dairy industry could decline substantially.

There are several possible alternatives to Napier grass which are high yielding tropical grasses that have already been studied and commercial cultivars developed. They include: *Panicum maximum, Brachiaria decumbens, Setaria sphacelata, Chloris gayana, Andropogon gayanus, Brachiaria brizantha,* and *Brachiaria ruziziensis*.

Another grass which is gaining popularity in some countries is *Brachiaria mutica*. As a second part to this study, yields are being compared for some possible alternatives to *Brachiaria mutica*, a popular grass in India and South America, which is being used for waste-water management. Possible grasses which are suitable for seasonal water-logging include: *Andropogon gayanus, Chloris gayana,* and *Setaria sphacelata.*

Introduction

Forage quantity and quality are the most important constraints affecting smallholder dairy production in the tropics. Dairy generates more regular household income and jobs than any other enterprise. In Kenya, resource poor smallholder dairy farmers produce more than 80% of the marketed milk (Peeler and Omore, 1997). Napier grass (*Pennisetum purpureum*) continues to be the major feed for cut-and-carry zero grazing dairy systems in East Africa. It constitutes between 40 to 80% of the forage for the smallholder dairy farms (Staal *et al.*, 1997). In Kenya alone, more than 0.3 million smallholder dairy producers (53%) rely on Napier grass as a major source of feed.

Napier grass has an average yield of 10-30 t DM/ha and a crude protein content of 7-15%. The possible alternatives include *Panicum maximum* (10-20 t DM/ha and 6-20% CP), *Andropogon gayanus* (4-20 t DM/ha and 4-10% CP), *Brachiaria brizantha* (8-20 t DM/ha and 4-10% CP), and *Brachiaria ruziziensis* (11-27 t DM/ha and 7-13% CP) (www.tropicalforages.info).

Brachiaria mutica performs best in seasonally inundated or high rainfall environments because if can withstand long-term flooding. The range in yield is usually from 5-12 t DM/ha with a crude protein content of 10-16%. The possible alternatives, *Brachiaria decumbens, Chloris gayana*, and *Setaria sphacelata* also grow well in seasonal waterlogged areas, with an average yield of 4-10 t, 10-25 t, and 10-15 t DM/ha respectively. Their crude protein ranges from 9-15%, 4-13%, and 6-10% respectively (www.tropicalforages.info).

Setaria sphacelata can grow on soils ranging from sand to clay loam and also heavy clay with low fertility and respond well to improved fertility. It also grows naturally at altitudes ranging from sea level to 3300 m and temperatures of 18-22^{0}C. Olsen (1973) determined the influence of two heights (8 and 20cm) and three frequencies of cutting (3, 6, and 9 weeks) on yield, botanical composition, and nutritive value of *Setaria sphacelata* grown in association with *Desmodium intortum* in Uganda. He noticed significant differences in CP among cutting frequencies. As the cutting interval increased, the CP content decreased. In vitro dry matter digestibility (IVDM) varied from 61.9 to 68.2%. As the cutting interval increased, the IVDM percent decreased.

Wan Hassan *et al* (1990) evaluated dry matter yield and nutritive value of *Setaria sphacelata, Pennisetum purpureum, Panicum maximum,* and *Brachiaria decumbens* at 2-, 4-, 6-, and 8-week cutting interval over a three year period in Malaysia. They reported that there were no significant differences between grasses in the first harvest year and only small differences in the later yield. Kitaba and Tamir (2007) reported on the effect of harvesting stage and nutrient levels on nutritive values of natural pasture in the central highlands of Ethiopia and found that advancing the harvesting stage significantly decreased the CP content of the herbage from the natural pasture (Kitaba and Tamir 2007).

Materials and Methods

Study site and plant selection

Grasses with high Dry Matter yield will be selected for this study. Up to 5 of the best biomass producing accessions based on visual inspection of each of the following grass species will be used to cover some of the diversity in genotypes within the species: *Panicum maximum, Brachiaria decumbens, Setaria sphacelata, Chloris gayana, Andropogon gayanus, Brachiaria brizantha,* and *Brachiaria ruziziensis*. *Brachiaria mutica* and *Pennisetum purpureum* will be used as controls in the experiment (See chart attached). These species are currently considered to be the best alternatives and are already established in plots of $10m^2$ at the International Livestock Research Institute Forage Production Site in Zwai, in the Ethiopian Rift Valley.

List of grasses used in the experiment

Grass species	**Common name**	**Accession number**
Andropogon gayanus	Gamba grass	852, 15748, 15750, 15755, 16211
Brachiaria brizantha	Brachiaria	684, 11088, 11257, 13620
Brachiaria decumbens	Signal grass	7364, 13165, 13205, 14720, 14721
Brachiaria mutica	Para grass	6964
Brachiaria ruziziensis	Ruzi grass	13332, 13614, 14743, 14771, 14774, 14813
Chloris gayana	Rhodes grass	645, 6628,6633, 6634, 7384, 13072, 15575, 15576, 19589, 19593
Panicum maximum	Guinea grass	13, 145, 1009, 9676, 13526, 16007
Pennisetum purpureum	Napier grass	14984, 16786, 16803, 16835, 16837
Setaria sphacelata	Setaria grass	143, 6543, 8671, 13102, 14757

The altitude of the location is 1640m a.s.l. (7◦54_N, 38◦44_E). The average annual rainfall of the area is 600mm, however, rains are irregular each year. The typical dry season ranges from October to February, and the rainy season peaks in July and August. The average yearly temperature in Zwai has a minimum of 13◦C and a maximum of 27 ◦C. The soil type is loamy sand, also classified as a Vitric Andosol (van de Wouw et al., 2008). The chemical properties of the soil at 0.15 and 0.5m depth were respectively pH 8.1 and 8.4, organic matter 2% and 1%, and nitrogen 0.13% and 0.07%. Available phosphorus was 5ppm and potassium was 5meq./100g soil at both depths (ILRI analysis).

Data collection

At the start of the long rains, plots will be clear cut to 5cm. Each plot of the selected accessions will be divided into two treatments and two $50cm^2$ quadrants clipped from each treatment (referred to as rep 1 and 2). One treatment will be harvested both at the 8^{th} and 16^{th} week, while the other treatment will be harvested once only in the 16^{th} week. Total fresh weight will be recorded and then a weighed sub sample of about 300g taken and dried at 60^0C in a drying oven for two days. These sub samples will be reweighed and sub sample dry weight calculated. Samples will be ground to pass a 1mm sieve and submitted for nutritional analysis.

Nutritional analysis

Analysis will be done using an infrared electromagnetic spectrum, FOSS NIRSystems. Before scanning, the samples will be oven-dried in paper envelopes at 55^{0}C overnight to reduce excess moisture. The next day samples will be put into a desiccator to cool down and packed carefully in cups for scanning. Care will be taken to keep cases clean and contamination away from the samples to ensure proper results for scanning. It is expected that 700 data points will be collected from the 1,100-2,500 nm range at every two wavelengths. The spectra file will be used with the 2010 Mixed Grass Equation to predict dry matter, ash, nitrogen/protein, fiber, and lignin content.

Outliers from the NIRS predictions will be submitted for nutritional analysis using the standard procedures and parameters from the ILRI-Ethiopia Analytical Services Laboratory in the lab manual, *Analytical Methods for Feeds, Animal Excrements, and Animal Tissues*, adapted and compiled by Mebrahtu Ogbai and Tenaye Sereke Berhan (1997). The samples will be analyzed for DM-Ash, NDF, ADF and Protein by collecting crucible weights, sample weights, ash, and acidic values in some cases. From this data it will be possible to obtain accurate results of the nutritive value of each sample tested. The results will then be used in the NIRS software to strengthen the equation and correlation for future scanning of mixed grass samples completed, resulting in fewer outliers and more accurate results.

Data analysis

Data will be analyzed using ANOVA, correlation and regression analysis. After the nutritional quality and productivity data has been collected, it will be possible to compare the results to previous results and studies done by others and determine validity. From the data we will compare the nutritional quality and productivity of each tropical grass accession and species, and in turn see which grass would be the best possible alternative to *Pennisetum purpureum* and *Brachiaria mutica.* Yield traits will be assessed to find if it is more productive to cut once or twice in a four month period. Nutritional traits will be evaluated to find which species have higher nutritional value and effects of cutting interval and harvest age on nutritive value. Standard equations will be used to calculate Metabolizable energy (ME) per kg of dry matter and relative feed value to compare among accessions.

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International Livestock Research Institute
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Gamba grass (*Andropogon gayanus*) for livestock feed on small-scale farms

Objective
To provide high quality forage for livestock feed in the tropics and warmer subtropics

Description

- A large perennial tufted grass up to 2m high
- Excellent drought tolerance withstanding dry spells of up to nine months
- High dry matter yields and can be cut at 30 day intervals
- Palatable when young
- Adapted to a wide range of soil types and performs well without fertilizer
- Used for continuous and rotational grazing

Limits of use
- As it approaches and reaches maturity, it coarsens and nutritional value declines after flowering
- Sensitive to cold and not tolerant of frost
- Potential environmental weed without grazing management

Management
Field preparation − prepared or semi-prepared seedbed
Establishment − sow at the beginning of the rainy season at 5kg per hectare of clean seeds at 1 to 2.5cm depth. Seeds may be of low quality, resulting in poor seedling vigour and unreliable establishment so young rooted tillers may also be used
Fertilizer − 100kg DAP per hectare after sowing to support early growth and establishment
Weeding − hand weed after establishment but may also suppress weeds by shading and root competition in dry areas
Harvesting − intervals of more than six weeks between cuttings and use a cutting height of about 4cm to maintain productivity and a good stand

Performance
Expect about 4-25 tonnes per hectare dry matter yields. Crude protein is 7-10% in young growth (on moderately fertile soils) declining to as low as 1.5% at maturity.

Information leaflet on livestock feeds and feeding technologies for small-scale farmers developed through collaboration between ILRI and its partners

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Brachiaria brizantha grass for livestock feed on small-scale farms

Objective
To provide high quality forage for livestock feed in the humid and sub-humid tropics

Description

- A leafy, perennial tufted grass 60-120cm high,
- Adapted to a wide range of soil types and grows well on acid soils
- Very palatable and good resistance to grazing
- Good resistance to spittlebug
- Can withstand dry seasons of up to 6 months
- Use as permanent pasture for grazing and cutting for fresh feed and for hay

Limits of use

- Will not tolerate fire or flooding
- Needs moderate to high fertility soils for good productivity
- May cause photosensitization, particularly in sheep and goats

Management
Field preparation – well-prepared seed-bed is preferred
Establishment – broadcast at 2–4 kg/ha lightly covered and compacted. It can be propagated vegetatively by root splits
Fertilizer – DAP at 100kg per hectare during establishment and nitrogen at 100kg per hectare after every cut. Very responsive to Nitrogen,
Weeding – weed twice after planting at monthly intervals during establishment. Once established it can spread and suppress weeds
Harvesting – should be cut before first flowering and then at 4 week intervals

Performance
Expect dry matter yields range from 8–20 tonnes per hectare per year with crude protein from 7–16%.

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Signal grass *(Brachiaria decumbens)* for livestock feed on small-scale farms

Objective
To provide high quality forage for livestock feed in the humid tropics and warmer subtropics

Description

- Low-growing perennial grass with trailing stolons
- Adapted to a wide range of soil types and grows well on acid soils
- Very palatable and good resistance to grazing and cutting
- Facilitates water infiltration and prevents erosion
- Very responsive to good soil fertility and tolerant of low soil fertility
- Good drought tolerance and can withstand dry seasons up to 4-5months
- Use as permanent pasture for grazing and cutting for fresh feed and for hay

Limits of use
- Will not tolerate frost, waterlogging or flooding
- Some shade tolerance but shading reduces tolerance to heavy grazing
- Susceptible to spittle bug

Management
Field preparation – will establish in poorly prepared soil but well-prepared seed-bed is preferable
Establishment – broadcast at 2–4 kg/ha, lightly cover and compact. It can be propagated vegetatively by root splits
Fertilizer – DAP at 100kg per hectare during establishment and nitrogen at 100kg per hectare after every cut. Very responsive to Nitrogen
Weeding – weed twice after planting at monthly intervals during establishment. Once established it can suppress weeds effectively
Harvesting – should be cut before first flowering and then at 4-6 week intervals. Very frequent cutting results in prostrate leaf growth which is difficult to harvest

Performance
Expect dry matter yields of around 10 tonnes per hectare per year with up to 30 tonnes per hectare per year under high soil fertility. Crude Protein content ranges from 9–20% and rapidly declines with age of plant.
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Para grass *(Brachiaria mutica)* for livestock feed on small-scale farms

Objective
To provide high quality forage for livestock feed in the tropics and warmer subtropics

Description

- A creeping perennial usually up to 1m high which spreads rapidly from stolons
- Very tolerant of waterlogged conditions
- Grows in partial shade but prefers full sunlight
- Very palatable young stems and leaves
- Adapted to a wide range of soil types and grows well on acid soils
- Use for grazing or as cut and carry fresh feed

Limits of use
- Very sensitive to frost
- Poor drought tolerance
- Potential weed if ungrazed.

Management
Field preparation – well-prepared seed-bed for sowing and an initial ploughing for stem cuttings
Establishment – broadcast seeds at 3–4 kg/ha, lightly covered and compacted but more commonly planted from stem cuttings disc-harrowed into soil
Fertilizer – DAP at 100kg per hectare during establishment and nitrogen at 100kg per hectare after every cut. Very responsive to Nitrogen under moist growing conditions
Weeding – weed twice after planting at monthly intervals during establishment. Once established it can suppress weeds effectively
Harvesting – should be cut before first flowering and not grazed until the grass is more than 20cm high and well-established and 4-6 week intervals after

Performance
Expect dry matter yields of 5–12 tonnes per hectare per year and crude protein contents from 14–20%.

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Ruzi grass (*Brachiaria ruziziensis*) for livestock feed on small-scale farms

Objective
To provide high quality forage for livestock feed in the humid and sub-humid tropics

Description

- A spreading perennial similar in habit to Para grass up to 1.5m tall when flowering
- Very palatable and withstands moderately heavy grazing
- Can tolerate dry seasons of up to 4 months
- Rapid establishment from seed or cuttings
- Use as permanent or semi-permanent pasture for grazing, cut and carry green feed or hay

Limits of use

- Needs well drained fertile soils and not tolerant of very acid soils
- Not tolerant to frost
- Very susceptible to spittlebug

Management
Field preparation – well prepared seed bed is recommended
Establishment – broadcast seed at 2.5–10 kg/ha or sow in rows 60cm apart no deeper than 2cm, lightly cover and compact. It can also be propagated vegetatively by root splits or stem cuttings
Fertilizer – DAP at 100kg per hectare during establishment and nitrogen at 100kg per hectare after every cut. Needs high phosphorus in the early growth on a wide range of soils
Weeding – weed twice after planting at monthly intervals during establishment. Once established it can spread and suppress weeds
Harvesting – should be cut before first flowering and then at 6 week intervals

Performance
Expect dry matter yield around 20 tonnes per hectare dry matter and 7-13% crude protein

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Rhodes grass (*Chloris gayana*) for livestock feed on small-scale farms

Objective
To provide high quality forage for livestock feed in the semi-arid and sub-humid tropics

Description
- Fast growing deep rooted perennial grass that makes excellent hay
- Good drought and salinity tolerance
- Tolerates seasonal waterlogging
- Wide adaptability and some cold tolerance
- Tolerant of cutting and heavy grazing
- Very palatable and good nutritive value

Limits of use
- Not adapted to acid infertile soils
- Poor shade tolerance
- High levels of soil fertility needed

Management
Field preparation- well prepared and ploughed field
Establishment- can be propagated vegetatively or from seeds surface sown no deeper than 2cm at a seed rate 1 to 4kg per hectare then rolled
Fertilizer- DAP at 100kg per hectare during establishment and nitrogen at 100kg per hectare after every cut
Weeding- weed twice after planting at monthly intervals during establishment
Harvesting- cut latest at flowering about 6 months after planting and then every 2 months to maintain quality

Performance
Expect from 10 to 25 tonnes per hectare dry matter. Crude protein is about13% in young grass.

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Guinea grass (*Panicum maximum*) for livestock feed on small-scale farms

Objective
To provide high quality forage for livestock feed in the wet tropics and subtropics

Description

- A tall tufted perennial with a deep, dense and fibrous root system
- Wide adaptation from sea level to 2500m altitude in the tropics
- Adapted to high rainfall areas but some tolerance to drought
- Tolerant to acid soils
- Suited to grazing and cutting
- Very palatable and high quality feed
- Good for erosion control

Limits of use
- Not adapted to areas with waterlogging
- Not adapted to heavy frosts
- Requires fertile soil or fertiliser application
- Intolerant of heavy grazing or severe defoliation

Management
Field preparation − well prepared seed bed is generally required
Establishment − broadcast seed, ahead of the expected rainy season, at a rate of 3 to 6kg per hectare and cover lightly. For soil erosion control it can be established from root splits, planted every 0.5 to 0.6m in rows from 1.25 to1.5m apart on contours
Fertilizer − DAP at 100kg per hectare during establishment and nitrogen at 100kg per hectare after every cut or manure
Weeding − weed twice after planting at monthly intervals during establishment
Harvesting − needs to become well-established before grazing. It should not be grazed or cut below about 30cm to ensure persistence

Performance
Expect around 14 tonnes per hectare dry matter, depending on variety and growing conditions. Crude protein ranges from 6-25% depending on age and nitrogen supply.

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Napier or elephant grass ILRI 14984 (*Pennisetum purpureum*) for livestock feed on small-scale farms

Objective
To provide high quality cut and carry feed for livestock in the sub-humid middle altitudes.

Description
- Very tall perennial grass which tends to become coarse as it matures
- Vigorous deep rooted grass which tolerates limited dry spells
- Tolerates poor drainage
- Good for soil stability and as a wind break
- Fast growing and good palatability in early growth stage if cut often
- Useful for cut and carry, hay or silage

Limits of use
- Not adapted to areas with frost
- Not suited to waterlogged areas
- Will not persist without fertiliser
- Coarse, fibrous and sharp leaves if not cut frequently

Management
Field preparation – ploughed field but can be used for zero tillage
Establishment – stem cuttings of 2 to 3 nodes planted at 50cm spacing
Fertiliser – urea at 100kg per hectare or manure after each cut
Weeding – after establishment and every cut
Harvesting – cut at 5cm 3 times per year, or every 3 months if good growth

Performance
Expect about 40 tonnes per hectare fresh forage for cut and carry. Protein content of the forage is about 9%.

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Setaria grass (*Setaria sphacelata*) for livestock feed on small-scale farms

Objective: -
To provide high quality forage for livestock feed in the humid lowland and highland tropics

Description

- Tufted perennial grass up to 2m tallAdapted to a wide range of soils but does not grow well on very acid soils
- Tolerant of flooding and waterlogging
- Some ecotypes are cold or frost tolerant
- Palatable when young but quality quickly declines wtih maturity
- Use for permanent pasture for grazing, cut and carry or silage

Limits of use
- Not well adapted to alkaline or very acid soil
- Not very drought tolerant
- Should not be fed young and as sole feed due to presence of oxalates

Management
Field preparation- well prepared seed bed preferred
Establishment- broadcast seeds at 2-5kg per hectare at a depth no deeper than 2cm and cover lightly. Can also be planted from root splits
Fertilizer- 100kg per hectare DAP or urea required during establishment and nitrogen at 100kg per hectare after every cut
Weeding- slow early growth so weed twice after planting at monthly intervals. Frequent weeding is necessary until well established
Harvesting- cut latest at flowering and then every three weeks at a height of 15cm to maintain quality

Performance
Expect about 10-15 tonnes per hectare dry matter per year and 6-15%% crude protein.

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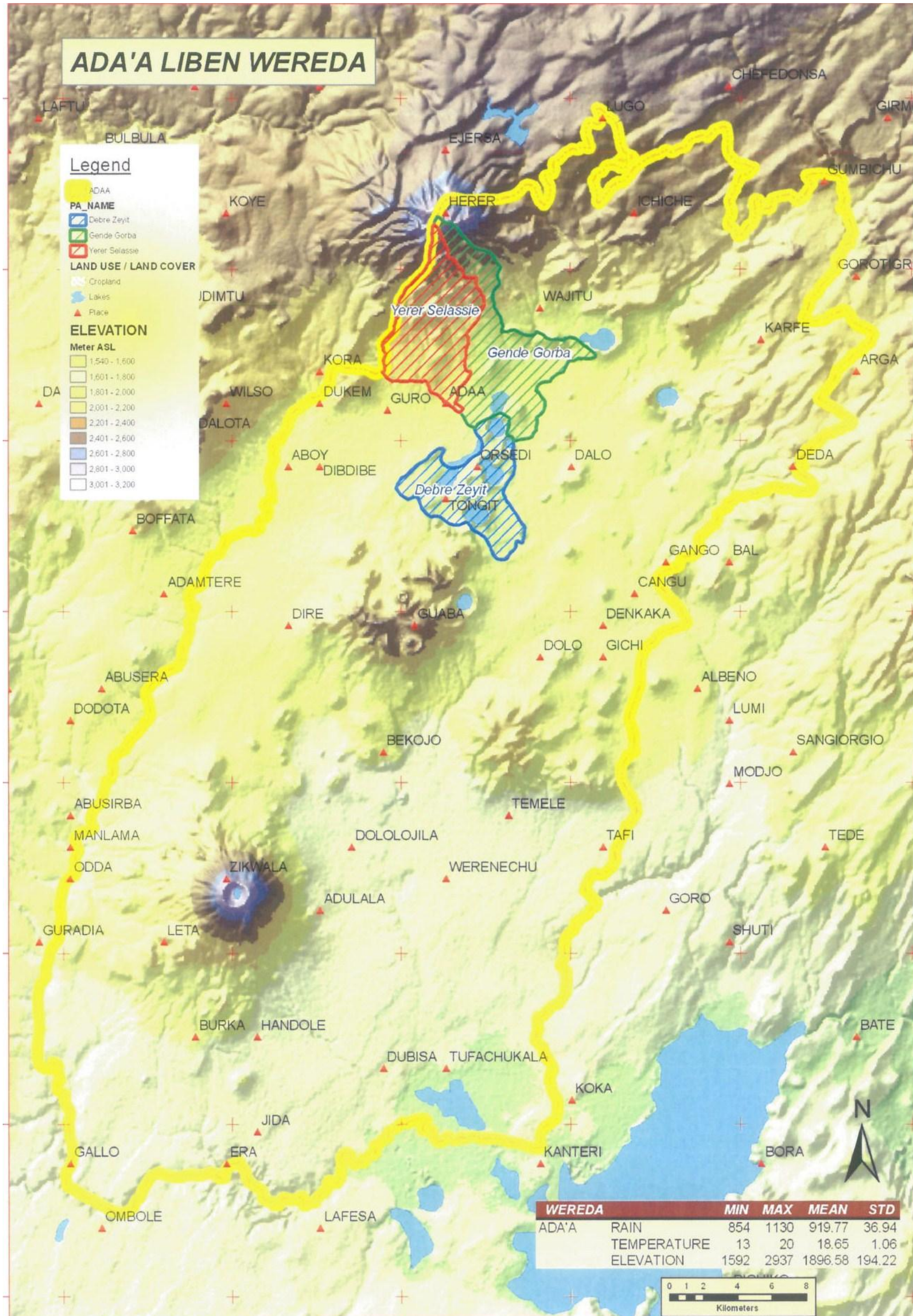
Appendix 4


ADA'A LIBEN WEREDA
Legend
ADAA
PA_NAME
Debre Zeyit
Gende Gorba
Yerer Selassie
LAND USE / LAND COVER
Cropland
Lakes
Place
ELEVATION
Meter ASL
1,540 - 1,600
1,601 - 1,800
1,801 - 2,000
2,001 - 2,200
2,201 - 2,400
2,401 - 2,600
2,601 - 2,800
2,801 - 3,000
3,001 - 3,200
LAFTU
BULBULA
EJERSA
LUGO
CHEFEDONSA
GIRMI
GUMBICHU
KOYE
HERER
ICHICHE
GOROTIGRI
WAJITU
Yerer Selassie
Gende Gorba
KARFE
KORA
ARGA
DA
WILSO
DUKEM
GURO
ADAA
DALOTA
ABOY
DIBDIBE
ORSEDI
DALO
DEDA
Debre Zeyit
TONGIT
BOFFATA
GANGO
BAL
CANGU
ADAMTERE
DIRE
GUABA
DENKAKA
DOLO
GICHI
ABUSERA
ALBENO
DODOTA
LUMI
BEKOJO
SANGIORGIO
MODJO
ABUSIRBA
TEMELE
MANLAMA
DOLOLOJILA
TAFI
TEDE
ODDA
ZIKWALA
WERENECHU
ADULALA
GORO
GURADIA
LETA
SHUTI
BURKA
HANDOLE
BATE
DUBISA
TUFACHUKALA
KOKA
JIDA
N
GALLO
ERA
KANTERI
BORA
OMBOLE
LAFESA
WEREDA MIN MAX MEAN STD
ADA'A RAIN 854 1130 919.77 36.94
TEMPERATURE 13 20 18.65 1.06
ELEVATION 1592 2937 1896.58 194.22
0 1 2 4 6 8
Kilometers

Appendix 5

Ada'a Liben Farmer Interview Questions

1. What is the number of adults in your household?
2. How much land do you own, and what do you use it for?
- Crops
- Grazing
- House/Yard

3. Do you own any of the following animals?
- If so how many?
  - Local Cattle
  - Local Oxen
  - Crossbred Cattle
  - Sheep
  - Goats
  - Donkeys

4. What is the primary feed for your animals?
- Crop Residues
- Stubble Grazing
- Natural Pasture/Roadside
- Household Waste
- Concentrate for Dairy Animals

5. Do you have any feed shortages?
- If so, when?

6. Do you grow any forages on your farm?
- If not, would you?

7. Where do/would you grow forages?
8. What do you look for in forages?
- Yield
- Good Early Establishment
- Ease of Producing Plant Material
- Persistance
- Ease of Propagation
- High Feed Value/Palatability
- Planting Method-Seed vs. Cutting
- Number of Times to Cut per Year
- Regrowth

9. Do you work with the local extension center?
- If so, is it helpful and how often do they visit/ you go to them?

10. Have you ever visited the FTC (Farmer Training Centre)?
- Why?

11. Additional comments-

Appendix 6

				Land Usage				Animals				
Number	Name	M/F	#	Ha. Of	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	Urgactha Bedada	M	4	3	2	1	1,000	1	5	1	0	4
2	Tehai Telahun	F	2	2.25	2	0.25	2,000	1	4	1	6	3
3	Frehiwot Gezahegn	F	3	1.5	1.5	0	1,000	0	2	4	0	0
4	Wegayehu Negash	F	2	1.75	1.5	0.25	500	0	2	4	0	1
5	Kflu Truneh	M	3	2	1.75	0.25	2,000	0	2	2	0	1
6	Mulatua Negash	F	3	1	1	0	500	0	3	2	8	2
7	Wana Abaguch	M	4	2.5	2.2	0.3	8,000	0	4	8	0	1
8	Regassa Dadi	M	1	0.75	0.75	0	500	0	3	2	0	2

	Current Feed								Extension			
Number	Crop Residues	Stubble Grazing	Nat.Pasture	Hsehld Waste	Concentrate	Feed Shortages	Forages Grown	Where Grown	Useful	How Often/ Where	Visit FTC	Purpose
1	1	2	3	If any	X-bred Only	None	Napier	Backyard	Y		Goes there	Crop Advice
2	1	2	3	If any	X-bred Only	Rainy Season	Oats, Vetch, Napier	Plot in Backyard	Y	Often come and gi	No	
3	1	Oxen	Straw		2	Must buy throughout	Oats	Plot	N	Not in contact		
4	1	Oxen			X-bred Only	Must buy throughout	Oats, Vetch, Napier	Around crops, and back	Y	Seldom t/o year	Yes, husband got training	Oats seed and how to grow forages
5	1		3	Sometime	2	Rainy Season	Oats	Cropland	N	Not as active		
6	1	Oxen	0	3	X-bred Only	Must buy throughout	Napier	Backyard	N			
7	1	Oxen	2	If any	X-bred Only	Must buy throughout	Oats, Vetch, Napier, Lablab, Fodder trees	Plot and field	Y	3-4 times per year	They come, wife got training	Dairy
8	1	2 (off crops)		3	X-bred Only	Must buy throughout	None	Backyard	Y	Every month	Got training	Compost
							All claimed they will begin to grow the forages we gave them, and some already have.					

Number	Yield	Good Early Est.	Ease of Productn	Persistance	Ease of Propgtn	High Feed Value	Palatability	Planting Method	Cuttings per year	Regrowth
1	1			2		0				3
2	1									2
3	1									
4	1									
5	1									
6	1									
7	1					X	X		X	
8	1	2				2				

Additional Comments:

1 Oats produce a lot, Vetch has too much persistence, and because it cannot produce seeds, it springs up volunteer and can't use land for other purposes, likes Lablab and Napier

2 Likes advice and discussion, it's good to share ideas

3 Advice is important

4 Contact is good, appreciates seed

5 ILRI gave him a heifer, shortly after it died

6 Divorce caused no more forages to be grown, now she's getting established with more X-bred cattle, one's getting old so she'll buy another

7 Shortage of land creates a shortage of feed, he had more cattle but has decreased because feed prices have risen, but milk prices have not, he's concerned with his production and how long he can continue with dairy

8 Keep contact and discussion, happy with what ILRI has started, drought caused a loss of forages (and divorce) it would be good to come back, discuss, and continue

Appendix 7

Total Number Male vs. Female	Male	Female
Number of Adults per Household	3	2.5
Hectares of Land (Including House)	6.9	3.15
Hectares of Land Rented	2.5	4
Heactares of Land for Grazing	1.28	0.25
Local Cattle	1	1
Oxen	14	11
X-Bred Cattle	12	11
Sheep	14	0
Donkeys	8	6
Feeding Shortages	3	4
Grow Napier Currently	2	3
Grow Oats Currently	2	3
Grow Vetch Currently	1	2
Grow Lablab Currently	1	2
Useful Extension	3	2
Visit FTC	3	1