Project Final Report 2017

Project No. A208FR10

Project Name	Participatory forage evaluation for improved milk production and quality
Description	Low milk productivity in Kenyan dairy is a function of poor feeding among other factors. Participatory on-farm feeding trials were implemented in areas where International Fertilizer Development Center (IFDC) works to improve dairy production. The forages grown were used to feed selected dairy cows under farmers' conditions and milk production and quality was monitored. In addition, the project contributed to training farmers on forage production and utilization. Relevant actors within the dairy value chain - including financial lending institution, agricultural extension service providers, forage seed suppliers - delivered on their expertise and empowered the trainees with the relevant information.
Project Sponsor	International Fertilizer development Center (IFDC), 2Scale Project
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Date	May, 2017

Project Successes

Name	Description
Participatory selection of best-bet forages	Participatory evaluation of adaptable forages was implemented in 2015 in OljoroOrok Nyandarua County. This is one of the areas where International Fertilizer Developing Center (IFDC) is working to improve on the diary value chain. Dairy farmers were involved in forages evaluation and selection. Some cultivars of fodder oat and vetch legume were found productive and acceptable by farmers. *See annex 1 for more information.*
On-farm feeding trials and impact on milk production using best bet forages	Using selected forages from the earlier evaluation (Oat-Conway, Vetch), a feeding trial on selected lactating cows under farmers' conditions was undertaken. Milk production and quality was compared to the performance when under farmer practice. The improved forages not only increased milk production, but quality as well. *More details can be found in annex 2.*
Positive cost benefit analysis (CBA)	*As can be seen in annex 2*, CBA of feeding oat and vetch returned positive results. As such, adopting the technologies by the farmers is economically sound with potential to increase incomes.
Training of trainers	To create awareness and dissemination of the forages, training of trainers (ToT) were conducted in Nyandarua and Meru counties. Trainees comprised farmer group leaders and frontline livestock extension staff. For multiplier effect, trainees were give targets on number of dairy

	farmers to reach in their respective localities. *We refer to annexes 3 and 4 for more details.* A farmer friendly video on forage production and utilization was developed by IFDC with participation of International Center for Tropical Agriculture (CIAT) and also used during the above training.

Unexpected Events

Description	Impact	Actions Taken
Dry weather-2016/17	Reduced forage production intended for the feeding trial	The number of farmers involved in the feeding trial was scaled down from 20 to 10

Lessons Learned

Description	Recommendation
Working with farmers' full participation in forage evaluation is important. Showing the difference the improved forages can make in livestock productivity (e.g. increased milk production) resonates well with farmers.	Results obtained in this study are capable of increasing milk production economically, and should be promoted, especially in similar areas as the study was done.
Farmer training should be a continuous process and requires innovative ways to impart the information.	Learning by farmers is better when in practice. Having field demonstrations delivers the message better and complement theory learnt.
The importance of matching forages with adaptable environment (Agro-ecological zone).	For the cold areas that are also frost prone, temperate forages (with C3 photosynthetic pathway) are better than tropical forages (with C4 photosynthetic pathway) as their growth is curtailed. Within a species, cultivar differences in herbage output exist and selecting high yielders is preferable. In the case of this study, use of Conway oat provides higher herbage output per unit area than the local oat cultivar.
Value chain approach in dairy development is paramount.	Availability of a market for milk is a key driver in dairy development and should be considered where promoting milk production is intended.
There is a need to develop sustainable access to a variety of forage seeds.	Forage seed system is not developed and therefore would require focus, for productive forage technologies such as identified in this study to have a practical meaning.

Annex 1: Participatory selection of best-bet forages

Project Title: Improving fodder availability in OljoroOrok, in Nyandarua, Central Kenya

Duration of project:

2015/16

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Summary of project

Smallholder farmers in central Kenya depend on dairy for their household nutrition in addition to incomes. One of the major constraints is inadequate fodder availability throughout the year, which could be attributed to several factors at play including small land holdings, lack of skills and fodder planning, lack of access to and appropriate fodder species that are matched to farming systems and ecological conditions. In the area of study, a survey was done to evaluate the feeds and fodder situation, which was followed-up with participatory fodder evaluations at two levels. Farmer-led trials where sample farmers were provided with test forages to try on their farms, and scientist-led trials where bio-physical data were measured in randomized trials. Although livestock and especially dairy remained important in household incomes and nutrition in the area, year-round fodder availability remains a challenge. The initiative by the Eldoville dairies to buy milk from the farmers within OljoroOrok provides an impetus to bolter household incomes and encourage farmers to increase their productivity. Whereas from the farmer-led trials farmers reported increased milk production using the improved forages, the scientist-led forage trials showed farmers could leverage on improving their feed resource base, just by the choice of fodder varieties within a species amongst the test forages that were considered. To improve livestock productivity, farmers would need to improve fodder availability through cultivation, especially using elite and tested forages.

Keywords: Fodder, Participatory evaluation, Dairy farmers, Oats, Rye grass, Festulolium

Background

In Kenya, livestock and especially dairy contribute significantly to the gross domestic product. Many household incomes and nutrition benefit from the sector including formal and informal employments generated within the livestock sector. The per capita milk consumption in Kenya is amongst the highest is eastern Africa averaging about 145 liters/person /yr. However, this remains low compared to the developed economies where the figure goes up to 200. According to projected figures for livestock products demand by the year 2050, they are expected to be three times as high. This is largely driven by increase in population that in Kenya has been at the rate of 2.2% annually. Albeit this situation, the available arable land remains the same, and expected to sustain the increasing food demand. As such, it becomes inevitable that the productivity efficiency has to increase per unit land, thus intensification, including livestock production. Already, in the project site, keeping of dairy cattle is shifting towards stall feeding especially the dairy animals for the reasons elucidated above (Mwendia *et al* 2015). Therefore, it becomes imperative for the necessity to empower the livestock keepers in such areas as OljoroOrok among others. This report presents such efforts in OljoroOrok in the year 2015 done in collaboration with IFDC under the 2SCALE project (http://ifdc.org/2scale/).

The aims of the project were to:

- Capture the importance of livestock in the study site[1]
- Assess the fodder availability in the area in a calendar year[1]
- Demonstrate forage options to the livestock farmers in the area
- Carry detailed forage trials with the farmers to identify the best bets
- Assist farmers to access the forage seeds/planting materials of the identified best-bets

[1] Presented in a separate report 'Assessing feeds and feed availability for dairy production in OlJoroOrok sub-county, Nyandarua County in central Kenya as a baseline for the 2SCALE project'

Farmer-led forage evaluation

Approach

After conducting the survey that showed livestock being important is the area whilst feeding remained a challenge due to inadequate fodder, 10 farmers from each of the three groups involved in the survey (Nyamarura, Kanguu and Hillten) were selected and provided with some forage seeds to try on their own and report back on their observations. The forages were oats, vetch, Lucerne, Sugargraze and Lupin. Except for Sugargraze whose seeds provided were adequate for 10m x 10m plots, the others were for 5m x 5m plots. Farmers selected comprised both male and female livestock keepers (Table 1). Demonstrations were conducted on planting the forages including agronomic measures required to be observed like weeding but all the decisions were left to the farmers. Initially the farmers were provided and explained on how to fill some data forms regarding the forages. However, it later turned out none of the farmers filled the forms and as such, interviewing the specific farmers was necessary to get some feedback.

Table 1. Women and men farmers from Nyamarura, Hillten and Kanguu farmer groups supplied with Lucerne, Lupin, vetch, local oats and Sugargraze for farmer-led trials.

Farmer group	*Women*	*Men*
Nyamarura	Rose Wacera (0713 188 066) Hellen Wangui (0720 612 778) Joyce Wajiku (07171 606 160) Rose Wanjiru (0726 004 240) Martha Njoki (0714 893 824) Esther Wangui (0706 803 350)	John Njoroge (0711 177 191) David Kuria (0729 055 011) Samuel Mwaura (0727 047 626) James Ngari (0736 574 828) Isaac Kaguai (0703 286 656)
Hillten	Beatrice Kagwima (0720 069 955) Lucy Kiragu (0712 589 316) Jadidah Waruguru (0725 336 833) Monicah Wangari (0722 709 746) Caroline Wangui (0714 889 022) Esther Wangui (0706 803 350)	Peter Njihia (0720341 161) Patrick Nachu (0726 749 941) Joseph Ngare (0722 288 116) Josphat Kinyua (0725 446 194) Shem Kariuki (0705 835 516) Eliud Mutura (0726 761 878)
Kanguu	Grace Wambiu (0729 209 187) Julia Kiago (0716 494 302) Freshiah Karindi (0721 256 978) Doreen Kinya (0725 627 876) Ellah Waltere (0735 222 059)	Samuel Mugo (0720 104 941) Peter Mwangi (0722 561 258) Simon Migwi (0721 806 542) Hezron Gichingiri (0725 487 701) Peter Mbucho (0704 415 692)

Outcomes

Out of the 33 farmers provided with the forages seeds only, only 19 (58%) were available to provide feedback. Generally the others indicated they never planted or were unable follow up with the trials, while others in Hillten group broke out from the group.

Fodder planting and management was largely similar across the farmer groups with farmers applying variable amounts of farm yard manure at planting across the sites and gender (Table 2). Differences in time spent on weeding varied widely among the groups with farmers at Nyamarura repotting almost five times as high that of Hillten.

Table 2 Means (± se) for manure application (kg), planting and weeding labor (hrs)

Farmer group	Gender	Manure (kg)	Planting Labour (hrs)	Weeding (hrs)
Hillten	Female	10.8 ± 4.9	3.5 ± 0.12	1.6 ± 0.20
	Male	3.9 ± 2.6	2.9 ± 0.74	1.1 ± 0.07
Kanguu	Female	10.5 ± 6.30	3.1 ± 0.73	3.6 ± 1.14
	Male	16.0 ± 4.37	2.9 ± 0.37	6.0 ± 2.40
Nyamarura	Female	17.2 ± 1.86	1.2 ± 0.22	5.6 ± 2.05
	Male	15.7 ± 7.41	3.4 ± 1.23	7.6 ± 5.10

Perceived fresh biomass production varied across the fodder types with Sugargraze attaining the most followed by oat, vetch Lucerne then Lupin (Table 3). However, Lupin referred to seeds and not the herbage.

Table 3 Mean fresh biomass production (kg) across farmer groups and fodder types

Fodder type	Hillten	Kanguu	Nyamarura	*Mean*
Lucerne	15.3	19.1	12.5	*15.6*
Lupin	10	28	8.3	*15.4*
Oat	60.4	37.8	58	*52.1*
Sugargraze	-	111.3	56.7	*84.0*
Vetch	24	32.3	22	*26.1*

Lupin figures refers to seeds weight. – Means not planted

Generally, the farmers indicated the reasons as to why they liked or did not like any of the forages as stipulated in Table 4.

Table 4. Attributes farmers liked or did not like about the fodder types

Fodder type	liked	not liked
Lucerne	• Most seeds germinated • Increased milk production • Accepted by cows • Regrows after harvesting	• Slow growth • Difficult weeding • Preferred and eaten by rabbits, gazelles • No seeds produced for propagation
Lupin	• Easy planting and weeding • Germination is excellent • Suppress weeds • Easy harvesting and management • Fast growth • High seed yield	• Differential seed maturity in a single plant • Wilting of some plants • Require grinding seeds before feeding • Does not regrow/recuperate • Herbage not accepted by cattle
Oat	• High herbage production • Fast growth and tillering • Increased milk production • Suppress weeds • Well accepted by cattle • Seed recycling possible • Can be conserved as hay	• Rust attack • Short plant height, and not preferable • Narrow leaves
Vetch	• Can regrow if harvested before flowering • Easy planting and establishment • Cover crop and weed suppressing • Palatable and Increase milk production • Vetch reseed and grow again • High forage production • No frost bite, pests or diseases • Can be intercropped with oats	• Difficult weeding at early stage • Senescence of leaves and shed off
Sugargraze	• Possible to get regrowth • Increase milk production	• Does not suppress weeds • Affected by frost

Inferences

Application of manure in the forage plots by the farmers signifies the willingness for high forage production. Further, investing time to attend to the forage plots could be attributed to anticipated benefits likely to accrue. In the process farmers were able to discern likes and dislikes against each of the fodder type as stipulated in Table 4 and it is through the processes farmers can be able to make informed decisions on selecting preferred forages. Forages that are likely to be adopted include those with high production per unit area, improve animal performance like increased milk output, and those that recuperate after the initial harvest as this saves on the costs likely to be incurred in replanting. However, if the forage produce seeds that can be recycled, this also cushions farmers on availability of the seeds as well as saving on cost of seed. In addition, forming ground cover helps to smoother weeds and in the process scale down weeding costs.

Among the forages given to the farmers, only oat and Sugargraze constitute the basal forage while the others (Lupin, vetch, Lucerne) are largely for supplementation. Oat is adapted to areas prone to occasional low temperatures and frost, and would be preferable in the area while for a supplementation fodder, vetch and Lupin could be perform well in the area.

The subsequent sections focused on basal forages (oat, rye, festuloliums) varieties that could potentially contribute to improved fodder availability for livestock productivity.

Scientist-led trials

Better oat varieties for forage production in Kenya

Introduction

Dairy production in Kenya is usually constrained by inadequate year-round fodder availability. Several factors contribute to the shortage including lack of high yielding forages that are adapted to the variable environments. There are estimated 1.8 m smallholder farmers in Kenya (ILRI, 2006), including those located in cold areas, where the widely adopted fodder Napier grass (Staal *et al.,* 1998) does not perform well because of low temperatures at high altitudes above 2000m (Boonman, 2003). Farmers in these areas rely on grazing unimproved pastures in addition to minimal fodder growing that include; Oat (*Avena sativa*), Napier grass (*Pennisetum purpureum*), Sorghum (*Sorghum bicolor*) (Mwendia, 2015). Except oat, the grasses are largely tropical that do not do well in cold and frost-prone areas. Further, the oats grown by farmers constitute recycled seeds, coupled with limited options of fodder oat varieties. Fodder oats have been successfully used elsewhere, and especially in temperate environments, to provide basal diet for livestock, and the trend is to encourage oat use for fodder in smallholder production systems (FAO, 2004). Use of oat for fodder has increased over the last 20 years probably also due to its versatility where it can be grazed, cut and carried, and conserved as either hay or silage (FAO, 2004). However, in Kenya oat cultivation for fodder declined by over 50%, from 11,331 ha to 5,000 ha in 10 years period (1960–70) attributable to changes in farming systems and land holding size. Albeit the drop, there is increased interest in livestock and especially dairy, and the adaptability of oat in fitting in a wide altitude range of 1,750–3,000 m (Boonman 2003), is likely to become important source of fodder provision. Apart from varieties that were available in the early 1960s, namely Suregrain, Lampton and Grey Algerian (Boonman 2003), anecdotal evidence shows there has been no much effort to evaluate and promote high yielding forage lines bred over the years. This work therefore aimed to introduce and evaluate fodder oats varieties for increased fodder availability in central Kenya.

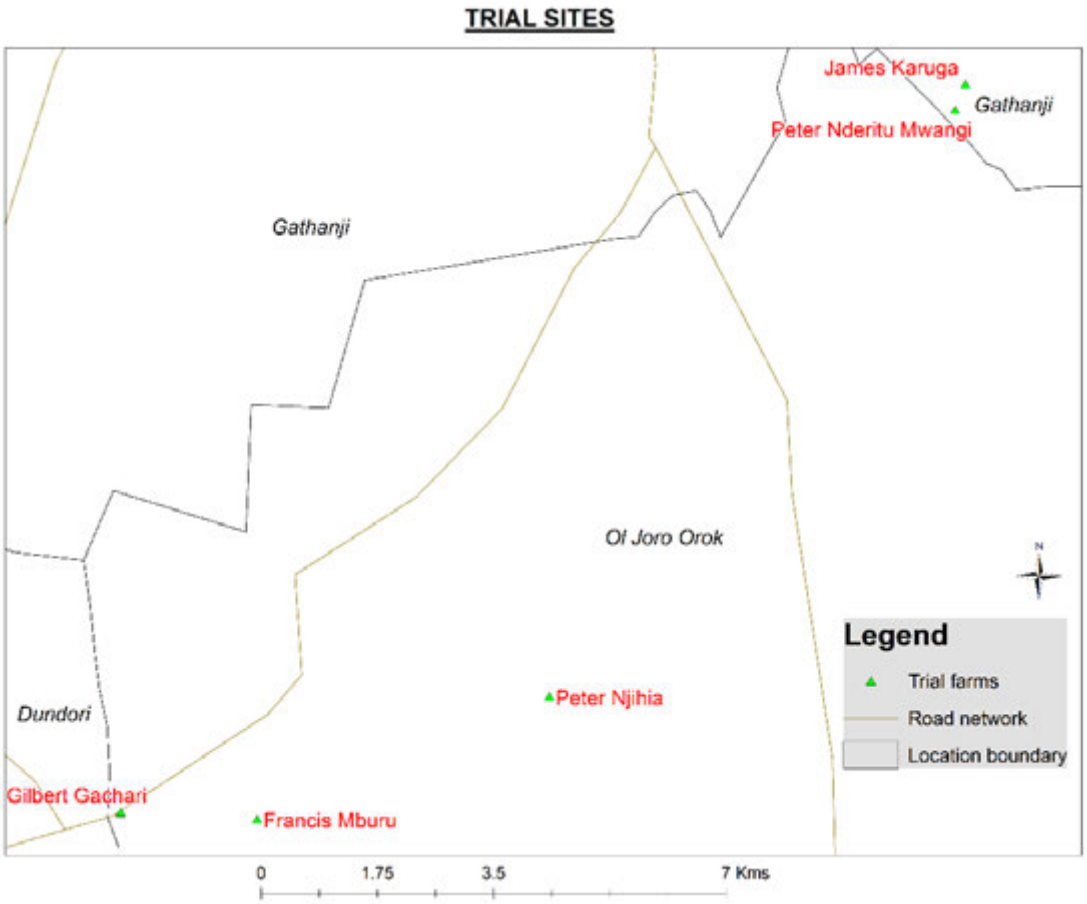
Materials and methods

Sites description and experimental design

The trials were conducted on farm at OljoroOrok in Nyandarua County in Central Kenya, and in five sites. Location of the farms are as follows, and host farmers in parentheses; 0° 09′ S; 036° 18′ E; 2667 m above sea level (Francis Mburu), 0° 09′ S; 036° 17′ E; 2808 m above sea level (Gilbert Gachari), 0° 08' S, 036° 20' E; 2546 m altitude (Peter Njihia), 0° 03' S; 036° 24' E; 2359 m attitude (Peter Mwangi) and 0° 03' S; 036° 24' E; 2368 m altitude (James Karuga). The activity was done in a participatory approach with farmers' groups involved in dairy where individual members are farmers who keep 2-5 dairy animals on their farms. The test forages included five oat (*Avena sativa*) varieties; Balado, Conway, Mascani, Glamis, Rhapsody against a local check namely referred to as 'Local' for purpose of this study. Except for the Local, the seeds were sourced from Prifysgol Aberystwyth University in United Kingdom. Three farmer groups namely; Nyamarura, Hillten, and Kanguu were sensitized about the trials upon which two farms in each of Nyamarura and Kanguu, and one farm by Hillten were selected to host the trials. Details of soils in the specific trial sites are in Table 1. The trials were laid out in a completely randomized block design with three replicates, in a farm, and in 5 farms as explained above.

Table 1. Soil properties (0-20cm depth) at oat trial sites in OljoroOrok. N = 5

Farmer group	Host farmer	pH	% Clay	% Sand	% Silt	% Total N	% Total C	Bray P mgP/kg	Soil type
Nyamarura	Francis Mburu	5.0	34.8	31.9	33.3	0.32	3.6	16.2	Clay loam
Nyamarura	Gilbert Gachari	5.6	37.5	34.5	28.0	0.27	2.9	12.9	Clay loam
Hillten	Peter Njihia	6.1	43.2	31.2	25.5	0.35	3.7	7.3	Clay
Kanguu	Peter Mwangi	5.2	42.1	35.9	22.0	0.19	2.1	8.3	Clay
Kanguu	James Karuga	5.4	47.7	34.3	18.0	0.18	2.1	2.6	Clay



Trials establishment and maintenance

Land preparation was done by the farmers manually with hoes to a fine a tilth. Plots sizes of $6m^2$ were marked out using wooden pegs. Furrows of about 6mm depth, and 15cm between the rows were made in each plot. NPK fertilizer (23:23:0) was applied at a rate of 50 kg N/ha. Seeds were then spread along the furrows within each plot at the rate of 100 kg/ha then shallowly covered with soil on 12-14th May, 2015. In the short rain season (October 2015- January 2016), the trial was repeated at one site (Gachari's farm) as seeds were not enough for more sites. All the planting protocol and biophysical data procedures were followed as in the previous season except harvesting that was done at boot stage attained at 95 days.

Figure 1. Planting oat trials by Kanguu (a) and Hillten (b) farmer groups in May 2015

Measurements
Tillering and plant height

Number of tillers were counted at day 20 and 42 after planting in a quadrat of 0.25m^2 per plot. The quadrat was randomly placed within the plot and the tiller counts within the quadrat recorded. Plant height was measured from the base of a tiller to the most-high standing point, and for four randomly selected plants within each plot before harvesting, and recorded.

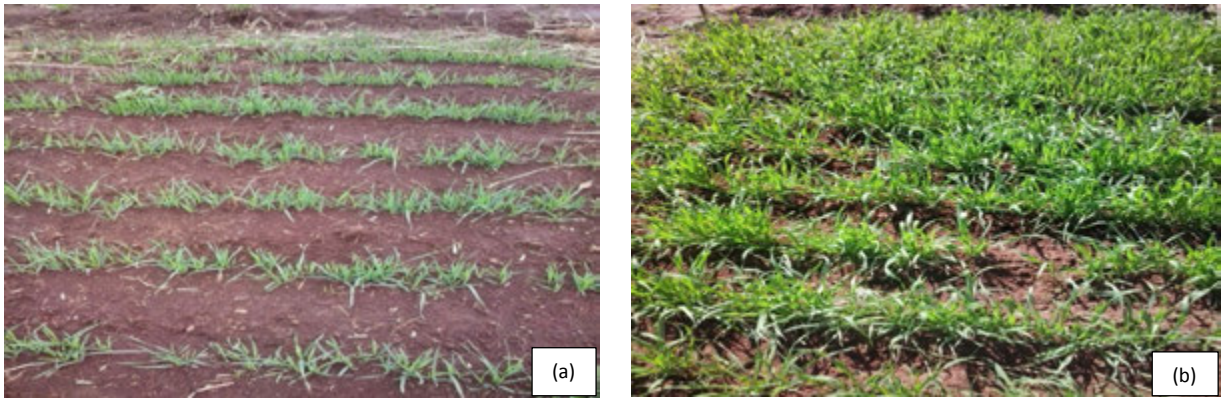


Figure 2. Appearance of the oats at 20 days (a) and (b) 42 days in 2015

Dry matter yield

A quadrat of $1m^2$ was harvested from each plot, and fresh weight determined using digital weighing balance (Hanging Scale CH50K100, Kern and Sohn, Balingen, Germany). Samples were randomly selected from the harvested biomass, and fresh weight taken. The samples were then dried to constant weight in the oven at 65^{o}C for 48h, and weighed to determine the dry matter content. The samples were further ground to pass 1mm sieve and stored in sample bottles for subsequent laboratory analysis.

Figure 3. Harvested (a) and weighing (b) fodder oats at Nyamarura farmer group in September 2015

After sampling, the remaining forage was pooled together and the farmer hosting the trial requested to feed to a cow in mid-lactation, over the days it takes to deplete the material, and note observations on any change in milk production.

Crude protein and acid detergent fiber (ADF)

Crude protein (CP) was determined by first analyzing for N by combustion method at 900^{o}C with Max Cube Elementar, Hanau, Germany. Nitrogen values were multiplied by 6.25 (Tarawali et al. 1995) to provide CP levels. Acid detergent fibre was estimated by Ankom bag technique (Analyzer (Ankom 143 Technology Fairport, NY, USA) following the AOAC procedure (AOAC, 1975).

Participatory evaluation

At 3 months after planting, farmer groups in their respective trial sites were guided in conducting participatory evaluations of the oat varieties. They developed a criteria and scored it on a scale of

0 to 10, where 0 as least important and 10 most important, the criteria was further used to score on each of the oat varieties, and on the same scale.

Figure 4. Participatory fodder oat evaluation by Kanguu farmers group in August 2015

Statistical analyses

Data were managed in Microsoft Excel and analyzed in GenStat software. Except the participatory scores, the other data were first checked for normality. Analysis of variance was performed and means separated by LSD (least significant difference). Standard error of mean was used to separate means presented in bar charts, and was calculated as; $sem = \sigma/\sqrt{n}$ where σ is the standard deviation and n the number of observations. The participatory scores were weighed according to Abeyasekere (2001).

Results

The oat varieties largely expressed varied performance on the parameters that were measured. Tillering at 20 days (Figure 5*a*) followed a similar pattern across the farms and was generally in the order Conway ≈ Glamis > Local > Balado ≈ Rhapsody > Mascani. The number of tillers per m^2 ranged 40-450. By 42 days there were changes as the tillers ranged 100–1000 representing an increase of 120–150%. Tillering order was; Conway > Balabo > Glamis > Local ≈ Mascani ≈ Rhapsody (Figure 5 *b*). Repeat of the trial in the short season (Figure 6 *a, b*) produced similar tillering pattern at both 20 and 42 days age. Tillers per $1m^2$ ranged 100-410 at 20 days and 550 - 970 at 42 days.

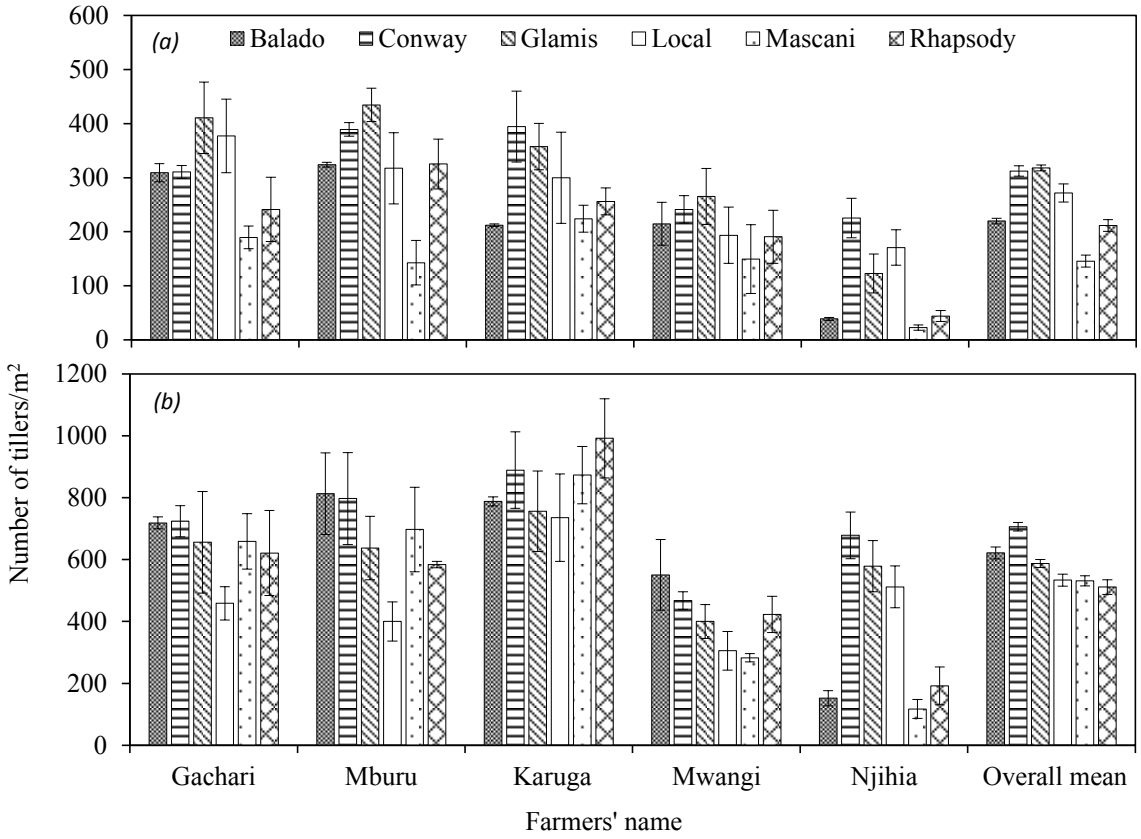


Figure 5. Means (± SE) of number of tillers (no. /m^2) of fodder oats across five farmers' farms during long rains in 2015.

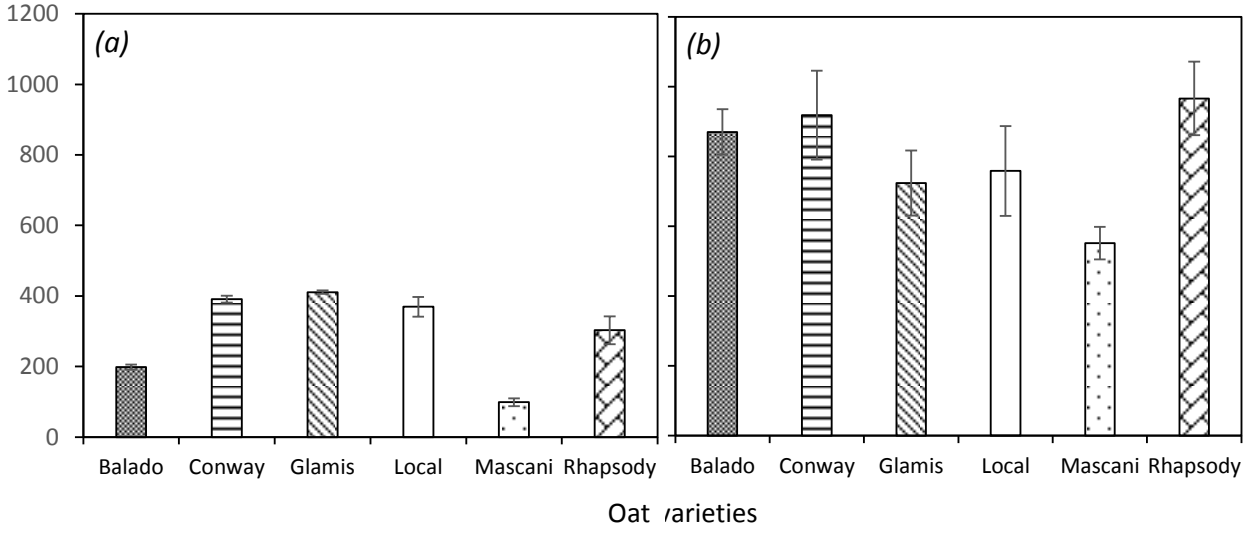


Figure 6. Means (± SE) of number of tillers (no. /m^2) of fodder oats at Gachari's farm during short rains in 2015/16

There were differences amongst farms on plant height, dry matter percentage, dry matter yields and panicle proportions. Mwangi's farm had generally lower values for plant height and dry matter yields compared to the other farms. However, the figures for percentage dry matter were higher than the other farms while panicle proportions were similar to those of the other sites. When data were pooled amongst the farms, plant height differed significantly ($P<0.05$) amongst the oat varieties (Table 2). Conway attained the highest height of 1.31 m while Balado had the least of 0.44m. Percentage dry matter content was in the order Local > Conway ≈ Glamis > Balado ≈ Mascani≈ Rhapsody. Dry matter yield ranged between 2 –17 t/ha/cut. Conway produced biomass that was three times that was produced by Balado, and had significantly ($P< 0.05$) dry matter yield than the Local check (Table 2). Rhapsody, Balado and Mascani produced similar biomass ($P>0.05$) that were significantly lower than either for Local, Glamis or Conway. By the time of harvest, Rhapsody, Balado and Mascani had not produced panicles while the other varieties had. The proportion of panicle to above ground biomass was in the order Local > Glamis ≈ Conway. Local produced most panicles was at least 4.5 times as high, compared to either Conway or Glamis (Table 2).

In the second season, dry matter production largely followed the earlier pattern amongst the varieties as Conway > Glamis > Local > Rhapsody > Mascani > Balado (Table 3). This confirmed the earlier results obtained on superiority of Conway and Glamis varieties on biomass production. Plant height was in the order Conway > Glamis > Local > Rhapsody > Balado > Mascani while dry matter content was similar ($P >0.05$) amongst the varieties.

Table 2. Plant height (m) and dry matter (DM) content (%), yields (t ha^{-1}) and panicle proportion of fodder oats varieties

Farm	Oat variety	Plant height (m)	DM (%)	Yield (t DM/ha/cut)	Proportion of panicle to biomass (%)
Gachari	Balado	0.42	16	5.4	-
	Conway	1.24	21	16.6	13.9
	Local	0.74	31	13.1	71.9
	Mascani	0.63	13	5.6	-
	Rhapsody	0.72	14	8.3	-
	Glamis	0.87	18	10.9	14.2
Mburu	Balado	0.47	18	6.4	-
	Conway	1.45	25	22.2	14.8
	Local	0.87	33	16.3	69.5
	Mascani	0.75	16	7.1	-
	Rhapsody	0.90	17	11.7	-
	Glamis	1.18	24	17.0	12.0
Karuga	Balado	0.50	17	4.6	-
	Conway	1.36	25	17.7	9.2
	Local	0.86	34	17.6	68.7
	Mascani	0.67	18	6.2	-
	Rhapsody	0.74	20	7.8	-
	Glamis	1.23	24	13.3	11.5
Mwangi	Balado	0.41	17	4.0	-
	Conway	1.02	29	11.3	17.3
	Local	0.63	40	5.1	60.7
	Mascani	0.42	20	3.6	-
	Rhapsody	0.49	20	4.0	-
	Glamis	0.96	30	7.7	24.0
Njihia	Balado	0.39	18	4.8	-
	Conway	1.45	25	17.7	12.5
	Local	0.85	30	18.8	52.5
	Mascani	0.49	18	3.5	-
	Rhapsody	0.64	18	5.5	-
	Glamis	1.28	23	14.0	8.9
LSD P= 0.05		0.11***	6.29*	*3.63***	*22.2**
Pooled means	Balado	0.44^{e}	17^{c}	5.0^{c}	-
	Conway	1.31^{a}	25^{b}	17.1^{a}	13.6
	Local	0.79^{c}	34^{a}	14.2^{b}	64.7
	Mascani	0.59^{d}	17^{c}	5.2^{c}	-
	Rhapsody	0.70^{c}	18^{c}	7.5^{c}	-
	Glamis	1.10^{b}	24^{b}	12.6^{b}	14.1
LSD P= 0.05		*0.105****	*2.81****	*2.68****	*9.92**

- *implies the varieties had not produced panicles by the time of harvest*

Table 3. Plant height (m) and dry matter (DM) content (%), yields (t ha^{-1}) of fodder oats varieties from second season

Oat variety	Plant height (m)	DM (%)	Yield (t DM/ha/cut)
Balado	0.50	15	7.3
Conway	1.20	13	21.8
Local	0.86	14	15.2
Mascani	0.49	13	9.7
Rhapsody	0.63	12	12.3
Glamis	1.04	15	17.4
LSD P = 0.05	*0.14***	*2.46*	*7.08****

Of the five farmers who had been requested to give the oat forage to a single cow in mid-lactation in first season, only two provided responses. One of the farmer, from Hillten group, observed an increase of half a liter from 4.5 to about 5.0 liters in two days, while the other from Kanguu reported an increase of three quarters of a liter from 5.0 to 5.75 liters. These represented milk increases of 11 and 15% respectively.

Larger ADF was observed in local variety and the least in Balado. The values in decreasing order were Local > Conway > Glamis > Rhapsody > Mascani > Balado. However, for CP level, the order was largely reversed as Balabo > Rhapsody > Mascani > Glamis > Local > Conway. Varieties that had high crude protein in the samples produced the least CP/ha (Table 4).

Table 4. Effect of oat varieties on acid detergent fiber (ADF), crude protein (CP) and crude protein production in per ha (kg/CP/ha)

Farm	Oat variety	ADF (%)	CP (%)	Kg CP/ha
Gachari	Balado	27.4	15.4	825
	Conway	45.4	6.9	1157
	Local	42.4	9.1	1222
	Mascani	32.5	13.9	781
	Rhapsody	33.4	12.7	1058
	Glamis	41.4	9.6	1036
Mburu	Balado	25.2	12	804
	Conway	40.2	5.6	1252
	Local	44.9	7.0	1082
	Mascani	32.1	10.5	749
	Rhapsody	29.3	11.3	1339
	Glamis	37.8	5.9	1011
Karuga	Balado	30.3	13.6	626
	Conway	41.6	5.3	917
	Local	45.4	5.7	1002
	Mascani	32.5	10.9	682
	Rhapsody	36.0	10.7	825
	Glamis	40.8	8.2	1090
Mwangi	Balado	27.7	21.2	833
	Conway	37.9	10.1	1128
	Local	38.6	10.5	502
	Mascani	25.6	16.8	607
	Rhapsody	27.9	18.9	746
	Glamis	36.1	11.9	921
Njihia	Balado	28.3	14.8	736
	Conway	45.2	7.1	1230
	Local	52.5	7.7	1460
	Mascani	28.5	14.4	503
	Rhapsody	32.1	14.2	780
	Glamis	46.8	7.1	975
LSD P= 0.05		*5.545**	*2.947****	*198.4***
Pooled means	Balado	27.8	15.5	765
	Conway	42.1	7.0	1137
	Local	44.8	8.0	1054
	Mascani	30.3	13.3	664
	Rhapsody	31.7	13.6	950
	Glamis	40.6	8.5	1007
LSD P= 0.05		*2.480****	*1.318****	*88.7****

*** P<0.001, ** P<0.01, * P<0.05*

Participatory evaluation criteria differed slightly amongst the groups but largely entailed attributes that are related to biomass production and what farmers perceived to be important. This ranged from perceived biomass accumulated, plant height and tillering to attributes like broad leaves, silica hairs and associated benefit of weed suppression. Across the groups, the first 3 ranked varieties were Conway > Glamis > Local. The rest three varieties (Rhapsody, Mascani, and

Balado) differed amongst the groups with Mascani considered the last by Kanguu and Hillten groups and Balado by Nyamarura (Table 5).

Table 5. Weighted scores of participatory evaluation of fodder oats by Nyamarura, Kanguu and Hillten farmer groups.

Farmer group	Farmers criteria	Criteria Score	Oat varieties					
			Glamis	Rhapsody	Mascani	Local	Conway	Balado
Nyamarura	Growth rate	10	5	3	3	6	9	2
	High biomass	10	7	3	3	7	8	4
	High plant height	8	6	3	3	7	9	3
	Frost resistance	6	10	10	10	10	10	10
	Lodging	7	10	10	10	10	10	10
	High tillering	8	8	9	8	8	9	9
	Broad leaves	6	9	7	5	5	10	7
	Disease tolerance	5	8	7	7	7	9	3
	Weighted Score		*7.6*	*6.1*	*5.7*	*7.4*	*9.2*	*5.7*
Kanguu	Growth rate	10	8	5	3	7	9	3
	High biomass	10	10	4	3	8	10	5
	Diseases tolerance	10	8	5	4	7	8	3
	Thick stem	7	9	4	3	8	9	3
	Broad leaves	8	9	4	3	8	9	3
	Weed suppressing	8	9	7	5	8	9	8
	High plant height	7	9	5	4	8	10	3
	Weighted score		*8.83*	*4.85*	*3.55*	*7.67*	*9.12*	*4.0*
Hillten	Germination rate	9	8	4	4	6	9	6
	Growth rate	8	9	3	2	6	10	4
	Biomass	10	8	2	1	6	10	2
	Disease and pests	5	8	9	9	7	8	7
	Weed suppressing	10	8	5	4	6	10	5
	Silica hairs	3	10	10	10	10	10	10
	Lodging	5	10	10	10	10	10	10
	High plant height	7	9	4	3	8	10	3
	High tillering	8	8	9	10	7	9	10
	Weighted score		*8.48*	*5.46*	*5.05*	*6.91*	*9.58*	*5.72*

Discussion

The main objective of the work was to evaluate oat varieties and identify possible high yielding lines that could be used to improve fodder availability in the high altitudes that are prone to low temperature stress. Amongst the test varieties, Conway produced 17% higher biomass than the Local check, which had similar yield with Glamis. The difference was equivalent to 2.9 tons of dry matter (DM), capable of feeding a cow weighing about 450 kg body live weight, for 7 months, at rate equivalent to 3% of its live weight (Wheeler, 1996). A repeat in the second season also had

Conway producing 16% higher than Glamis that followed it and 30% compared to the Local. In cattle production systems that are tending towards intensive like in the study area (Mwendia, 2015), increased forage output per unit of land becomes critical to contribute to feed supply that had been found to take between 60–70% of the costs, in livestock enterprises (Madubuike, 1993). These results show the variety of choice in fodder oats can make a significant difference in fodder provision. The order of DM production of the study varieties remarkably followed the weighed ranks by the farmer groups (Tables 2 and 5) supporting the need for farmers' perspective towards increasing forage outputs.

Forage quality is key in choice of pasture and fodder crops. From the current study, oat varieties that had samples with high crude protein also produced the least biomass and acid detergent fiber. However, considering crude protein yield per ha, varieties that produced highest biomass had the most crude protein per ha (Table 4). Low percentage crude protein was compensated by the high biomass eventually surpassing the varieties with high crude protein and low biomass. Further, estimating digestible organic matter (g kg^{-1} DM) according to Givens et al. (1992), across the farms, the varieties in reducing order were Balado (989), Mascani (986), Rhapsody (984), Glamis (973), Conway (972) and Local (968). The values were within <2% of each other and as such not revealing any remarkable differences amongst the varieties, leaving the biomass yields as the main driver of preferable lines.

Plant height attribute that was cited by all the groups (Table 5) becomes important under cut and carry system as taller plants enable easier handling during harvesting, emphasizing the importance of the agricultural context within which an agricultural technology is targeted. Indeed one of the key attribute considered during forage breeding is agricultural context in addition to species and environment (Casler and Santen, 2010). Therefore, it is likely under extensive system, varieties like Mascani, Rhapsody and Balado could have ranked highly, because of low height, as animals could graze directly without much trampling on the foliage.

Conclusion

On the strength of biomass performance, crude protein yield and farmers perception, likelihood of Conway and Glamis varieties being adopted and accepted in the area, and other similar areas are high. The potentially low crude protein in samples of Conway and Glamis was compensated by the relatively high biomass yield, that led to these varieties cumulating high crude protein per ha.

It is highly likely that adoption could probably be bolstered by the dairy sector that has continued to support household incomes coupled with increasing per capita milk consumption in Kenya, that was estimated at 100 liters in 1999 and currently standing at about 145 liters. Increasing population will most likely push up milk demand, and this market drive, requires to be matched with milk at the production level, will in turn likely see adoption of viable technologies such as these productive fodder oats.

Currently, seeds for these productive lines and not available, and as such, there is need for deliberate effort to make them available. Linking with the Prifysgol Aberystwyth University in United Kingdom or any other source, and facilitating seed availability through private sector would be key in uptake and sustainability of these technologies.

Potential of rye and festulolium forages in central Kenya

Introduction

Cold and frost prone areas mete cold stress on crops and forages. However, temperate crops are better adapted to withstanding low temperatures than tropical crops (Larcher, 2003). In temperate regions several temperate grasses have been evaluated and utilized for forage and pasture production over the years. *Lolium perrene* L (perennial rye grass) and Festuloliums (Italian grass x Perennial rye) have been used with successes in temperate regions (Korte *et al*., 1984). In addition to withstanding low temperature stress, these grasses are nutritious, and are capable of recuperating after grazing (Lee *et. al*., 2010). Ratiray and Joyce 1974 reported rye nitrogen content of 3.28% that translates to crude protein level of 20.5%, while (Dierking *et al,* 2008) observed a similar value of 20% in festulolium. These figures are relatively high compared to most forages given to cattle in Kenya. For example, Napier grass, the most popular fodder grass in tropics and sub-tropics (Mwendia *et al.* 2013), has crude protein that range 8–13% (Wijitphan et al., 2009; Tessema et al., 2010), in addition to poor performance in cold areas, and especially above 2000 m (Boonman, 1993). Rye and festulolium have been found to accumulate comparable biomass yields to other pasture grasses. Dierking *et al*, (2008) reported 864 kg DM ha^{-1} for festulolium similar to 814 kg ha^{-1} for tall fescue *Schedonorus phoenix* (Scop.) Holub in second year of production, while Lee *et. al*., (2010) observed 1600 kg DM ha^{-1} in *Lolium perrene*. Although Kenya lies in the equatorial belt, and as such largely warm throughout the year, there are areas that are high in elevation and experience low temperatures and occasional frost bites (Jaezold, 2006). Such important arable lands include foots of Mt. Kilimanjaro, and the Aberdare ranges in central Kenya, and especially in Nyandarua region (Miua, *et al.,* 2011). The work reported here therefore, evaluated rye and festulolium varieties with the aim of quantifying their productivity potential, in the dairy potential Nyandarua County in Central Kenya.

Materials and methods

Sites description and experimental design

The trials were conducted on farm in OljoroOrok in Nyandarua County in Central Kenya located S 00º 09'; E 036º17'; 2808 m above sea level in one farm, and S 00º 09'; E 036º18'; 2667 m above sea level in the other. The activity was done in a participatory approach with Nyamarura farmers' group involved in dairy where individual members are farmers who keep 2-5 dairy animals on

their farms. The test forages included four varieties of perennial rye grass (*Lolium perrene)* namely; AberNiche, AberGen, AberBite, AberWolf in a rye trial while Festuloliums also comprised of 4 cross bred varieties between *Lolium perrene* X *Festuca* spp. The four are *L. perrene* (2x) X *F. arundinacea* (6x); *L. perrene* (2x) X *F. arundinacea* var *glaucescens* (4x); *L. perrene* (4x) X *F. arundinacea* var glaucescens (4x) and *L. perrene* (4x) X *F. mairei* (4x) in a separate trial. All the seeds were sourced from Prifysgol Aberystwyth University in United Kingdom. The experiments were completely randomized block design with three replicates, for each of the varieties in each farm.

Nyamarura group members were sensitized about the trials upon which two farms were selected to host rye and oat in each of the farms. Host farmers were Gilbert Gachari and Francis Mburu at altitudes 2808 and 2667 m described above, respectively. Details of soils in the specific sites are in Table 1.

Table 1. Soil properties at Rye and Festulolium grasses trial sites at OljoroOrok. N = 5

Farmer	pH	% Clay	% Sand	% Silt	% Total N	% Total C	Bray P mg P/kg	Soil type
Gilbert Gachari	5.6	37.5	34.5	28.0	0.27	2.9	12.9	Clay loam
Francis Mburu	5.0	36.1	31.6	32.3	0.30	3.5	12.6	Clay loam

Climate

OljoroOrok climate is warm and temperate. The average annual temperature is 13.7°C, a mean minimum of 6.5^{o}C, and about 946 mm of precipitation annually (Climate-Data.org 2015).

Trials establishment and maintenance

Land preparation was done by the farmers manually with hoes to a fine a tilth. Plots sizes of 2m^2 for planting rye, and 1m^2 for festuloliums were marked out using wooden pegs. Furrows of about 6mm depth, and 10cm between the rows were made in each plot. NPK fertilizer (23:23:0) was applied at a rate of 90 kg N/ha in both rye and festuloliums plots. Seeds were then spread along the furrows within each plot at the rate of 20 kg/ha for rye, and 16 kg/ha for festuloliums, then shallowly covered with soil on 12th May 2015.

Measurements

Plant density and height

Plant density was visually assessed on a variable scale of 0 to 100 where; 0 implies no plants and 100 equals full in-row ground cover (Deleuran *et al.,* 2010) on both rye and festulolum trials. Plant height was measured from the base of a bunch of tillers growing adjacent, to the end of the leaves, and at four randomly selected positions within each plot.

Figure 4. Measuring plant height in rye and festulolium at Gacharis' farm a site belonging to Nyamarura group

Dry matter yield

Quadrats of 0.25m^2 were harvested from each plot, and fresh weight determined using digital weighing balance (Hanging Scale CH50K100, Kern and Sohn, Balingen, Germany). Samples were randomly selected from the harvested grass, and fresh weight taken. The samples were then dried to constant weight in the oven at 65^{o}C for 48h, and weighed to determine the dry matter (DM) content. The samples were then ground to pass 1mm sieve and stored in sample bottles for subsequent laboratory analysis.

Figure 5. Harvested Festulolium from a plot (a), and (b) weighed samples in Kraft bags at Nyamarura trial site (Gacharis' farm).

After sampling, the remaining forage was pooled together and the farmer hosting the trial requested to feed to a cow in mid-lactation, over the days it takes to deplete the material, and note observations on any change in milk production.

Crude protein and acid detergent fiber

Crude protein (CP) was determined by first analyzing for N by combustion method at 900^{o}C with Max Cube Elementar, Hanau, Germany. Nitrogen values were multiplied by 6.25 (Tarawali et al. 1995) to provide CP levels. Acid detergent fibre (ADF) was estimated by Ankom bag technique (Analyzer (Ankom 143 Technology Fairport, NY, USA) following the AOAC procedure (AOAC, 1975).

Participatory evaluation

At 3 months after planting, 61 farmers from Nyamarura group were guided in conducting a participatory evaluation of the varieties in the trials. They developed a criteria and scored it on a scale of 0 to 10, where 0 means least important and 10 most important, the criteria was further used to score on each on the test varieties, and on the same scale.

Statistical analyses

Data were managed in Microsoft Excel and analyzed in GenStat software14 (GenStat, 2011). Except the scores, the other data subjected to analysis of variance and means separated by least significant difference. Standard error of mean was used to separate means presented in bar charts, and was calculated as; $sem =$

$\sigma/\sqrt{n}$ where σ is the standard deviation and n the number of observations. The participatory scores were weighed according to Abeyasekere (2001).

Results

Plant density, height and dry matter yields

Plant density score for rye grasses ranged 74 – 83 (Table 2). AberNiche had significantly (P<0.05) higher plant height than either of the other rye grasses, that had similar. However, the dry matter content was similar (P> 0.05) ranging between 14–16.8%, with subsequent similar (P>0.05) dry matter yields that ranged 7.2–9.9 t/ha.

Festulolium plant density score ranged 45–72. Further, the hybrids produced similar (P> 0.05) plant height, dry matter content and dry matter yields. While height ranged 0.43–0.49 m, the dry matter content was 13.8–15.3% and DM yield 7.4–8.6 t/ha. In the second cut (Table 3), AberNiche maintained larger plant height than either AberBite or AberWolf and also produced the most DM yields despite having the least DM content. Unlike in the initial cut where the four festulolium varieties had similar plant height, DM content and DM yield, in the second, the Festulolium cross: *L. perrene* (2x) X *F. arundinacea* var *glaucescens* (4x) had significantly higher (P<0.05) DM content and yield (t/ha).

Table 2. Plant density, height (m) and dry matter (DM) yields for rye and festulolium grasses during first cut.

Grass type	Variety	Plant density (Score)	Plant height (m)	DM (%)	DM yield (t/ha)
Rye	AberBite	83	0.41	14.9	7.2
	AberNiche	74	0.56	14.0	9.9
	AberWolf	80	0.39	16.8	8.8
LSD P=0.05			*0.13**	*3.1ns*	*6.3ns*
Festulolium	*L. perrene* (2x) X *F. arundinacea* (6x)	64	0.45	15.3	8.1
	L. perrene (2x) X *F. arundinacea* var *glaucescens* (4x)	72	0.43	14.3	8.6
	L. perrene (4x) X *F. arundinacea* var *glaucescens* (4x)	45	0.45	13.8	7.4
	*L. perrene (*4x*)* X *F. mairei* (4x)	66	0.49	14.4	7.5
LSD P=0.05			*0.11ns*	*2.7ns*	*4.2ns*

Plant density was at 20 days after planting. All data pooled from the two farms.

Feeding a cow in mid-lactation on mixture of the rye and festulolium resulted in milk increase from 16 to 17.5 liters in 3 days representing a rise of 9.4% in one farm, and an increase of 16.7% in the other from 18 to 21 over the same period.

Table 3. Plant height (m) and dry matter (DM) yields for rye and festulolium grasses during second cut

Grass type	Variety	Plant height (m)	DM (%)	DM yield (t/ha)
Rye	AberBite	0.29	22.1	6.7
	AberNiche	0.54	21.0	10.0
	AberWolf	0.30	28.5	8.6
LSD P=0.05		*0.16**	*0.04**	*4.2ns*
Festulolium	*L. perrene* (2x) X *F. arundinacea* (6x)	0.39	28.1	9.4
	L. perrene (2x) X *F. arundinacea* var *glaucescens* (4x)	0.39	29.2	10.9
	L. perrene (4x) X *F. arundinacea* var *glaucescens* (4x)	0.38	25.6	7.8
	*L. perrene (*4x*)* X *F. mairei* (4x)	0.31	22.3	5.8
LSD P=0.05		*0.12ns*	*0.03***	*3.9**

Forage quality

The quality was analyzed for the initial cut only. The three rye varieties produced similar (P>0.05) ADF and CP levels (Table 4), with similar results for festuloliums. Acid detergent fiber in rye ranged 26.4–27.7%, and 27.4–28.1 in festuloliums while corresponding values for crude protein were 16.9–19.0% in rye, and 16.3–18% in festuloliums.

Table 4. Acid detergent fiber (%) and crude protein (%) of rye and festulolium varieties

Grass type	Variety	ADF (%)	CP (%)
Rye	AberBite	26.4	19.0
	AberNiche	27.7	17.8
	AberWolf	27.2	16.9
LSD P=0.05		*2.08ns*	*4.8ns*
Festulolium	*L. perrene* (2x) X *F. arundinacea* (6x)	28.0	18.0
	L. perrene (2x) X *F. arundinacea* var *glaucescens* (4x)	28.1	16.5
	L. perrene (4x) X *F. arundinacea* var *glaucescens* (4x)	27.3	17.7
	*L. perrene (*4x*)* X *F. mairei* (4x)	27.8	16.3
LSD P=0.05		*1.19ns*	*2.51ns*

Participatory evaluation

Biomass accumulation criterion was scored highest attaining the most possible score of 10. The rest of the criteria scored in the range of 2–9. Weighted scores were in the order AberNiche > AberBite > AberWolf, with the corresponding weighted scores as 9.6, 6.8, 6.7 for the grasses respectively

(Table 5). For the Festulolium hybrids, the order was 4>1>3>2, and the scores ranged 7.9–8.8 (Table 5). Although both rye and Festuloliums were scored the maximum 10 on frost tolerance and disease tolerance, the criteria were scored only 4 and 2 respectively.

Table 5. Weighted scores for Rye and Festulolium forage varieties across criteria

Forage type	Variety	Criteria							
		Growth rate	Biomass	Height	Frost resistance	Broad leaves	Disease tolerance	*Weighted score*	*Rank*
Criteria Score		9	10	6	4	6	2		
Rye	AB	6	6	6	10	7	10	*6.8*	*2*
	AN	10	9	9	10	10	10	*9.6*	*1*
	AW	7	6	6	10	5	10	*6.7*	*3*
Festulolium	*1*	9	8	7	10	9	10	*8.7*	*2*
	2	8	7	7	10	8	10	*7.9*	*4*
	3	8	8	8	10	7	10	*8.2*	*3*
	4	9	9	8	10	8	10	*8.8*	*1*

Numbers in Festulolium variety column denote hybrid crosses as*;* 1=*L. perrene* (2x) X *F. arundinacea* (6x), 2 = *L. perrene* (2x) X *F. arundinacea* var *glaucescens* (4x), 3 = *L. perrene* (4x) X *F. arundinacea* var *glaucescens* (4x), 4 = *L. perrene (4x)* X *F. mairei* (4x). *Rye grasses and Festuloliums are assessed separately*. AB (AberBite), AN (AberNiche), AW (AberWolf).

Discussion

The objective of the work was to test the potential of rye and Festulolium as pasture grasses under central highland conditions in Kenya. The dry matter yields obtained from the rye grasses were consistently similar (P>0.05) among AberNiche, AberWolf and AberBite (Table 2, 3). However, the yields obtained ranging 6.7–10.0 t/ha/cut were much higher than values obtained for perennial rye grass elsewhere. Olson, *et al.* (2014) observed dry matter yields ranging 5.3–7.5t/ha/yr. among six perennial rye varieties that were considered. As observed in this current study, the six varieties produced similar (P>0.05) dry matter yields. Possible explanation for the high yields, include the conditions at the study farms that had favorable soil attributes (Table 1). Clay-loam soils have better water holding capacity than sandy soils, coupled with P and N values that were medium levels according to rating by Hazelton and Murphy (2007). Further, these values must have been boosted by application of NPK fertilizer (23:23:0) at planting equivalent to 90 kg N/ha. Despite AberNiche having a lower plant density than the others, it attained significantly higher (P<0.05) plant height, likely to have contributed to the higher dry matter yield, though not significant, as plant height is usually positively correlated with biomass accumulation (Mwendia, 2015). The similar dry matter content (Table 2) being within <16% of each other, meant any potential differences amongst the varieties was likely to arise from biomass accumulated, and not the differences in dry matter content. Even in second cut when one of the hybrid had higher (P<0.05) DM content, the DM yields ended being similar (Table 3)

The biomass accumulated were quite comparable and even higher than other pasture and fodder grasses grown in the area or under similar conditions. Boonman (1979b), in OljoroOrok reported the following yields (t DM/ha/yr.); 3.8, 4.5, 5.3, 6.5, 7.2, 7.4, 7.5 and 11.3 respectively for the following species, *Pennisetum clandestinum, Panicum maximum* cv Makueni*, Setaria splendida, Cynodon* spp*, Setaria sphacelata* cv Nandi*, Tripsacum laxum, Pennisetum purpureum* cv French Cameroons and *Chloris gayana* cv Boma. Given the yields obtained in a single cut (6.7–10.0 t/ha) in the current study, either rye or festulolium surpassed the tropical grasses considered by Boonman (2003), and would therefore be pastures of choice in the area and other similar areas.

Only about 41% of farmers in Nyandarua use improved fodders (Muia *et al*., 2011), suggesting a possible room to for adoption and improvement, given the 59% not using improved fodders.

Although the feeding trial by farmers from the rye and festulolium obtained from the agronomic trials were not replicated, nor trialed over adequate time, farmers reported increased milk production after feeding materials harvested from trials, what is likely to happen under a well-executed feeding trials. Relatively high quality for both rye and Festulolium varieties, with crude protein ranging 16.3– 19.0% is likely to have contributed to the observed milk increases, in addition to the relatively low ADF in the range of 26.4 –28.1% , compared to other grasses like Napier grass 41.5–43.0 % (Wijitphan et al. 2009) suggested better digestibility. Given the yields and quality of rye and festulolium reported here, adoption is likely, if supported by increased milk yields, and especially for farmers with relatively large land sizes that could allow grazing.

Conclusion and recommendations

The forage evaluation work reported here has shown the potential of using rye and festulolium grasses to improve animal feed resources, and therefore cattle nutrition in Nyandarua, and other similar areas. These grasses would fit well with farmers who still have grazing land available for grazing, given that cattle system in the area is tending towards intensive.

Farmers involved in the study were enthusiastic about the performance. However, availing seeds by the private sector is key for farmers to access as is likely to be sustainable and meet the need to improve pastures. Germinal Holdings a commercial subsidiary of the Aberystwyth University in the UK or any other dealer should be approached and linked with seeds dealers in Kenya.

Coopers Kenya, a local company that deals with livestock inputs was approached on possibilities of including the promising forages in their business. Although noncommittal, the need of establishing market potential was highlighted, and the information provided on potential of oat, rye and festulolium required presentation to the companies' business committee and if agreed, survey to establish market potential would follow. Seed regulation by Kenya Plant Health Inspectorate Service (KEPHIS) was raised, but was reported importation was possible as long as the seeds are not repackaged.

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Appendices

Lucerne, farmer-led trial Protocol

Planting

1. You have been given 15 grams of Lucerne seed
2. You can plant them in a 5m x 5m plot (i.e. an area of ≈ 5 by 5 strides). The Seed rate is 6 kg/ha.
3. Make sure the plot is prepared such that it has fine soil tilth
4. Preferably, apply farm yard manure and incorporate in the plot
5. To plant, make shallow furrows spaced about 20cm apart. Spread the seed sparingly to cover all the furrows. Repeat in sections that appear to be less covered with the seed until all the seeds are exhausted.
6. Cover the seeds with little soil and compact lightly to ensure the seeds are in proper contact with the soil.
7. Alternatively, mix the seeds thoroughly with a handful of saw dust/soil
8. Broadcast the seeds evenly within the plot. To ensure even distribution, start by broadcasting sparingly the whole plot and repeat until all the seeds + saw dust/soil mixture get exhausted.
9. Cover the seeds with little soil and then compact lightly with hands or feet to ensure the seeds come in to proper contact with the soil.
10. Visit your plot regularly and make observations i.e. germination, pests or diseases and record.
11. When necessary, do hand weeding by uprooting the weeds

Harvesting

12. Harvest the Lucerne for feeding when there is about 50% flowering
13. Cut the herbage with a sharp sickle or panga, leaving a stubble of about 3 cm
14. Wilt, the harvest and supplement to the animals after they have had the basal roughage. A cow weighing about 400 would take about 90kg fresh Napier grass to get enough roughage
15. Preferably give to the milking cows if not enough to give all animals
16. The harvest can be dried slowly, preferably under the shade and stored as hay for later feeding

Lupin, farmer-led trial Protocol

Planting

1. You have been given 295 grams of Lupin seed
2. You can plant them in a 5m x 5m plot (i.e. an area of ≈ 5 by 5 strides). The Seed rate is 117.6 kg/ha.
3. Make sure the plot is prepared and ready for planting
4. Preferably, apply farm yard manure and incorporate in the plot
5. Plant at the recommended spacing of 50 x 30 cm and 2 seeds per hill
6. Drill the seeds to a depth of 1-2 inches
7. Visit your plot regularly and make observations i.e. germination, pests or diseases and record.
8. When necessary, do hoe weeding to keep the plot weed free

Harvesting

9. Harvest the Lupin for feeding when there is about 50% flowering
10. Leave 1 row for seed production to assist in expanding the forage coverage in your farm
11. Cut the herbage with a sharp sickle or panga,
12. Wilt, the harvest and supplement to the animals after they have had the basal roughage. A cow weighing about 400 would take about 90kg fresh Napier grass to get enough roughage
13. Preferably give to the milking cows if not enough to give all animals
14. The harvest can be dried slowly, preferably under the shade and stored as hay for later feeding

Vetch, farmer-trial Protocol

Planting

1. You have been given 50 grams of vetch seeds (seed rate 20 kg/ha)
2. Plant the seeds at onset of rains
3. You can plant them in sole plot and is enough for 5m x 5m plot (i.e. an area of ≈ 5 by 5 strides)
4. Make sure the area you are planting has been ploughed and without big soil clods.
5. Preferably, incorporate FYM to improve productivity
6. Make shallow furrows 30cm apart
7. Spread the seeds sparingly in the furrows first until the whole plot is covered and then repeat areas that are less covered with the seeds until all the seeds are exhausted
8. Cover the seeds lightly with soil
9. Inspect your plots regularly, make observations and record i.e. germination, pests or diseases.
10. Uproot the weeds by hand when necessary

Harvesting

11. Vetch will be ready to harvest for feeding when there is about 50% flowering
12. Leave one row to produce seeds that you can use to expand vetch forage on your farm.
13. If you leave it much longer after this the quality will deteriorate and thus less benefit to your animal.
14. Cut at the base with panga and wilt the harvest before feeding your animal.
15. Feed to the animal to supplement when they have had the basal roughage
16. The harvest can be dried and kept as hay to feed later if need be

Oat, farmer-led trial Protocol

Planting

17. You have been given 250 grams of oat seeds (seed rate 100 kg/ha)
18. Plant the seeds at onset of rains
19. Plant them in sole plot and is enough for 5m x 5m plot (i.e. an area of ≈ 5 by 5 strides)
20. Make sure the area you are planting has been ploughed and without big soil clods.
21. Preferably, incorporate FYM to improve productivity
22. Make shallow furrows about 15cm apart
23. Spread the seeds sparingly in the furrows first until the whole plot is covered and then repeat areas that are less covered with the seeds until all the seeds are exhausted
24. Cover the seeds lightly with soil
25. Inspect your plots regularly, make observations and record i.e. germination, pests or diseases.
26. Uproot the weeds by hand when necessary

Harvesting

27. Oat will be ready to harvest for feeding when there is about 50% flowering
28. You can leave one row to produce seeds to enable expand oat forage in your farm.
29. If you leave it much longer after this the quality will deteriorate and thus less benefit to your animal.
30. Cut at the base with panga, wilt the harvest before feeding your animal.
31. Feed to the animal as the basal roughage and preferable to the milking cows
32. The harvest can be dried and kept as hay to feed later if need be

Oat varieties Scientist-led trial Protocol

Site

Five farms

- 2 farms at Nyamarura and 1 at Hillten group
- 1 farm at Kanguu contact group
- 1 site at Eldoville

Replication

Three replicates per farm
Plot sizes 3m x 2m = $6m^2$

Seed rate 100 kg/ha

Amount of seeds per plot
60 grams
Amount of seed/variety/ farm = 60 x 3 = 180g
Amount of seed per variety for 5 farms = 180 g x 5 = 900 grams
Row Spacing 15 cm
Use Local variety as the check

Fertilization

50 kg N/ha at sowing
Use fertilizer (23:23:0) of N, P, K)
10000m2 - 50kg N
$6m^2$ - ?
= (6 x 50)/1000 = 30 grams N
To get 30 g N from 23:23:0
0.23 X ? = 30
? = (30/ 0.23) = 130 grams of 23:23:0 per plot
For the 5 farms need 90 lots (18 x5) of 130 g of 23:23:0
Amount of 23:23:0 buy = 11.7 kg

Trial layout

Oat varieties

Rep 1	Balado	Conway	Local	Mascani	Rhapsody	Glamis
Rep 2	Rhapsody	Mascani	Conway	Balado	Glamis	Local
Rep 3	Glamis	Local	Balado	Rhapsody	Mascani	Conway

For all the farms rep 1 is the one at the higher gradient and to locate the plot stand below the whole block such that Glamis in rep 1 will be at your extreme right and Balado still in rep 1 is at your extreme left.

Management

- Weeding- hand weeding of major weeds (keep weed free)
- Inspect regularly for diseases and pests

Data to be collected

Parameter	when	How
Stand	At 20 days after planting	Count plants in each plot in a 0.25m^2
Stand	At 42 days after planting	Count plants in each plot in a 0.25m^2
Participatory evaluation	Just before harvesting	Focus group discussions (farmers to develop criteria they use to evaluate fodder and score it, then score each oat variety against the criteria. For all the sites
Plant height	Just before harvesting	take height of 5 plants randomly in each plot and average to get plot height
Biomass yield	Early dough stage (Approximately 95-115 days)	• Harvest at 2cm at above ground at the Centre of each plot a quadrate of 1m^2 • Weigh the yield and record for each plot (kg) • Take samples of about 500 grams of the harvest from each plot and record fresh weight • Separate into leaves, stems and panicle and record their fresh weight immediately • Then oven dry at 65^{o}C for 48h and record their dry weights
CP, NDF, ADF,	Samples dried above to be mixed respectively and ground to pass through 1mm sieve	CIAT Lab

Oat harvesting

Data sheet

Farmers name…… *Harvest Date:……*

Rep	***Plot no.***	***Oat variety***	***stand at 20 days***	***Stand at 42 days***	***Plant height (m)***	***Fresh yield (kg) from 1m² quadrate***	***sample fresh weight (leaves +stem) (g)***	***sample dry weight (leaves +stem)(g)***	***Panicle fresh weight (g)***	***Panicle dry weight (g)***
1	1	Balado								
1	2	Conway								
1	3	Local								
1	4	Mascani								
1	5	Rhapsody								
1	6	Glamis								
2	7	Rhapsody								
2	8	Mascani								
2	9	Conway								
2	10	Balado								
2	11	Glamis								
2	12	Local								
3	13	Glamis								
3	14	Local								
3	15	Balado								
3	16	Rhapsody								
3	17	Mascani								
3	18	Conway								

Perennial Ryegrass (*Lolium perenne)Scientist-led trial protocol*

Site

Five farms

- 2 farms at Nyamarura and 1 at Hillten group
- 1 farm at Kanguu contact group
- 1 site at Edoville

Replication

Three replicates per farm

Plot sizes 1m x 2m = $2m^2$

Seed rate 20 kg/ha

Amount of seeds per plot

4 grams

Amount of seed/variety/ farm = 4 x 3 = 12g

Amount of seed per variety for 5 farms = 12 g x 5 = 60 grams

Seeding depth 0.6cm

Row Spacing 10 cm

Fertilization

180 kg N/ha/yr.
To be split into two i.e. at sowing and after harvesting/grazing (90 kgN/ha at planting and repeat after harvesting).
Use fertilizer (23:23:0) of N, P, K)
10000m2 - 90kg N
$2m^2$ - ?
= (2 x 90)/10000 = 18 grams N
To get 18 g N from 23:23:0
0.23 X ? = 18
? = (18/ 0.23) = 78 grams 23:23:0 per plot
For the 5 farms need 75 lots (15 x5) of 78 g of DAP
Total 23:23:0 = 75 x78 = 5.9 kg

Trial layout

Rep 1	Bite	Gen	Wolf	Niche
Rep 2	Wolf	Niche	Bite	Gen
Rep 3	Niche	Wolf	Gen	Bite

For all the farms rep 1 is the one at the higher gradient and to locate the plot stand below the whole block such that Niche in rep 1 will be at your extreme right and Bite still in rep 1 is at your extreme left.

Management

- Weeding- hand weeding of major weeds (keep weed free)
- Inspect regularly for diseases and pests

Data to be collected

Parameter	when	How
Stand	After establishment	Plant density (visual variable scale 0 to 100 : 0 = no plants and 100 = full in-row ground cover)
Lodging at flowering		Variable scale based on visual judgment where 0 equals 'no lodging' and 100 equals 'full lodging'
Participatory evaluation	Just before harvesting	Focus group discussions (farmers to develop criteria they use to evaluate fodder and score it, then score each oat variety against the criteria. For all the sites
Plant height	Just before harvesting	take height of 5 plants randomly in each plot and average to get plot height
Biomass yield	Early dough stage	• Harvest at 2cm at above ground at the Centre of each plot a quadrate of $0.5m^2$ • Weigh the yield and record for each plot (kg) • Take samples of about 500 grams of the harvest from each plot and record fresh weight • Then oven dry at 65^oC for 48h and record their dry weights
CP, NDF, ADF,	Samples dried above to be ground to pass through 1mm sieve	CIAT Lab

Rye

Data sheet

Farmers name:…… *Harvest Date:……*

Rep	***Plot No.***	***Festulolium variety***	***stand after establishment***	***Plant height(m)***	***Fresh yield (kg) from 0.25m^2 quadrate***	***sample weight fresh(g)***	***Sample dry weight (g)***	***Panicle weight (g)***
1	1	Bite						
1	2	Gen						
1	3	Wolf						
1	4	Niche						
2	5	Wolf						
2	6	Niche						
2	7	Bite						
2	8	Gen						
3	9	Niche						
3	10	Wolf						
3	11	Gen						
3	12	Bite						

Festulolium scientist-led trial Protocol

Site

Five farms
15. 2 farms at Nyamarura and 1 at Hillten group
16. 1 farm at Kanguu contact group
17. 1 site at Edoville.

18. Replication

Three replicates per farm

Festulolium hybrids varieties

1.
2.
3.
4.

Farm 1& 2 (Nyamarura)

Rep 1	3	2	1	4
Rep 2	1	3	2	4
Rep 3	4	1	3	2

Farms at Hillten, Kanguu and eldoville (N/B hybrid 3 and 4 seeds got depleted) thus only one and two.

Rep 1	2	1
Rep 2	1	2
Rep 3	1	2

Seed rate 16 kg/ha

Plot space 1m x 1m
16kg = 10000 m^2
? = 1m^2
= 0.0016 kg = 1.6 grams

Fertilizer: Use 23:23:0 at 90 kg N/ha just as rye grass

Management

- Weeding- hand weeding of major weeds (keep weed free)
- Inspect regularly for diseases and pests

Data to be collected

Parameter	when	How
Stand	After establishment	Plant density (visual variable scale 0 to 100 : 0 = no plants and 100 = full in-row ground cover)
Lodging at flowering		Variable scale based on visual judgment where 0 equals 'no lodging' and 100 equals 'full lodging'
Participatory evaluation	Just before harvesting	Focus group discussions (farmers to develop criteria they use to evaluate fodder and score it, then score each oat variety against the criteria. For all the sites
Plant height	Just before harvesting	take height of 5 plants randomly in each plot and average to get plot height
Biomass yield	Early dough stage	• Harvest at 2cm at above ground at the Centre of each plot a quadrate of $0.25m^2$ • Weigh the yield and record for each plot (kg) • Take samples of about 500 grams of the harvest from each plot and record fresh weight • Then oven dry at 65^oC for 48h and record their dry weights
CP, NDF, ADF,	Samples dried above to be ground to pass through 1mm sieve	CIAT Lab

Data sheet

Farmers name:…… *Harvest Date:……*

Rep	***Plot No.***	***Festulolium variety***	***stand after establishment***	***Plant height(m)***	***Fresh yield (kg) from 0.25m² quadrate***	***sample weight fresh (Stem + leaves)(g)***	***Sample dry weight (stem +leaves) (g)***	***Panicle Fresh weight (g)***	***Panicle dry weight (g)***
1	1	3							
1	2	2							
1	3	1							
1	4	4							
2	5	1							
2	6	3							
2	7	2							
2	8	4							
3	9	4							
3	10	1							
3	11	3							
3	12	2							

N/B varieties 3 and 4 will miss for some farms as described above.

Better oat varieties for fodder production in Kenya

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Abstract

Fodder quality and quantity is a major constraint limiting smallholder dairy productivity, despite the projected future increase in demand for animal products, milk included. To contribute towards addressing this, oat varieties were evaluated on-farm for fodder production and quality under mixed smallholder farming systems in Kenyan highlands. With farmers' participation, 5 oat varieties (Balado, Rhapsody, Mascani, Glamis, and Conway) were evaluated together with a 'Local' check for dry matter (DM) production, crude protein (CP), acid detergent fiber (ADF) and farmers' preference. Five farms were involved in the study, with the trials being replicated three times in each farm. The lines differed significantly ($P<0.05$) in biomass accumulation that ranged 5–17.1 t/ha, crude protein 7–15.5% and ADF (27.8–44.8%). Biomass production was in the order Conway > Local > Glamis > Rhapsody > Mascani ≈ Balado, which was largely the same order of the farmers' preference except for the interchange of Glamis and Local varieties. Estimation of total crude protein production (Kg CP/ha) based on both biomass production and crude protein content, had varieties with high biomass production also producing high kg CP/ha, and in the order; Conway > Local > Glamis > Rhapsody > Balado > Mascani. Based on biomass production, farmers' preference and kg CP/ha, we concluded that Conway and Glamis varieties, among the test varieties, could be used to improve fodder availability in the area and other similar areas.

Key words: Biomass production, Farmers preference, Fodder quality

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Oat photos after 44 days (second season)

Balado

Conway

Local

Mascani

Rhapsody

Glamis

Perennial ryegrass photos from Mburu' farm after two defoliations

AberBite

AberGen

AberWolf

AberNiche

Annex 2:

Effect of feeding oat and vetch forages on milk production and quality in smallholder dairy farms in OljoroOrok, Nyandarua, Central Kenya

Technical Report

May 2017

CIAT

Duration of project:

2017

Contributors: Mwendia SW, Mwungu C, Notenbaert A (2017) International Center for Tropical Agriculture (CIAT), Tropical Forages Program, Africa Regional Office

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Summary of the project

Through participatory forage evaluation in OljoroOrok with farmers linked to Eldoville dairy under the IFDC (International Fertilizer Development Center) 2SCALE project (http://ifdc.org/2scale/), productive and farmer preferable forages were identified. In order to validate the farmers' perceptions and to provide some first empirical evidence of the benefit of using these improved forages compared to farmer practice in the area, on-farm feeding trials using farmers' cows were implemented in 2017. The assessment zeroed in on changes in milk production and quality accompanied by cost benefit analysis associated with the improved feeding. The milk production was observed to increase by up to 21%, while also a slight improvement on the quality parameters was noted. Concomitantly, the cost benefit analysis showed it was economically viable for the farmers to adopt the improved forages.

PART I: Milk productivity and quality

Introduction

For dairy farmers to adopt any technology, convincing evidence is important that demonstrates the benefit(s) that could come from the implementation of to the suggested innovation. For example, a technology that results in extra monetary income is likely to interest farmers more than one that just shows gains that don't translate in to any economic gain.

Improved feeding of dairy cows targets increasing milk yield, providing more milk for sale. It has been shown that in dairy enterprises, the feeding component accounts for 60-70% of the costs associated with dairy (Madubuike, 1993). As such, success in dairy is a strong function of feat achieved in provision of adequate and quality feeding. Broadly, the farmer should have an understanding of feeds budgeting/planning so that he/she can estimate the amount of feeds required in a year. Although growing the forages on-farm is cheaper than buying off-farm, feeds budgeting/planning would enable the farmer to estimate his/her fodder deficit and plan to procure off farm when the demand is low and prices favorable.

Compared to other areas in central Kenya, the farmers in the area of study have relatively large farms as suggested by population densities (people/km2) of 182 for Nyandarua compared to 204, 352, 366, and 630 for Nyeri, Kirinyaga, Murang'a and Kiambu counties respectively (Wiesmann, *et al.,* 2014). This means that growing of forages would be less constrained by land availability.

However, for farmers to invest in forages for dairy production, there has to be ready market for the produce. In the area of study this has been addressed by the entry of a commercial dairy processor, Eldoville. Unlike food crops which farmers have to wait for the produce during the growth period, a farmer could be able to produce milk daily throughout the year, making regular monthly incomes which is attractive.

The aim of the study was to demonstrate, with farmers' participation, the use of adaptable quality livestock forages that can be grown on-farm and utilized to increase milk production and quality in the area.

Hypotheses

We hypothesized that:

- compared to farmers' current dairy feeding practice, feeding fodder oat and vetch improves milk quality and quantity;
- It is economically beneficial to grow and use fodder oat and vetch for milk production in the area.

Study approach

Growing of oat and vetch for feeding trial

One and a half acre of land was set aside at Eldoville Dairies in OljoroOrok in 2016. The land was ploughed and harrowed in November 2016 in readiness for planting in the short rains from October-December 2016. One acre was set aside for oat fodder production. Fodder oat cv Conway was used, as this had been evaluated previously in the area and selected best by the farmers. Seeds were obtained from Aberystwyth UK. The remaining half an acre was used for planting fodder vetch. Purple vetch seeds were obtained from KALRO-OljoroOrok. Both forages were sown at the onset of rains on 9th October 2016. Oat was planted in furrows spaced at 15cm apart and at seed rate of 100 kg/ha, while vetch was in 30 cm apart furrows, at 20kg/ha seed rate. At planting fertilizer application was 50 kg N/ha for oat while none was applied for vetch. After establishment, vetch was weeded manually as necessary while oat was sprayed with broad leaf herbicide.

The rains were below average as no substantial rains occurred in November and December. The crops thus suffered moisture stress which minimized the herbage. Vetch was harvested at flowering stage and dried under shade, producing 308 kg of hay. Fresh fodder production from

Oat was estimated at 6700 kg by first harvesting from three 2 m^2 plots, which produced mean fresh matter of 3.37 kg.

Fodder oat field at one month age- Eldoville

Fodder vetch just before harvesting at Eldoville

Farmer selection

The initial plan was to select 20 famers to be involved in the trial. However, due to poor rains in the season and low herbage production, only 10 farmers were selected. All selected farmers sell their milk to Eldoville dairies OljoroOrok, have a cow in early to mid-lactation and cows under similar parity (2-3) and were willing to cooperate with data collection from their lactating cows. All the farmers had cross-bred cows of exotic genetics that phenotypically appeared as either Friesian or Ayrshire. Table 1 provides the farmers who were selected and involved in the trial.

Table 1. Selected farmers and their contacts

Farmer name	*Mobile Contact*	*Parity of the cow*
Jane Nduta Mwaniki	0700528630	1
Jane Wairimu Githinji	0718507877	3
Julia M. Kiago	0716494302	5
Ellah Nyokabi Mwangi	0713871076	2
Jane Wanjiru Gitau	-	2
Daniel Nderitu Gachungi	0795645371	2
Paul Ngotho	0711545545	1
Grace Wanjira Munyeki	0707155205	2
James Ndungu	0717910424	2
Chege Mundia	0733572650	2

- *Means not applicable*

Following selection, the farmers were invited for a discussion at Eldoville. The aim and objectives of the feeding trial were explained and the roles that were expected to be covered by either Farmers, Eldoville Dairies or CIAT discussed. While farmers were to provide lactating cows and allow data

collection from them, Eldoville was to assist in measurement of milk quality samples and coordinate issuance of test forages to the famers. CIAT was to provide test forages and collect data necessary to answer the hypotheses.


Discussing with the selected farmers

Photo of the dairy cows that were selected




Feeding protocol and data collection

Starting 4th January 2017, an agricultural officer collected data on farmer feeding practice, milk production and quality was collected on daily basis for 2 weeks in each of the farms. The amount of morning and evening milk (kg) was recorded and a milk sample of about 50ml collected and

taken to Eldoville dairies for quality analysis (described later). Each farmer had previously been provided with a spring balance to facilitate taking weights. Further, types of animal feeds provided to the cattle were recorded and quantified were possible.

After the two weeks, farmer practice was replaced with feeding oat and vetch. Where under farmer practice the animals were being supplemented with concentrates and minerals, the type and quantities of these were maintained with the intervention, such that the only difference was change of the forages to enable estimating the influence of the introduced forages on milk production and quality. Under either farmer practice or oat-vetch intervention, the cows were provided with clean drinking water adlib. Therefore, the treatments i.e. farmer practice and oat-vetch intervention were within the animals and not between animals (University of Reading, 2000). The amount of fodder oat and vetch produced earlier was enough to feed the 10 cows for 10 consecutive days at a daily rate of 60 kg of wilted fodder oat and 2kg of vetch. Since the test forages were based at Eldoville Dairies farmers, the farmers would carry weighed amounts for two days and return after two days for the subsequent two days. Ten days after intervention feeding, the farmers resorted to farmer practice which was trailed for a further two weeks. However, two farmers (James Ndungu, Chege Mundia) were not were not willing to avail milk sample for the quality tests and thus were dropped from the trial, which continued with the 8 farmers that were compliant.

Vetch hay that was used for feeding

Wilted fodder oat used for feeding

Milk quality analysis

Milk quality was analyzed using a Lactoscan. Several parameters were measured including fat content, solids-non-fat (SNF), density, lactose and protein. While measuring the quality was consistently possible up end of intervention feeding, the Lactoscan machine was taken for a repair for one week during which the quality was not assessed (5^{th} week), but however continued after the machine was back.

Lactoscan

Analyses printout

Data analyses

All data were managed in excel spread sheets. Despite variation in parity, descriptive analysis by individual animals showed similar pattern so all the data were combined. Standard errors were calculated as $\sigma/\sqrt{n}$ and plots done in excel. Where applicable, analysis of variance was done in GenStat statistical software and means separated by least significant (LSD).

Results

Farmer' practice

Farmers' feeding practice entailed what the dairy farmers fed their dairy animals. Among the farms studied, conventional feed crops were largely Napier grass and hay (bought), and to lesser extent, fodder oat and sorghum. Crop residues including maize stovers, other residues (pea haulms, potato peelings) and weeds from crop land also were included. In addition, animals spent at least 2 hour per day grazing in paddocks. Although, there was no method used to estimate the feed intake from grazing, as it was outside the objective of this study, it was dry during the trial period (January-February 2017) suggesting little benefit from grazing. Supplementation with dairy meal and

mineral salts was adopted in all the farms. Table 1 summarizes quantities of feeds offered to the animals at individual farms studied.

Table 1. Feeds and forages offered under farmers' practice during the study in January-February 2017.

Farmer	Average /day (kg)										
	NG	MS	Weeds	Hay	CR	FS	FO	DM	Bran	GZ (hrs.)	MN (g)
Paul Ngotho	7.0	5.7	9.6	-	8	-	-	1.3	-	7.7	adlib
Julia Kiago	8.3	6	-	-	1	-	-	0.6	-	1.9	80
Daniel Nderitu	21.3	30	-	10	-	-	-	1.2	1.1	5.2	120
Ellah Nyokabi	6.0	-	3.4	-	3	-	-	1.2	-	7.0	adlib
Grace Wanjiru	6.9	-	30.0	10	1	-	4.7	1.4	-	-	100
Jane Nduta	4.0	4.0	15.0	16	-	-	-	1.2	-	-	80
Jane Wairimu	6.1	8.8	4.1	-	-	3.4	-	1.2	-	5.0	80
Jane Wanjiru	-	5.5	4.2	-	-	-	-	1.2	-	6.8	80

NG (Napier grass); MS (Maize stovers); CR (crop residue); FS (Fodder Sorghum); FO (Fodder Oat); DM (Dairy meal); GZ (Grazing); MN (minerals); - implies not applicable.

In terms of quantities availed to the animals on daily basis large contributions were in the order; weeds > maize stovers > Napier grass and hay (Figure 1). While fodder oat would have done well in the farms, Napier grass was the dominant grown fodder. Use of maize stovers and weeds were key especially in the dry season as a coping strategy.

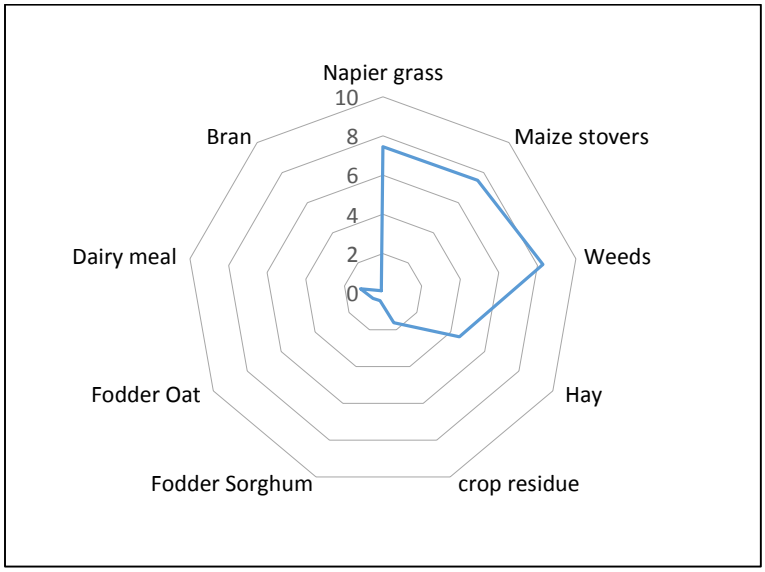

Figure 1. Feeds and forages contribution (kg/day) under farmers' practice during the study period at OljoroOrok, Nyandarua central Kenya in January 2017. Grazing not included as daily intake was not estimated.

Milk yields

Comparing morning and evening milk production (Figure 2), under farmer practice and the oats/vetch intervention, milk increased by 21 and 18 % respectively under the improved feeding. The increases were desirable, and the farmers could also easily discern and appreciate. However, adoption is likely to depend on whether the cost of the increased production also makes economic sense. To address this, cost-benefit analysis is presented in part II of this report.

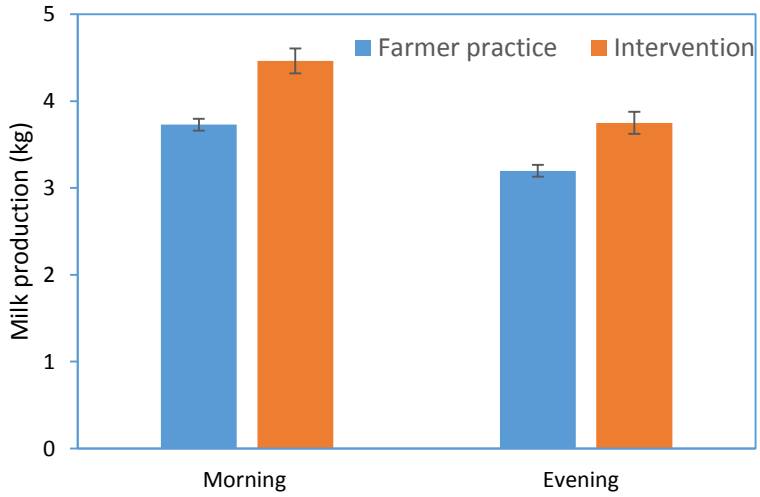

Figure 2. Milk production (kg) under farmer practice compared to intervention (oat +vetch) at OljoroOrok in January 2017

Over the 42-day trial period, pooled milked yields across the 8 farms, separately for morning and evening production increased steadily (Figure 3) to a peak at day-22 that coincided with 8th day of intervention feeding, after which there was a drop especially after reverting to farmer practice at day-25. The drop continued steadily to the end of the trial, day-42. At no time did the evening production surpass the morning production, however the pattern over the 42 days was similar. Physiologically, a lactation curve that lasts 305 days usually peaks at about 3 months and gradually drops until the cow gets to dry period. Milk production under farmer practice at the start of the trial appears slightly higher than the farmer practice at day 42 and could be explained by the lactation curve concept.

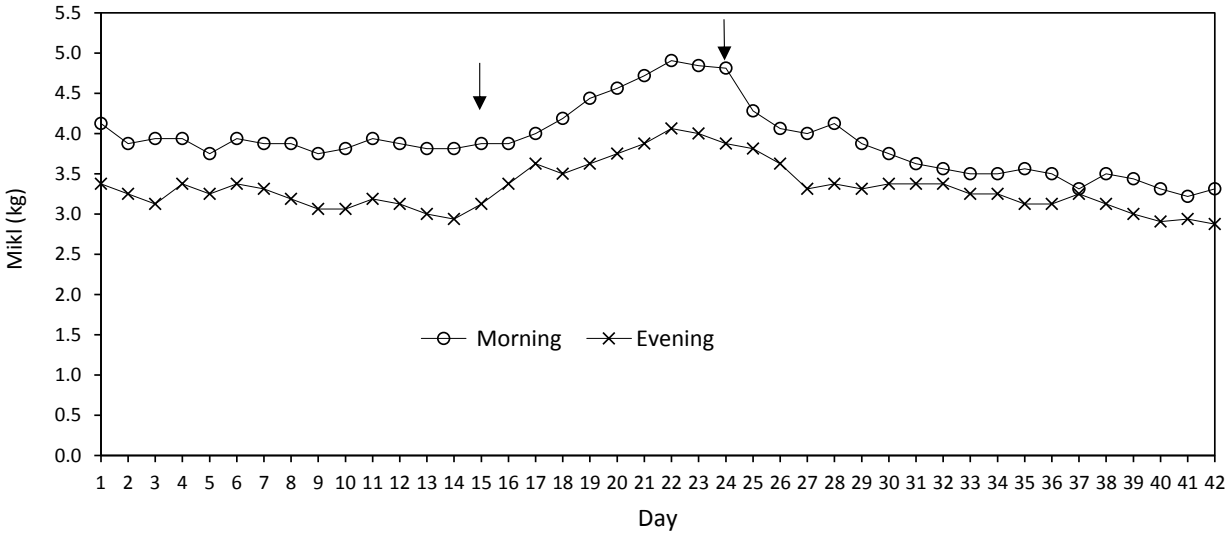

Figure 3. Mean morning and evening milk production (kg) over 6 weeks experimental period at OljoroOrok, Nyandarua Central Kenya. The 10-day period between the arrows depict intervention feeding.

Key milk quality attributes measured over the experimental period are summarized in Figure 4. For all the attributes (butter fat, lactose, solid-non-fat, density, protein) there was a slight increase in percentage in all animals when fed on the intervention (oat, vetch) compared to farmers practice. Except for the butter fat, these changes were not statistically significant (Figure 4 *a*). However, when the respective percentages were used to compute the net increase based on the milk produced per day, net increases were highly significant for butter fat, lactose, solid-non-fat and protein (Table 2). In terms of percentage (%), increases were in the order; butter fat (18.2), protein (16.5), lactose (16.3) and solid-non-fat (16.1) Table 2.

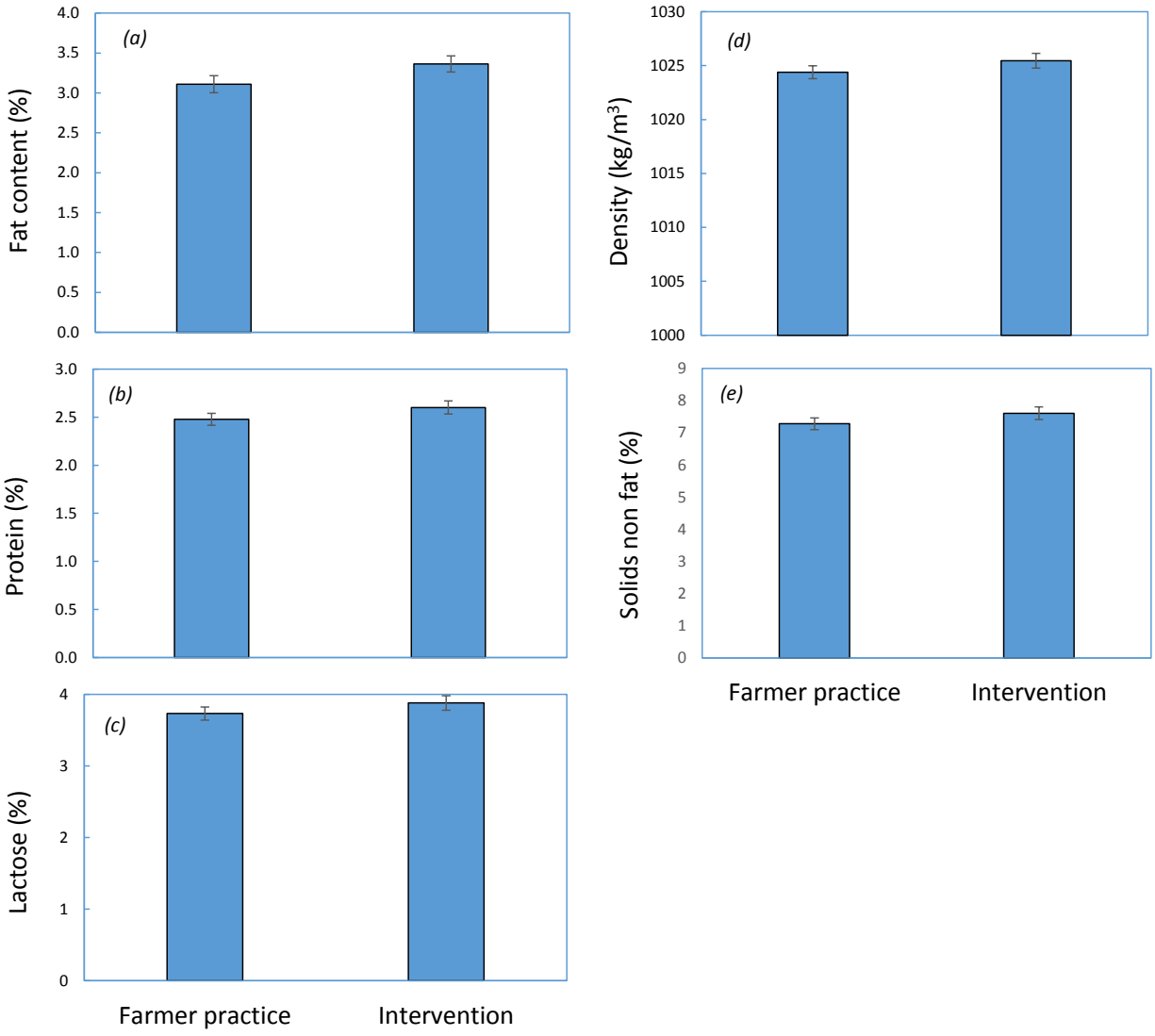

Figure 4. Milk quality attributes measured under farmer practice or intervention (a) fat content (b) protein (c) lactose (d) density and solid non-fat (e) at OljoroOrok, Nyandarua central Kenya in January 2017.

Table 2. Farmers' milk production (kg) under farmer practice and intervention with associated quality attributes (g) during the trial period in OljoroOrok, Nyandarua Kenya.

Farmer	Treatments	milk production (kg)		BF (g)	Lactose (g)	Protein (g)	SNF (g)
		Morning	Evening				
Daniel Nderitu	Farmer practice	4.3	3.7	229.5	345.1	230.2	671.9
	Intervention	5.8	5.2	219.3	477.8	318.4	929.0
Ellah Nyokabi	Farmer practice	3.3	2.2	222.6	220.0	146.9	430.6
	Intervention	3.1	2.5	223.4	225.4	150.6	441.1
Grace Wanjira	Farmer practice	4.3	3.9	250.6	335.4	223.7	655.4
	Intervention	4.5	4.1	310.2	356.4	241.7	706.7
Jane Nduta	Farmer practice	5.4	5.1	319.9	422.9	281.9	840.3
	Intervention	6.4	5.5	436.9	475.1	321.7	937.7
Jane Wairimu	Farmer practice	3.3	2.4	261.0	251.4	167.8	489.2
	Intervention	4.5	3.2	299.1	326.3	217.8	635.2
Jane Wanjiru	Farmer practice	3.0	2.2	173.4	198.8	132.8	376.5
	Intervention	3.2	2.7	203.5	234.2	147.3	458.7
Julia Kiago	Farmer practice	3.9	3.2	230.2	270.6	182.6	531.9
	Intervention	4.6	3.5	291.2	307.1	204.9	603.4
Paul Ngotho	Farmer practice	2.7	2.4	141.1	194.4	129.6	383.1
	Intervention	3.3	2.7	183.5	224.6	149.7	441.2
LSD		*0.4753****	*0.3836****	*52.68****	*34.22****	*24.13****	*71.91****
All Farmers	Farmer practice	*3.8*	*3.2*	*230.2*	*284.3*	*189.9*	*556.0*
	Intervention	*4.4*	*3.7*	*272.2*	*330.3*	*220.4*	*648.0*
LSD		*0.31****	*0.31***	*24.58****	*26.47****	*18.06****	*53****

*Degree of freedom (df) 209. BF- butter fat; SNF-Solids-Non-Fat; **P<0.01; ***P< 0.001*

Discussion

While the focus of the study was to compare the milk quality and production under farmers practice with milk quality and production with improved feeding, understanding what constituted the farmers practice was also important. Largely, the farmers fed the cows on Napier grass, maize stovers and weeds collected from crop land (Table 1). Despite the known relatively poor quality from maize stovers and Napier grass (Methu *et al.,* 2001), farmers continue relying on them for milk production. During the trial period it was relatively dry, with grazing fields visually having no pastures. Despite this situation, farmers kept animals in grazing areas (Table 1). However, this is likely to be different following rains when the unimproved grasses could recuperate and provide ingestible material, but unlikely to surpass animal performance with improved feeding.

Poor nutrition, abetted by lack of fodder planning, leads to poor animal performance. Poor feeding limits the production potential and negates any gains made in livestock breed improvement as may be happening with the farmers in the study who keep crosses rather than local breeds. Usually, the silent viewing of livestock as secondary to crops, and within livestock, feeds and forages as inferior to livestock diseases and breeding has aggregated poor livestock productivity. Addressing this would be a step in the right direction. Intervening on feeds and forages component, which constitutes at least 60% of the costs in livestock production (Madubuike, 1993), would make a leap in improving productivity. The results presented here provide empirical evidence about the differences improved feeding would make in increasing milk production and quality.

Feeding the cows on oat and vetch compared to the farmers practice increased milk production and quality (Figure 2, 3, 4 and Table 2). An increase in milk production by at least 18% would mean that more milk would be available for sale or consumption especially if improved feeding is maintained throughout the lactation period, and over several lactations.

Milk is a raw-material for processing higher-value products such as butter, whey and cheese. The production of these, however, requires high quality milk. For example, to increase butter and cheese production at processing level, milk with high levels of butter fat and protein contents respectively, would be desirable (Rønholt, et al., 2013; Wedholm, *et al.,* 2009). In some cases, in developed countries, raw milk is bought at a price based on the milk quality. Eldoville dairies, who is buying the milk from the farmers that were involved in the study, is also involved in butter and cheese production and envisages to pay milk prices based on quality in future (A. Waithaka Pers. Comm.). Farmers would thus be able to not only sell more milk but also fetch a higher price for their milk due to the improved quality of the milk.

Conclusion and recommendation

Our results suggest that feeding improved forages has the potential to increase milk production and quality in the areas studied and other similar areas. Lack of fodder planning/budgeting by farmers also contributes to the low and variable productivity. Productivity currently oscillates with the rain season and gets depressed during dry spells, which are now frequent. The increased production of forages that can easily be conserved as hay would enable farmers to produce milk throughout the year, and thus be ideal for the dairy industry.

Promotion of such technologies will be important to create awareness among the farmers for purpose of adoption.

PART II - Cost-benefit analysis

Introduction

Cost benefit analysis (CBA) is an eminent structured process that compares costs and benefits of a given project in monetary terms. A well-constructed CBA involves identifying direct and indirect costs and benefits of given investment then assigning monetary value to the indirect costs and benefits (Whinnery, 2012). In this study we applied CBA to evaluate the return on investments (ROI) of investing in forage technologies (vetch and Conway oat) that were introduced and tried by CIAT on 8 smallholder dairy farms in OljoroOrok Sub County, Nyandarua County in Central Kenya, in January 2017. CBA gives the farmer, policy makers and investors means to compare between two or more technologies based on the yield, social welfare and ecosystem services propelled by the technologies.

Most CBA studies have used Net Present Value (NPV) and Internal Rate of Return (IRR) to appraise projects (McConnachie *et al*., 2003; Kimenju *et al*., 2010). IRR refers to investment percentage rate received on each dollar for each period it is invested. Mathematically, it is computed by setting NPV equal to zero. The investment is viable if IRR is positive and greater than the market discount rate. NPV refers to the difference between cash outflows and inflows discounted to the present time. Just like IRR, it takes into account the time value of money. Payback period (PBP) can also be used to evaluate profitability of new investments. It tells time taken by an investment to recover initially invested amount.

Materials and Methods

This study was conducted using data from OljoroOrok, Nyandarua County. This county was selected because it is one of the major milk producing regions in the country (Muia *et al*., 2011). Data was collected by means of a household survey to gather general information about the household (Age of the household head, educational level of the household head, size of agricultural land and dairy farming experience), costs and milk production during the experiment period.

This study is based on field trials and experiments that were conducted by CIAT in 2017. For the purpose of this study, 8 farmers that owned dairy cattle that had calved for at least not more than three months at the time of the study were randomly selected. The introduced forages (Conway oat and vetch) were planted on a field trial in the region. The first two weeks farmers used their

normal feeds to feed the selected cattle as they recorded milk production in that period. The next ten days farmers were instructed to feed the selected cows with 60kg of Conway oats and 2kg of vetch per day. The other feed supplements (Dairy meal, mineral salts and water) were maintained in their normal ratios during the entire experiment period.

The main objective of this activity was to assess the costs and benefits of adopting Conway oat and vetch in OljoroOrok, Nyandarua County. Specifically this study assessed the main costs and benefits associated with adopting Conway oat and vetch and to determine if the benefits outweigh the costs. The study considered direct costs and benefits. The costs that were considered in this study were inputs and labor while the only benefit was increase in milk production. Thus this study was conducted to determine the economic viability of Conway oat and vetch that were introduced by CIAT to farmers in OljoroOrok Sub County.

Results and Discussion

A total of 8 households, earlier involved in feeding trials, were interviewed for this study. The average age of the sampled farmers was 49 years old. The youngest farmer was 29 years old while the oldest farmers was 63 years old. Most of the households (5) were male-headed, however dairy farming was managed by the females (7) with a mean dairy farming experience of 12.5 years and standard deviation of 8.07. The level of education attained by majority of the households' head was secondary school (5) followed by primary level (3).

Table 3: Cost of producing main fodder crops per acre

Cost	Oat (Conway)	Vetch	Napier Grass	Local oats
Inputs				
Vegetative Materials (Cuttings/Splits)	0	0	3500	0
Seeds	4000	4000	0	4500
Fertilizer (DAP)	4000	0	0	3000
Fertilizer (CAN)	0	0	0	2800
Organic Manure	0	0	6000	0
Herbicide (Round up)	800	0	0	0
Omex (Foliar feed- oats)	250	0	0	0
Bellamine (Herbicide broad leaf)	600	0	0	0
Orus (control rust in oat)	1300	0	0	0
Labour				
Ploughing and Harrowing	4000	4000	4000	4000
Planting and fertilizer/manure application	3000	2000	4000	3000
Manual weeding	0	4000	3000	0
Spraying herbicides and pesticides	500	0	0	0
Harvesting and Transportation	8600	10600	1500	3500
Total cost of production per acre (KES)	27050	23600	22000	20800
Production potential (Kgs/acre)	7769.97	623.22	19600	2000

Source: Field Survey, January 2017

The most common fodder crops used by famers in the region are Napier grass and local oats (either as a green fodder or hay). However farmers also feed livestock on maize stovers, silage and green maize stovers and other crops residues such as Irish potatoes and beans but the crops are mainly intended for human food production. The average size of the owned land was 6.16 acres with a minimum range of 2 acres and maximum range of 15 acres. The average area under Napier grass per farm was 0.5 acres while for oats was 0.33. Table 1 above provides a summary cost of producing the main fodder crops per acre in the region.

As shown in the table production cost per acre of vetch and Conway oats were higher than the conventional fodder crops (Napier grass and local oats). The other commonly used feeds namely weeds, maize stovers and crop residues were estimated in monetary value per acre since they were produced for human food. Weeds were not classified as crops but they are used as livestock feeds. Grazing was captured in hours and valued per hour basing on the daily wage rate in the region.

Table 4: Value of additional livestock feeds per acre

Livestock Feed	Value per acre (In KES)
Maize Stover	2000
Crop Residuals (Irish potatoes)	1800
Crop Residuals (Beans)	2500
Weeds	1800

Source: Field Survey, January 2017

The intervention had a positive NPV and IRR was greater than the discount rate meaning that it is profitable. The results shows that producing Conway oat and vetch is slightly more expensive than producing the common fodder crops. However, the new fodder crops have higher milk returns of an average increase of 26% which could vary depending on the livestock breed and season.

Table 5: CBA analysis of Conway oat and vetch

CBA Indicator	Value
NPV	22
IRR	15%
PBP	65 days

Source: Field Survey, January 2017

Farmers are rational thus they will prefer investing in a technology/enterprise that is profitable. The CBA presented in this study was conducted at a household level. Farmers were assumed to be homogenous. Previous studies have used CBA to assess economic analysis of various technologies. The introduced feeds were profitable when all the cost and benefits are considered due to a positive NPV and IRR greater than the discount rate.

Conclusion and policy implication

With data from 8 dairy farmers from OljoroOrok, this study analyzed the benefits and cost of implementing Conway oat and vetch on smallholders' farms with varying opportunities and cost. Focusing mainly on the private costs and benefits, our analysis indicates that implementing the new feed yields positive benefits. The analysis thus provides significant information to policy makers and government to promote high yielding dairy feeds. The results can also be generalized to all dairy farmers in Nyandarua County. The study recommends further research that includes indirect costs and externalities.

Acknowledgments

We would like to thank immensely the support from the farmers who offered and cooperated to have data collected from their dairy cows and also interviews. Mr. B.M. Kimani from Ministry of Agriculture who assisted with daily data collection from the farms, Eldoville dairies especially Mr. Andrew Waithaka who facilitated growing of oat and vetch on Eldoville land, Mr. Mutembei who supervised the forage fields and Mr. Julius Njuguna who tirelessly measured the milk quality samples at Eldoville dairies. Last but not least International Fertilizer Development Center (IFDC) for providing finances to carry out the study.

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Annex 3: Training of trainers in Nyahururu, Nyandarua County, Central Kenya.

Training of Trainers Report held on 29th August to 1st September 2016 at Laikipia Comfort Hotel- Nyahururu

Prepared By

Solomon Mwendia

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

Introduction

One of the major problems that impede development of a vibrant dairy value chain in Nyandarua has been cited as lack of information by the dairy farmers on various aspects. Although, a survey in 2015 in the area showed that dairy is the major source of household incomes, various shortcomings were stipulated including; lack of capital, livestock diseases, shortage of feeds and limited breeding skills (CIAT-IFDC). To meet the future milk demand, milk productivity inevitably has to increase. Addressing constraints within the value chain using the example of IFDC- Eldoville dairy value chain improvement, provide a fertile ground, whose success could be replicated elsewhere. Despite existence of various dairy technologies and innovations along the dairy value chain, much of information has not filtered properly to the end users- dairy farmers and in a form that can be readily consumed by the farmers. Existence of dissemination structures especially through the ministry of Agriculture and Livestock, and in the mode of demand-driven, may not have effectively reached or adopted by the farmers. Empowering leaders (trainers) close to farmer groups or cooperatives with information from experts in various aspects of dairy production in the value chain, provides an opportunity to contribute towards addressing this.

Against this background, training of trainers (ToT) was organised and implemented, with different expert resource people, within the dairy value chain to empower trainers in OljoroOrok, and especially to those affiliated to Eldoville dairies, under the 2Scale project (http://ifdc.org/2scale/) led by IFDC (International Fertilizer Development Centre). The broad objective was for the trainees to be able to share through training the information gained with dairy farmers they are engaged with. The trainees comprised of 12 persons drawn from different institutions and farmer groups as tabulated in Table 1.

Table 1. List of trainers trained at Nyahururu between 30th Aug. and 1st Sept. 2016.

Name	*Gender*	*Affiliation*	*Contact*
Joel G. Muraguri	Male	Eldoville dairies	0725785697
Mary Nduta K.	Female	farmer	0711948633
Zippora Muchiri	Female	MOALF	0728321841
Susan W. Irungu	Female	Farmer	0729587493
Pharis Munene Njagi	Male	MOALF	0723462215
Cyrus K. Chege	Male	Much. Agri. Limited	0724986688
Dancun Mugo Njunge	Male	Weru dairy	0715400431
Samuel King'ori Nderitu	Male	Kirima dairy	0727788754
Rahab N. Rono	Female	Ark Kanguu	0722276911
Josphat Karanja	Male	Farmer	0723087571
Julius Njuguga	Male	Eldoville dairies	0723444944
Joseph Kamau Mwangi	Male	Wendoss group	0701201038

MOALF-Ministry of Agriculture Livestock and Fish

Day 1

Ice breaker

The first day it started off by self-introductions stating names and affiliations of all the participants. Further the trainees were asked to state their expectations from the training including ground rules to be observed as stipulated in Table 2. Language of communication was unanimously agreed to be a combination of English and Kiswahili.

David Njenga from IFDC and Solomon Mwendia from CIAT (International Center for Tropical Agriculture) introduced their respective institutions and the roles they play biased to livestock productivity.

Table 2. Trainees' expectations and ground rules

	Expectations	*Ground rules*
1.	Learn new things on dairy farming	Time management
2.	Dairy feeding	Always pay attention
3.	Silage making	Minimize movement (in and out)
4.	Dairy cow housing	Phones in silent mode
5.	Agribusiness in dairy farming	Respect of others opinion
6.	Learn new varieties of fodder	All to participation
7.	Sharing experience to improve dairy farming	Orderliness
8.	Breeds and breeding in dairy	Fine: Energizer/ song
9.	Quality milk production	
10.	Sources of quality dairy cows	

Training on 30th August 2016

Table 3. Four major topics were covered delivered by different resource people as stipulated below.

Topic	*Resource person*	*Affiliation*
Fodder –training- Land preparation, Soil testing, fodder management	Solomon Mwendia	CIAT
Fodder management- Weed , pest and fertilizer application	Kennedy	Osho Chemicals
Dairy supplementation and Animal health	Kimathi	Osho Chemicals
Livestock products and loans by Equity Bank	Zachary Ndirangu	Equity Bank

Fodder training- Land preparation, Soil testing, fodder management- by *Solomon Mwendia*

1.

2.

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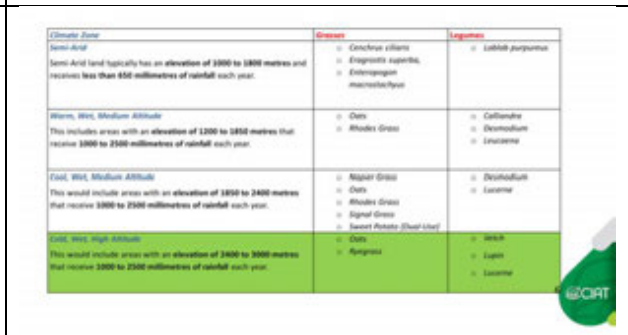


7.

Climate zone	Areas in Kenya
Semi-arid	Northern Kenya, Parts of eastern
Warm, wet , medium altitude	Taita Hills, Meru, Embu, Kirinyanga, Muranga, Kiambu and Nyeri districts in eastern and central Kenya. In western Kenya, the region covers Bungoma, Kakamega, Busia, Siaya, Kisumu, Kisii and South Nyanza districts.
Cool wet medium altitude	Trans Nzoia, Nandi, Kericho, Kisii and Narok districts, Nyandarua, upper Kiambu, Nyeri, Kirinyanga, Muranga, Embu and Meru districts in Central Kenya
Cold, wet high altitude	Mau Narok in the Rift Valley, the upper Cherangani hills and upper Mt. Elgon in Western Kenya, and the upper Nyandarua, Nyeri, Kiambu, and Aberdare Range in Central Kenya

8.

9.

Soil testing

Why test?

- Acidity and alkalinity
- Nutrient deficiency esp. P and N

- Most crops require neutral soils
- Nutrients may be there but if the soil is to acidic will not be available to the plants especially Phosphorus
- Take soils samples from your farm (20cm depth)- most roots in this region for crops

10.

Remedy

- Liming
- Manure –ameliorate the soil pH

Table 1. Soil properties (0-20cm depth) at out trial sites in Oljoro Orok.

Farmer group	Host farmer	pH	% Clay	% Sand	% Silt	% Total N	% Total C	Bray P mg/l/kg
Nyamaruru	Francis Mburu	5.0	34.8	31.9	33.3	0.32	3.6	16.2
Nyamaruru	Gilbert Gacheri	5.6	37.5	34.5	28.0	0.27	2.9	12.9
Hilltex	Peter Njihia	6.1	43.2	31.2	25.5	0.35	3.7	7.3
Kangus	Peter Mwangi	5.2	42.1	35.9	22.0	0.19	2.1	8.3
Kangus	James Karuga	5.4	47.7	34.3	18.0	0.18	2.1	2.6

Bray P levels
Very low <5
Low – (6 – 12)
Medium – (13 -25)
High - >25

Total N (%)
Very low - < 0.05
Low (0.05 – 0.15)
Medium (0.15 – 0.25)
High (0.25 – 0.5)
Very high > 0.5

11.

Planting -Example oat

- ✓ Drill seeds in rows at 20cm apart and 3-6cm depth (100kg/ha i.e. 40kg/acre) or
- ✓ Broadcast (increase seed rate slightly i.e. 10%)
  - ✓ Disadvantage- loose soil contact
- ✓ Fertilizer rate -50 kg N/ha i.e. 216 kg of 23:23 :0 /ha (Approx. 100 kg/acre)

12.

Weed control

- ✓ Herbicide
- ✓ Uproot weeds /weeding
  - *Herbicide:*
    - *When the intended fodder crop is a grass e.g. oat, spray broadleaf*
    - *When intended fodder is broad leaf or pinnate- spray herbicide that kills grass based weeds.*
- ✓ In case of minimum tillage- Could spray weeds once they die, then plant

Kennedy- Osho Chemicals

13.

Harvesting

- ✓ Boot stage (first head appear in fodder field)
  - ✓ Quality of good (protein high approx. 20%)
- ✓ Cut slightly (5cm) above the ground
- ✓ A regrowth will occur (oat)
- ✓ Hay making (150-200 bales/acre)

14.

Rye grass and festulolium

- Land preparation applies
- Ideal for cold and tolerant to frost
- *Seed rate* 20 kg/ha or 8kg/acre
- 90 kg N/ha or 36 kg N/acre at planting
- Broadcasting applicable
- DM t/ha yield
  - ryegrass 14.7–18.0
  - Festulolium 14.3–20.2
- CP (16.3–19.0%),
- Could be grazed directly

15.

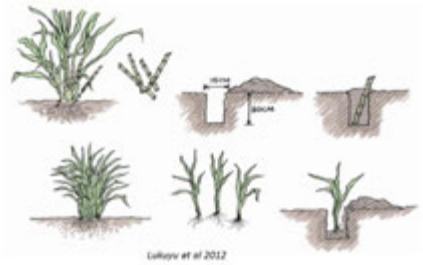
Sorghum E6518

- Seed rate: 3kg/acre, spacing: 75 cm x drill
- Soils: Medium fertile soils
- High yielding, drought resistant crop good for silage making.
- Propagation: By use of seeds.
- Planting: Fine soil tilth is best for seed drilling. Use planting fertilizer at the rate of 50 kg per acre. Thin plants when 15 cm high to 10 cm intra plant.
- Maturity: 7 - 8 months (dough stage) for silage making.
- Yields: 28-40 tons / per acre of silage material. Up to 3 ratoons (re-growths) are possible.
- Feeding: Ensiling destroys chemical subsistence present in fresh material which may cause death. DM 32, CP 9, CF 27

16.

Vetch

- Land preparation applies
- Seed rate 20 kg/ha or
- Seed rate: 8 kg per acre in pure stand
- Drill in shallow (3-6cm) furrows 30 -45cm apart
- Weed by uprooting or use pre-emergence herbicide for grass-based weeds before panting

17.	**Vetch** • Will be ready for feeding or hay making at about in about 4 months • For vetch leave a portion to harvest seeds- for planting • Soils - Should be well drained and not acidic. Neutral of pH 6-7 is preferred. • Feeding value: - CP 17-22, DM 89, CF 30 • Yields: Average hay yields is 150-300 bales/acre of pure vetch	18.	**Napier grass** • Most planted fodder crop in Kenya by small holder farmers in Kenya • Does not perform well in cold and frost prone areas • Can grow from sea level up to 2000 m • Yield variable depending on management up to 40t/ha under irrigation.   
19.	**Napier grass** ✓ Can be established from canes or splits ✓ Spacing 1 x 1 m  LuAyov et al 2012	20.	**Napier grass** • Fertilization- Use DAP (100 kg/acre) or manure at planting-depending on availability e.g. 2 spades/ hill • Weeding- when necessary especially after harvesting • Don't heap soil at the base- leave soil uniformly spread • Intercropping with Desmodium reduce on weeding costs • Manure application • Make small furrows between the Napier rows and burry manure. Why?  
21.	**Napier harvesting** • With good rains can be harvested up to 3 times in a year • Harvest at 3ft height or waist height • Crude Protein- (8- 10%) • Can be fed as green chop (Wilt) or conserved as silage.  	22.	**Napier grass challenges- diseases** • Smut • Smut-1998– has spread • Reduce harvestable yield • Infection spread- planting material, farm tools, manure-feeding infected material, Mechanically • Remedy- use tolerant cultivars: Kakamega I & II • Stunt • Stunt 2004- Has spread • Reduce harvestable yield • Infection spread- Insect vector (tiny hoppers) • Remedy- Use tolerant cultivar: Ouma and South Africa I and II  

Question: Does Lupin utilization require treatment?

Answer; Lupin is good as protein level can be as high as in soya beans, however it requires processing including roasting to make it readily utilizable by the ruminants as it does contain some anti-nutritional factors.

Weeds, pests and fertilizer application in fodder- by *Kennedy*

Couch grass was highlighted as the most notorious weed amongst crops fodder included. It stoloniferous growth enable it to run beneath the soil surface and produce shoots at randomly within the farm. It can only be eradicated by spraying systemic herbicide. 'Kick-out" available with Osho chemicals is capable of killing couch grass including other weeds.

When applying in Napier grass for example, is preferable to harvest the fodder first, then apply the herbicide at the rate of 250ml/20 liters of water/0.25 of an acre. When weeding grass based crops, selective herbicide capable of killing broad-leaf weeds is advisable. However, it should be noted that there is no herbicide capable of killing grass based weeds leaving behind broad-leaf crops. D-Amine (2 4 D). For example, this could effectively be used to kill weeds in fodder oats field. The mixing ratio is 150ml/20 liters of water. Both D-Amine and Kick-out do not affect the soil and when spraying does not require the soils to be moist, unlike for pre-emergence herbicides. The effect of D-Amine start showing after 4 hours following spraying, while for kick-out is 6 days. Pre harvest interval (PHI) in Napier grass is 3 days, a lag period before a sprayed |Napier grass is safe for harvesting and subsequent feeding. It is paramount to use flat nozzle (not adjustable nozzle) when spraying herbicides so as to release droplets during spray.

Pests in crops can lead to reduced and poor quality produce. Stalk borer, for example, does affect both Napier grass and maize negatively. The borer could be controlled by spraying Alpha 'degree' pesticide at a rate of 10ml/20 liter water. If aphids are a problem in any other crop, spray 'Oshothion' –a synthetic pyrothroid at a rate of 50ml/20liters of water. For grain –based produce, post-harvest pests e.g. weevils could be controlled by application of 'Skana Super'. Remember to always read the manufacturers manual for rates and application methods. For cold areas like OljoroOrok, a chemical like 'green miracle" could be sprayed to reduce/ prevent frost bite. It forms an oil-like layer on leaf surfaces thus curtailing frost bite. Application rate is 25ml/20 liters of water. Rust which is common in fodder oat when humid conditions prevail especially below the canopy, spraying 'Cotaf' at rate of 25ml/20 liter of water does prevent and take care of the disease.

On soil amendment, application of 'Blackearth" does ameliorate soil pH from either acidity or alkalinity towards neutral which is desirable for most crops. For effective application, mix 1 kg of 'blackearth' with 1 bag of fertilizer.


Mr. Kennedy during the training

Dairy supplementation and animal health - by Kimathi

The focus was on mineral supplementation of cattle. After feeding on roughages and supplemental feeds, animals do not get all the required minerals and in enough quantities. As a remedy, animals should be supplemented with minerals licks *adlibitum*, and essentially a mature cow should consume about 100g on minerals daily. A key element P (phosphorus) is associated with fertility and the cow returning on heat, deficiency of which could mean poor reproduction. Essentially a good cow should parturate yearly and milked for 305 days allowing only 60 days (two months) since calving-date to return to heat and conception. Other minerals are also essential including calcium for bone formation and milk synthesis, including minor element like zinc (Zn) responsible for integrity of keratin that lines up the teat canal.

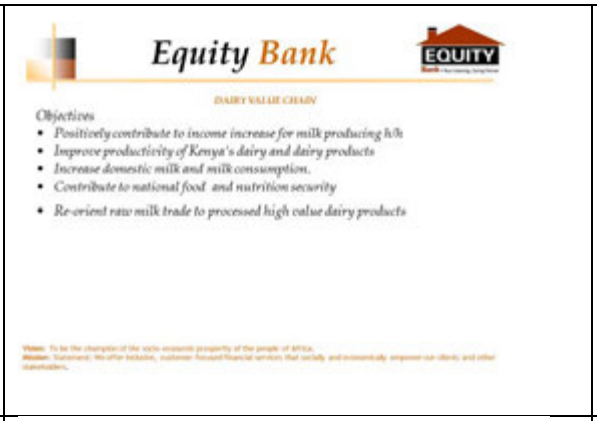
Deworming and acaricides application control parasites that would otherwise cause diseases and reduce productivity. Dewormers are available that expel internal parasites that include, roundworms, tapeworms, liver flukes. Dewormers from Osho include; Starzol, Aniverin, Endact and Prazidol for dogs. Always remember to read and use the manufacturers' instructions. Acaricides are for external use only to tackle ectoparasites including; ticks e.g. red legged ticks (*Rhipicephalus appenduculutus*) responsible for the notorious East coast fever (ECF), blue tick (*Boophilus decoloratus*) that cause red-water or cattle fever.

One of the most import dairy production disease is mastitis. The disease affects the mammary glands and not only reduce the benefits of quality milk yields but also one of the most common disease that affect most dairy herds reducing profitability. It presents at two levels, of clinical and sub-clinical mastitis with the sub-clinical being the most difficult, as milk tools okay only to be rejected at the milk collection center. Poor hygiene is the key driver underpinning this problem and observing all aspects of clean milk production, should start with the cow itself being healthy. Cleanliness in the cow sheds is paramount especially where the animals lay down. Use of disinfectants is important around the milking parlor, including udder cleaning and milking equipments. Some products are available that could be used to address mastitis concern e.g. *mastrite* and other antibiotics.

Mr. Kimathi during training session

Livestock insurance and loans by Equity Bank - by *Zachary Ndirangu*

1.



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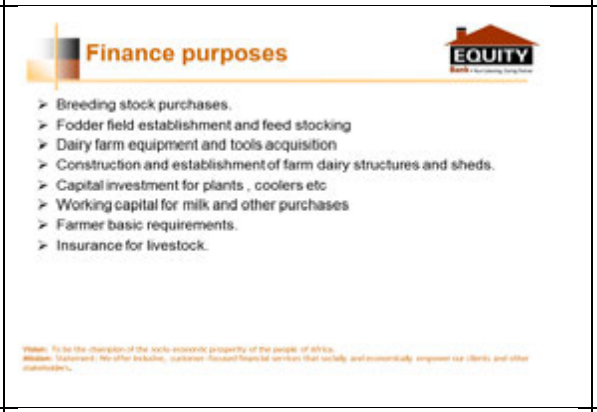

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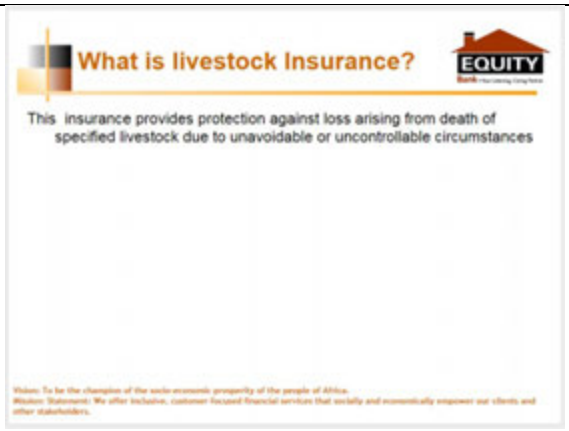
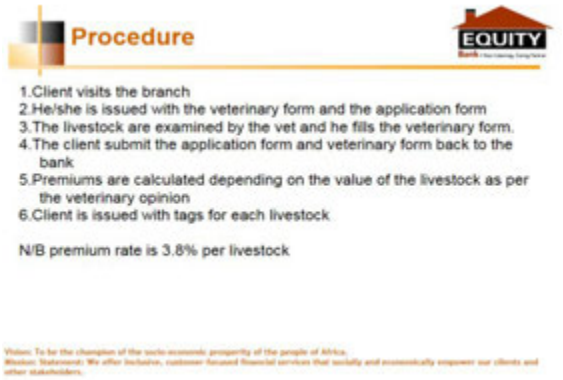
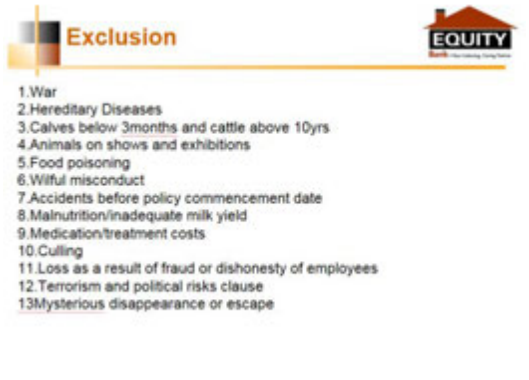
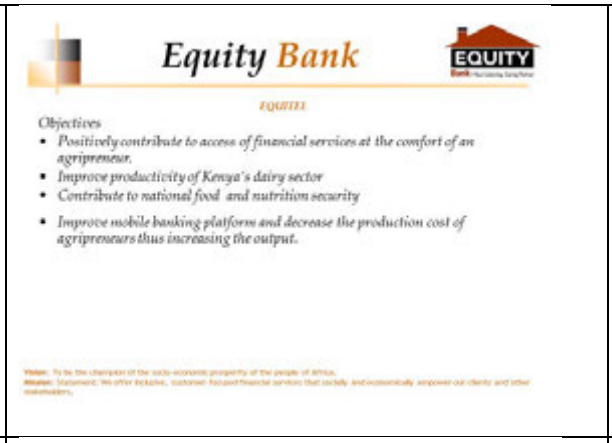
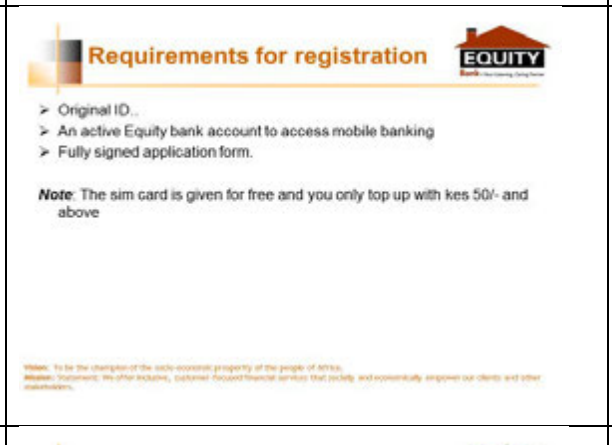
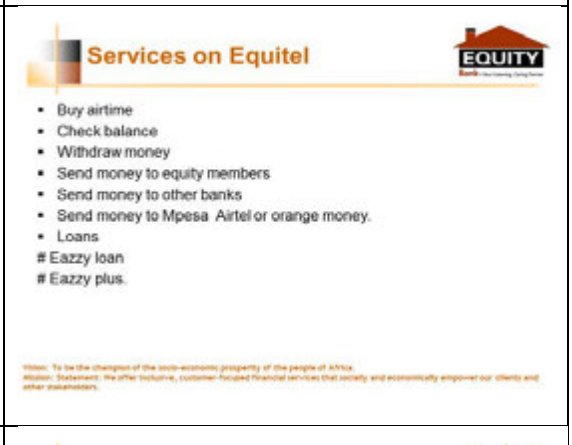
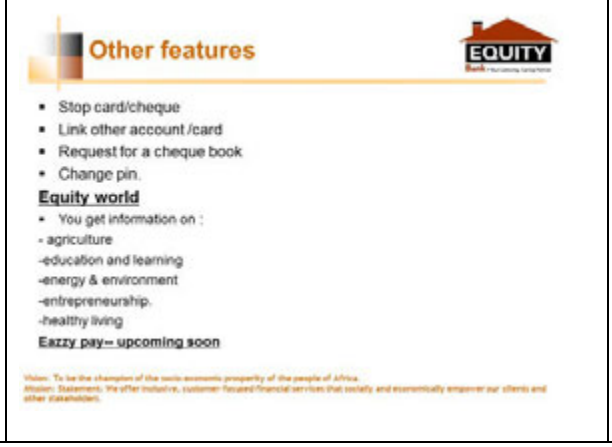
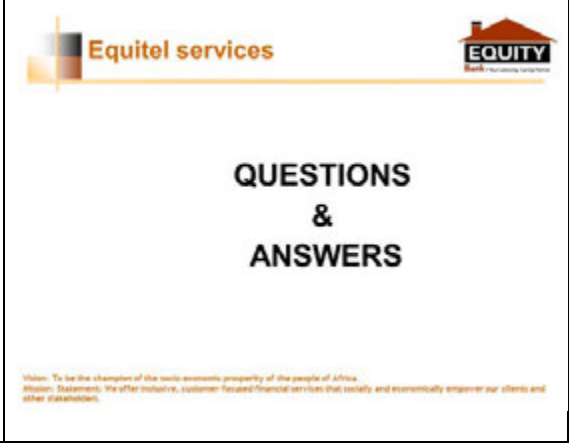
7.		8.	
9.		10.	

Question: if my cow dies of lightning strike, can I be compensated?

Answer: Lighting is a natural cause and you will be compensated but cannot be compensated to conditions that are avoidable e.g. neglecting a disease that could have been treated.

Question: if my cow dies and was using it to pay my loan through milk sales what happens?

Answer: you need to inform the bank so that a different arrangement can be made.

11.		12.	
13.		14.	
15.		16.	

Question. What is the benefit of having equitel?

Answer: transactions over your phone are much cheaper than being attended at the bank. Banks encourage it so that there is efficiency and convenience for you as a customer and the bank can concentrate on other areas.

Comment: Using of 'thin' sim cards was allowed and is now possible to use two sim cards in your phone manufactured with only one slot for a sim card.

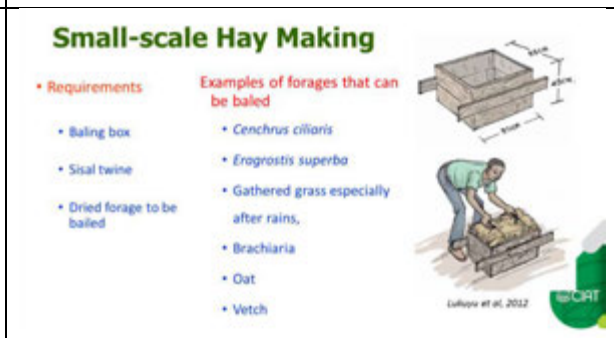
Day 2

Fodder conservation- by *Solomon Mwendia*

1.

2.

3.



4.

5.

6.

7.

8.

9.

Silage

- Fodders that can make silage
  - Sorghum forage
  - Green maize stovers
  - Sugar cane tops
  - Napier grass
  - Oat
  - Maize thinnings




10.

Qualities of good silage

- Made from material when crude protein is optimal and at grain formation
  - Maize dough stage
  - Sorghum at grain formation
  - Napier grass 1m
- Smell –sour milk
- Colour- bright or light green-yellow
- pH- 4.2
- Course texture- (not slimy)

11.

Tube silage

- **Requirements**
  - 2 m length 1000 gauge polytube (1.5 m width)
  - Molasses
  - Sisal twine
  - *Chandarua* or polythene sheet
  - Material to be ensiled
  - Watering can

12.

- **Step 1**
  - Chop forage to about 1 inch (Panga chaff-cutter)
  - On *Chandarua* or polythene sheet place 1 bag of the chopped material (50 -70Kg)
  - Spread it into a thin layer


13.

- **Step 2**
  - Dilute 1 liter of molasses (about 1 kg kasuku-tin –full with 1 -3 litres of water
  - This is enough to sprinkle on to the 50-70 kg chopped material.
- **Step 3**
  - Sprinkle the diluted molasses on to the chopped forage as evenly as possible
  - Turn and mix the forage repeatedly to ensure even spread.


Lukuyu et al 2012

14.

- **Step 4**
  - Tie one end of the 2m tube to make a plastic bag
  - Place the 50-70 kg forage already mixed with molasses into the plastic bag
  - Compact as much as possible


Lukuyu et al 2012

15.

Step 5
- Repeat steps 1 -3 twice
- Each time compact thoroughly after adding forage into the plastic bag.

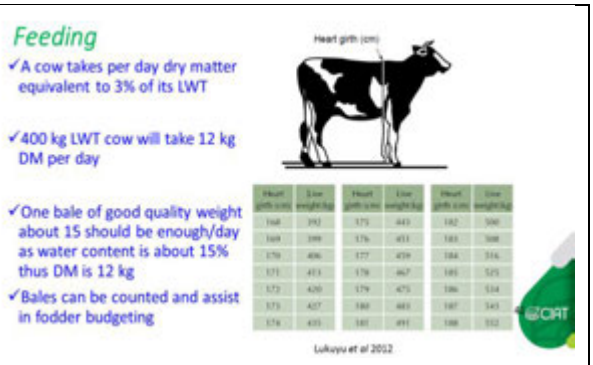
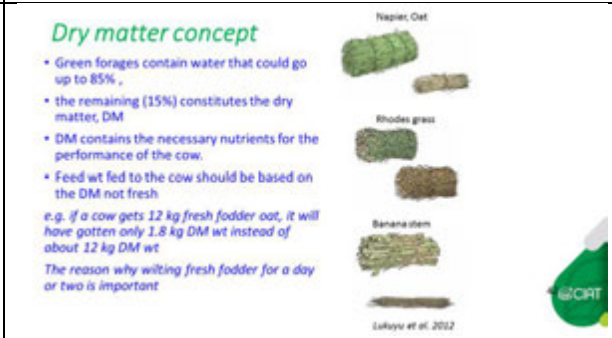
Step 7
- Store away from direct sun-light
- Place some weight on the tied sack to maintain compacting

Step 6
- Tie the top of the plastic bag tightly ensuring no air remains in the bag


Lukuyu et al., 2012

16.

- Within 21 days the material will be silage
- The silage can keep for years so long as anaerobic conditions are maintained!

17.		18.	
19.		20.	

Comments: fodder planning /budgeting is key in dairy success. At least 65% of the cost in dairy are feeds related and once this is address could mean 65% success. Conserved fodder is easy to quantify and know what period of feeding can be covered depending on herd size.

Conservation allows you to remain in milk production even during dry spells when milk prices are likely to be better.

Breeds and breeding (A.I, ET, Technician training)- *by Eunice*

Eunice from Indicus genetics covered the importance of using improved genetics to improve dairy productivity. Indicus Company, does provide breeding services including use of proven quality semen as well as embryo transfer (ET). Although ET done at a cost of KES 44,000 appear costly at the face value, in the long run pays as the technology could directly give pedigree animals, cutting short time (years) that would be required to improve own herd to the same level.

Although farmers in the area to some extent use artificial insemination (A.I), lack of recording keeping and understanding basic breeding principles could still lead to inbreeding. Use of same bull to the daughters' even if through A.I. is inbreeding which could negate gains attained. There is need for the farmers to be the ones requesting the inseminator the bull they would prefer to use other than allowing the inseminator to select for them. Since an inseminator is in business, chances are s/he would use what is at his/her disposal. To understand bulls to use, yearly catalogues are available with details of bulls available with production traits and scores. Whenever, an insemination is done, the farmers should keep the straws used, as details of the semen used are inscribed on it for future reference for breeding.

Attributes of a good dairy cow were highlighted including; wide pin bone for ease of calving, udder not extending below the hock, udder attachment should start few centimeters below the vulva, udder should have an intact suspensory ligament holding the udder quarters in place, straight backline, hind legs should be at an angle not straight, hooves contact with the ground should not be sharp but extended increasing the contact surface. The pendulous the udder, the higher the chances of mastitis, which has also being found to be positively correlated with somatic cell count (SCC). This traits could be selected for during breeding. Trainers were provided with bull catalogue available from Indicus Company.

Eunice training on breeding

Dairy meal supplementation and Total mixed ration- *by Daniel Kuruga*

The presenter is a processor of dairy meal and calf feed 'Digital feeds' at Nyahururu town. In addition, he is also a dairy farmer who supplies150 liters of milk to Eldoville dairy and an equal amount to hotels in Nyahururu on daily basis. All his 20 milking cows are zero-grazed. His feeding strategy is largely on maize and sorghum silage roughage. He plants, about 8 acres of silage and prefers sorghum silage as it goes up to 3rd ratoon thus reducing the cost of fodder production. For maize silage, yellow maize is the best and obtains from large farms in the rift valley and the seeds are recycled. He also strategically buys Rhodes grass hay when the prices are low especially during rains when the demand is low. When feeding hay, it is first treated with yeast that improves the digestibility.

During feeding, 6 kg of concentrates are mixed with the silage or hay and the animals allowed mineral licks and clean water adlib.

Concentrate formulas for dairy meal and calf meals as applied on weight basis, is as stipulated in Table 4 for 1 ton. The availability of the raw-materials exist in Nyahururu, Thika or Nakuru towns. It is key to ensure the materials do not have moulds to avoid aflatoxins.

Table 4. Ingredients for dairy and calf meals at digital feeds on weight basis (kg).

Ingredient	*Dairy meal*	*Calf meal*
Maize germ	292	30
Wheat bran	210	-
Pollard	70	28
DCP	-	0.5
Cotton seed cake	112	5
Sun flower cake	112	-
Bone meal	-	1
Soya/canola/baked ground nuts	121	6 (canola)
Lime stone	28	
Fish meal	-	10
Magandi	21	-
Dairy premix	1.4	-
yeast	700 (g)	-
Molasses	42	-
Barley	51	-
Stinging nettle	-	3

Day 3

Farm visit

The participants visited *Daniel Kuruga* Friesian dairy farm (Pictures below) on the 3rd day before departure.

Trainees were able to see underground maize silage, housing structure for the zero-grazed cows including calves raised for replacement and sale as in-calf heifers.

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Yellow maize silage currently half way in use</td><td>Hay in feeding troughs</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>A cow resting after parturition</td><td>Calves being reared for replacement or sale</td></tr>
</table>

Way forward

The trainees agreed to train their groups when they get back. To equip them for the same, they were provided with all the training materials that were covered by different presenters during the training. Where possible they could use vernacular or Swahili if these could help relay the message they want to pass. They were expected to later provide a report after the trainings.

Annex 4: Training of trainers in Meru, Meru County, Eastern Kenya.

Training of Trainers Report held on 25th-27th October 2016 at Nevada Palace Hotel- Meru

Prepared By

Solomon Mwendia

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

Introduction

Meru region in central Kenya highlands is a high agriculture potential area boosted by the being on the windward side of Mt Kenya receiving an average of 1362 mm rainfall annually (World weather online, 2016). Human population in the area stood at 1,443,555 in 2012 and may be higher than this currently (ASDSP, 2013). Mixed agriculture is the practice with crops and livestock forming the major activities in the county. The number of cattle in the county was 439,197 according to 2009 census making Meru rank number 9 amongst 47 counties in Kenya, in cattle numbers. (KNBS 2009 census).

Smallholder dairy, in addition to nutrition does contribute to household incomes. With the rising human population, is pushing the demand for livestock products-milk and meat high. However, the production of the same has not been growing at the same rate attributable to several reasons. In many smallholder farms in Kenya and especially dairy, lack of skills and technologies by the dairy farmers that could be used to leverage on improving the productivity contribute to the under development of the sector. Noble ones include animal feeds and feeding, breeding, and diseases control. Although agricultural extension system in Kenya is elaborate, farmers are not proactive in visiting experts to seek relevant information

Against this background, training of trainers (ToT) was organised and implemented, with different expert resource people, within the dairy value chain to empower trainers in Meru, and especially to those affiliated to farmer groups and are linked to 2Scale project (http://ifdc.org/2scale/) led by IFDC (International Fertilizer Development Centre). The broad objective was for the trainees to be able to elicit a knock on effect through training on information they were trained on touching on dairy production. The trainees comprised of 14 persons drawn from different institutions and farmer groups, Table 1.

Table 1. List of trainers trained at Meru on 24th-27th October 2016.

Name	*Gender*	*Affiliation*	*Contact*
Joseph Kinoti	Male	FESKA dairies	0728077829
Francis Maingi	Male	FESKA dairies	0720310626
Humphrey Mugambi	Male	FESKA dairies	0723118758
Florence Ngugi Mbae	Female	FESKA dairies	0700317276
Tabitha M. John	Female	FESKA dairies	0727281093
Gediel Kirigia	Male	FESKA dairies	0707895186
Franklin Mutugi	Male	FESKA dairies	0711697468
Josphao Mutea	Male	FESKA dairies	0700215127
John Muthuri	Male	FESKA dairies	0711950418
Franklin Mwenda	Male	FESKA dairies	0715136186
Johnson Mbaya	Male	MOALF	0711924815
David Njoka	Male	MOALF	0725841634
Hudson m. Mwangi	Male	FESKA dairies	0723107374
Joseph Muthee	Male	FESKA manager	0720317594

MOALF-Ministry of Agriculture Livestock and Fish.

Day 1

Ice breaker

Self-introductions were used to break the ice, stating names and affiliations by all the participants. Further the trainees were asked to state their expectations from the training including ground rules to be observed as stipulated in Table 2. Language of communication was unanimously agreed to be a combination of English and Kiswahili.

David Njenga from IFDC and Solomon Mwendia from CIAT (International Center for Tropical Agriculture) introduced their respective institutions and the roles they play biased to livestock productivity.

Table 2. Trainees' expectations and ground rules

	Expectations	*Ground rules*
1.	How to increase milk production	Time management
2.	Animal husbandry	Always start with prayer
3.	Dairy technologies	Avoid unnecessary movement
4.	Make new friends –net work	Phones in silent mode
5.	Challenges in milk production	Penalty for breaking rules - energizer
6.	Share and learn from others	Welfare-and have a contact person
7.	Running dairy as business	
8.	Dairy diet for healthy animals	
9.	Dairy breeds	

Training on 25th October 2016

Table 3. Three major topics were covered delivered by different resource people as stipulated below.

Topic	*Resource person*	*Affiliation*
Fodder –training- Land preparation, Soil testing, fodder management	Solomon Mwendia	CIAT
Fodder management- Weed , pest and fertilizer application	Sabana Simon	Osho Chemicals
Dairy supplementation and Animal health	Alex Kimathi and Sabana Simon	Osho Chemicals

Fodder training- Land preparation, Soil testing, fodder management- by *Solomon Mwendia*

1.

CIAT International Center for Tropical Agriculture

Topic: *Forage growing and feeding*

Training of trainers

August, 2016
Nyandarua, Kenya
Solomon Mwendia

2.

Outline

- *Introduction and background*
- *Feed categories*
  - *Roughages (Basal diet)*
  - *Supplementary*
- *Examples (Roughage + supplementary)*
  - *Establishment and agronomy*
- *Fodder conservation*
  - *Feeding – dry matter concept*

3.

Introduction and background

- *The Cost of Feeding Dairy Animals*
  - Livestock feed is the highest cost for most dairy farmers.
- To increase income farmers either;
  - Sell more milk
  - Obtain a higher price per litre of milk or
  - Reduce their costs for cattle, feed and other expenses

4.

Approaches

- *Maximum Production*
  - Buy large amounts of feed and concentrates at market
  - effective if the price of milk

- *Least Cost*
  - feed on naturally occurring pasture, crop residues
  - not always plentiful and usually not very nutritious

5.

Growing Forages

- One cost-effective approach for feeding dairy cattle is cultivating forage crops on your farm.

✓ Roughages (grasses)
  - source of energy
  - contain only low or medium levels of protein

✓ Supplementary (Legumes)
  - greater amounts of protein and other nutrients

Especially for lactating and pregnant cows and growing calves

6.

Climate Zone	Grasses	Legumes
Semi-Arid Semi-Arid land typically has an **elevation of 1000 to 1800 metres** and receives **less than 650 millimetres of rainfall** each year.	Cenchrus ciliaris Eragrostis superba, Enteropogon macrostachyus	Lablab purpureus
Warm, Wet, Medium Altitude This includes areas with an **elevation of 1200 to 1850 metres** that receive **1000 to 2500 millimetres of rainfall** each year.	Oats Rhodes Grass	Callandra Desmodium Leucaena
Cool, Wet, Medium Altitude This would include areas with an **elevation of 1850 to 2400 metres** that receive **1000 to 2500 millimetres of rainfall** each year.	Napier Grass Oats Rhodes Grass Signal Grass Sweet Potato (Dual-Use)	Desmodium Lucerne
Cold, Wet, High Altitude This would include areas with an **elevation of 2400 to 3000 metres** that receive **1000 to 2500 millimetres of rainfall** each year.	Oats Ryegrass	Vetch Lupin Lucerne

7.

Climate zone	Areas in Kenya
Semi-arid	Northern Kenya, Parts of eastern
Warm, wet , medium altitude	Taita Hills, Meru, Embu, Kirinyanga, Muranga, Kiambu and Nyeri districts in eastern and central Kenya. In western Kenya, the region covers Bungoma, Kakamega, Busia, Siaya, Kisumu, Kisii and South Nyanza districts.
Cool wet medium altitude	Trans Nzoia, Nandi, Kericho, Kisii and Narok districts, Nyandarua, upper Kiambu, Nyeri, Kirinyanga, Muranga, Embu and Meru districts in Central Kenya
Cold, wet high altitude	Mau Narok in the Rift Valley, the upper Cherangani hills and upper Mt. Elgon in Western Kenya, and the upper Nyandarua, Nyeri, Kiambu, and Aberdare Range in Central Kenya

8.

Land preparation

✓Land preparation

✓Well before start of rains

✓Plough/dig seedbed to a fine tilth

✓Harrow if necessary

9.

Soil testing

Why test?

- Acidity and alkalinity
- Nutrient deficiency esp. P and N
- Most crops require neutral soils
- Nutrients may be there but if the soil is to acidic will not be available to the plants especially Phosphorus
- Take soils samples from your farm (20cm depth)- most roots in this region for crops

10.

Remedy

- Liming
- Manure –ameliorate the soil pH

Table 1. Soil properties (0-20cm depth) at out trial sites in OljoroOrok.

Farmer group	Host farmer	pH	% Clay	% Sand	% Silt	% Total N	% Total C	Bray P mg/l/kg
Nyamaruru	Francis Mburu	5.0	34.8	31.9	33.3	0.32	3.6	16.2
Nyamaruru	Gilbert Gacheri	5.6	37.5	34.5	28.0	0.27	2.9	12.9
Hilltop	Peter Njihia	6.1	43.2	31.2	25.5	0.35	3.7	7.3
Kangoo	Peter Mwangi	5.2	42.1	35.9	22.0	0.19	2.1	8.3
Kangoo	James Karuga	5.4	47.7	34.3	18.0	0.18	2.1	2.6

Bray P levels
Very low <5
Low – (6 – 12)
Medium – (13 -25)
High - >25

Total N (%)
Very low - < 0.05
Low (0.05 – 0.15)
Medium (0.15 – 0.25)
High (0.25 – 0.5)
Very high > 0.5

11.

Planting -Example oat

- ✓ Drill seeds in rows at 20cm apart and 3-6cm depth (100kg/ha i.e. 40kg/acre) or
- ✓ Broadcast (increase seed rate slightly 1.e. 10%)
  - ✓ Disadvantage- loose soil contact
- ✓ Fertilizer rate -50 kg N/ha i.e. 216 kg of 23:23 :0 /ha (Approx. 100 kg/acre)

12.

Weed control

- ✓ Herbicide
- ✓ Uproot weeds /weeding
  - *Herbicide:*
    - *When the intended fodder crop is a grass e.g. oat, spray broadleaf*
    - *When intended fodder is broad leaf or pinnate- spray herbicide that kills grass based weeds.*
- ✓ In case of minimum tillage- Could spray weeds once they die, then plant

Kennedy- Osho Chemicals

13.

Harvesting

- ✓ Boot stage (first head appear in fodder field)
  - ✓ Quality of good (protein high approx. 20%)
- ✓ Cut slightly (5cm) above the ground
- ✓ A regrowth will occur (oat)
- ✓ Hay making (150-200 bales/acre)

14.

Rye grass and festulolium

- Land preparation applies
- Ideal for cold and tolerant to frost
- *Seed rate* 20 kg/ha or 8kg/acre
- 90 kg N/ha or 36 kg N/acre at planting
- Broadcasting applicable
- DM t/ha yield
  - ryegrass 14.7–18.0
  - Festulolium 14.3–20.2
- CP (16.3–19.0%),
- Could be grazed directly

15.

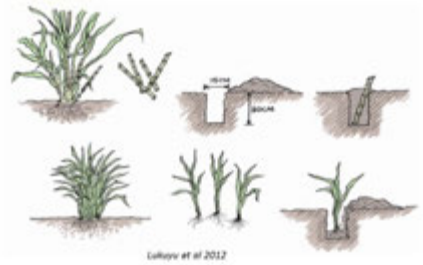
Sorghum E6518

- Seed rate: 3kg/acre, spacing: 75 cm x drill
- Soils: Medium fertile soils
- High yielding, drought resistant crop good for silage making.
- Propagation: By use of seeds.
- Planting: Fine soil tilth is best for seed drilling. Use planting fertilizer at the rate of 50 kg per acre. Thin plants when 15 cm high to 10 cm intra plant.
- Maturity: 7 - 8 months (dough stage) for silage making.
- Yields: 28-40 tons / per acre of silage material. Up to 3 ratoons (re-growths) are possible.
- Feeding: Ensiling destroys chemical subsistence present in fresh material which may cause death. DM 32, CP 9, CF 27

16.

Vetch

- Land preparation applies
- Seed rate 20 kg/ha or
- Seed rate: 8 kg per acre in pure stand
- Drill in shallow (3-6cm) furrows 30 -45cm apart
- Weed by uprooting or use pre-emergence herbicide for grass-based weeds before panting

17.	**Vetch** • Will be ready for feeding or hay making at about in about 4 months • For vetch leave a portion to harvest seeds- for planting • Soils - Should be well drained and not acidic. Neutral of pH 6-7 is preferred. • Feeding value: - CP 17-22, DM 89, CF 30 • Yields: Average hay yields is 150-300 bales/acre of pure vetch	18.	**Napier grass** • Most planted fodder crop in Kenya by small holder farmers in Kenya • Does not perform well in cold and frost prone areas • Can grow from sea level up to 2000 m • Yield variable depending on management up to 40t/ha under irrigation.   
19.	**Napier grass** ✓ Can be established from canes or splits ✓ Spacing 1 x 1 m  Lukuyu et al 2012	20.	**Napier grass** • Fertilization- Use DAP (100 kg/acre) or manure at planting-depending on availability e.g. 2 spades/ hill • Weeding- when necessary especially after harvesting • Don't heap soil at the base- leave soil uniformly spread • Intercropping with Desmodium reduce on weeding costs • Manure application • Make small furrows between the Napier rows and burry manure. Why?  
21.	**Napier harvesting** • With good rains can be harvested up to 3 times in a year • Harvest at 3ft height or waist height • Crude Protein- (8- 10%) • Can be fed as green chop (Wilt) or conserved as silage.  	22.	**Napier grass challenges- diseases** • Smut • Smut-1998– has spread • Reduce harvestable yield • Infection spread- planting material, farm tools, manure-feeding infected material, Mechanically • Remedy- use tolerant cultivars: Kakamega I & II • Stunt • Stunt 2004- Has spread • Reduce harvestable yield • Infection spread- Insect vector (tiny hoppers) • Remedy- Use tolerant cultivar: Ouma and South Africa I and II  

Question: How do you control Napier grass smut?

Answer: uproot smutted tillers and bury deep of burn. Better still, plant Napier grass cultivars that have been found tolerant to the disease e.g. Kakamega I and II

Question: Kakamega I not yielding as much as Bana! What is your comment?

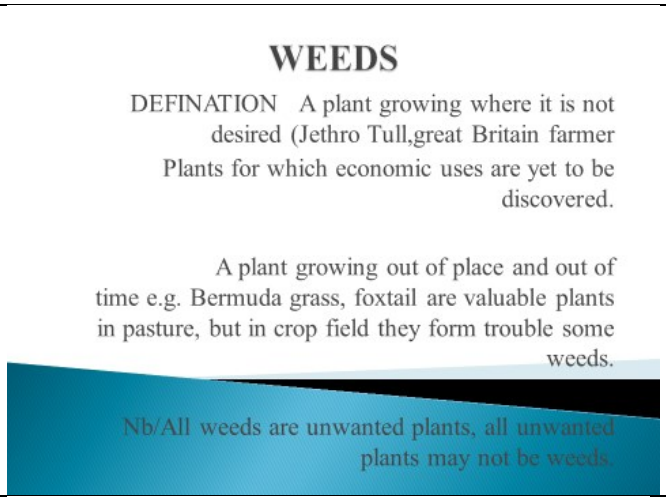
Answer: yes Bana yield more but very susceptible to smut and if you have no smut problem on your farm, could continue with it but if the disease challenge is there, consider the tolerant varieties

Question: Is the smut that affect Napier grass the same as that affect maize?

Answer: Although both are caused by fungus, they are of different species and do not cross infect between the two crops

Weeds management- by *Sabana Simon from Osho chemicals*

1.



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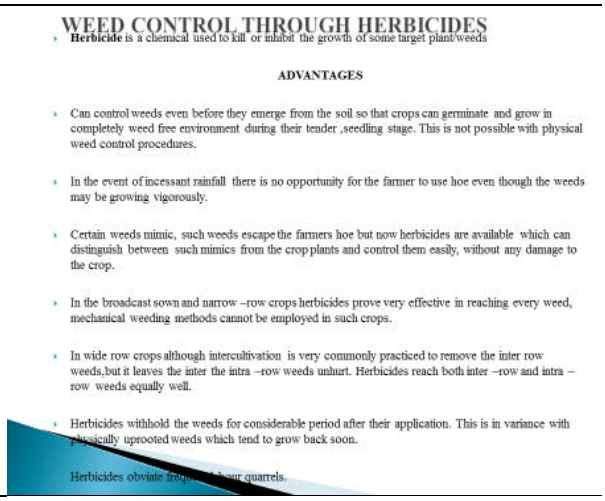

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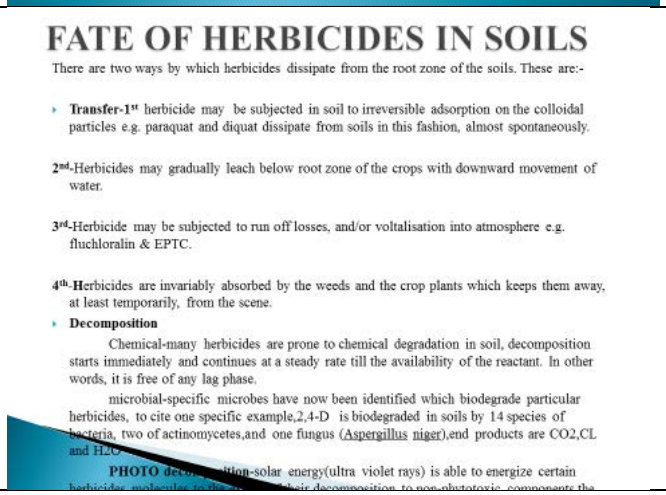

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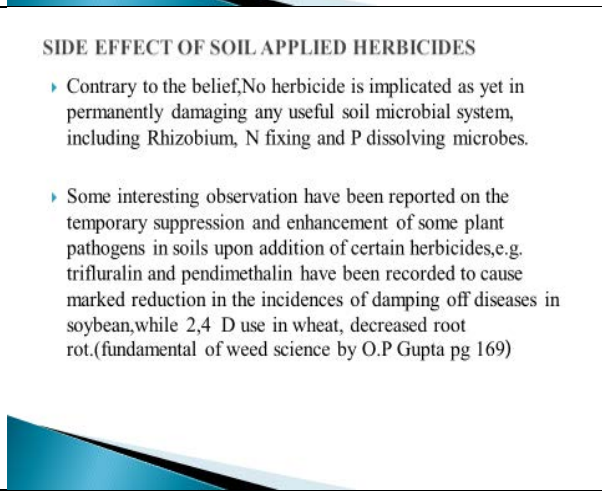

5.

HERBICIDE FORMULATION

- They include EC (emulsiafiable concetrates,W.P(wettable powders,G(granules)
- SR(slow release e.g. ME (micro encapsulation)
- Active ingredient refers to chemical that is directly responsible for the herbicidal effect,E.G. 40EC means that it is an emulsiafiable concetrate,containing 40g of active ingredient per 100g of the formulation if it was marked as W/w,**BUT** if it was marked as W/v,then it amounts to 40 g per 100ml of the formulation

6.

WEED MENACE IN AGRICULTURE

- Weeds reduce crop yield, in wheat 15-30%,rice 30-35%maize sorghum, oil seeds by 18-85%(mukhopadhyay,1991-92,Balyan and Malik,1994,Rita et al1995 and Yadav et al.,1995).**HOW**, competion for mineral nutrients, competition for soil moisture,competition for light,Allelopathy(green plants produce numerous secondary metabolites, many of which are capable of initiating chemical warfare among the neighboring plants growing in a community)
- Affect/elevate production efficiency ,weedy fields farm operations like application of fertilizer,pesticides,irrigation become cumbersome, it may be difficult to harvest.
- Weedy crops harbour pests by providing shelter or act as alternate hosts to pest and diseases.
- Weeds at harvest time also bring about excessive wear and tear of farm machines.
- Weeds reduce crop quality
- Loss of animal produce
- Loss of animal health
- Weed menace to human health, fever and asthma
- Cause direct food poisoning e.g. wheat flour contaminated with seed of corn cockle
- Weed menace to aquatic ecosystem
- Weeds menace to industry and public utilities, weeds growing on industrial sites, air fields form source of fire hazards
- In forests dry weeds offer potential source of fire hazards weed like Lantana camara can catch fire even when green.
- In advanced countries lowering of aesthetics values is the primary objection to weeds, their presence around living, working places makes the surrounding dull and insipid.

7.

ECONOMIC USES OF WEEDS

- Medicinal use
- Leafy vegetables for human consumption e.g. Amaranthus viridis
- Certain weeds have exhibited nematicidal properties, reduce root knot nematode population.
- Some entomologists have found that parasites and predators of certain crop pests also survive on insect pests of certain weeds.

8.

CLASSIFICATION OF WEEDS

- **Annual weeds**–attain their full growth in one season, living for a few weeks, few months, or at most for one year. within the period they produce flowers and set seeds, and then die at the end of season e.g. Amaranthus spp,best to control before they flower, tillage and herbicide(soil active herbicides) prove more effective against annual weeds.
- **Biennial weeds**–are those weedy plants that live for two years.1st year they attain their full vegetative growth, they produce flowers and set seeds in the second year, after which they die. Compared to annual weeds their number is much limited e.g. Daucus carota,Cirsium vulgare
- **Perennial weeds**–they persist for more than two years; usually for a numbers of years. Their aerial parts may wither every year at the end of a season after producing flowers and seeds,but new shoots develop again from the underground vegetative organs like roots,rhizomes,tubers,stolons and bulbs at appropriate time,they are very difficult to control.
- **Grasses ,sedges and broadleaf weeds**–it took its roots from the time when the first successful herbicide 2,4 D and MCPA was found to easily kill the broadleaf weeds in cereals like wheat, barley and oat, without damage to crop plant.
- **Woody and herbaceous weeds**–woody weeds are also called brush weeds, they are broadleaf, largely perennial shrubs and under –shrubs e.g. Lantana camara,Prosopis juliflora and wild Indian plum. **Herbaceous weeds** have green succulent stems and are common on farmlands e.g. arrowwood (Pluchea lanceolata)
- **Parasitic weeds**–they attach themselves to the roots or the shoots of the host plants and survive on food materials available to them,the parasitic weed are host specific e.g. dodder on Lucerne broomrape on tobacco and witchweed (striga spp.) on sorghum, pearl millet ,maize
- **Others include** noxious weeds, aquatic weeds, objectionable weeds, industrial weeds and grassland weeds.

9.

CHEMICAL CLASSIFICATION

TOXICITY	CORD COLOUR	SIGN	REMARKS
EXTREMELY TOXIC	RED	POISON	
HIGHLY TOXIC	YELLOW	POISON	
MODERATELY TOXIC	BLUE	DANGER	
SLIGHTLY TOXIC	GREEN	CAUTION	

10.

WEED MANAGEMENT

- Prevention of weeds-embodies all measures to deny the entry and establishment of new weeds in an area,it involves also to check the every year spread of the already existing weed species on the farm.
- Weed control –is the process of limiting any given weed infestation to the extent that it permits economic crop production

11.

CULTURAL & PHYSICAL METHODS

- Good crop husbandry practices include:
- **Proper crop stand**- gapy & under population crops are prone to heavy weed infestation which become difficult to control later,use adequate seed rate & protection of seed from soil borne pests and diseases.
- **Selective crop stimulation**-basal placement of fertilizer in the seed rows often helps in selectively stimulating the crop seedlings which can withstand competition from the weeds. Abnormal soil PH should be corrected.
- **Crop rotation**-monoculture i.e. growing of same crop year after year in the same field should be avoided by introducing break crop
- **Summer tillage**-initial tillage of the field in summer for this purpose should encourage clod formation, subsequent tillage operation should break these clods into smaller units to further expose the shrivelled weed propagules directly to the hot sun.

12.

FACTORS AFFECTING HERBICIDES EFFICANCY

- **Atmospheric factors** e.g. rainfall,humidity,temperature,sunshine,wind velocity.
- **Soil environment variables, clay** content,organic matter, rainfall pattern, soil PH,stage of plant growth.
- **Agronomic practices** e.g. crop variety,crop rotation, quality of seed bed, planting on ridge compared to flat sowing,in rice depth and time of flood.

13.

TYPES OF APPLICATION OF HERBICIDES

- **Pre plant (PP)/pre transplant**–application of herbicide BEFORE sowing/transplanting(or along with sowing).
- **Pre plant incorporation (PPI)**-when the pp herbicide is also required to be incorporated in the soil soon after its application.
- **Pre emergence treatment**-when herbicide is applied to the soil soon after sowing a crop **BEFORE** emergence of the weeds i.e. soil active compounds e.g. ACETO(acetochlor),CYATRA(atrazine)
- **Post emergence** –when herbicide is applied on the weeds themselves directly e.g. wound out(glyphosate),herbikill(paraquat)

14.

FORMULAE TO EVALUATE WEED CONTROL EFFECTS

- **Weed Control Efficiency (WCE) OR/Weed Control Index (WCI)**

$$= \frac{Wc - Wt}{Wc} * 100$$

Where **Wc** = Average weed count or average weed weight per unit area in the unweeded control plot.

Wt = Average weed count or average weed weight per unit area in plot under some weed control treatment.

Weed Index (WI)

$$= \frac{YHW - Yt}{YHW} * 100$$

Where **YHW** = Average yield of the crop in hand weeded plot and

Yt = Average yield of the crop in weed control treatment plot,under study.

15.

BIOLOGICAL CONTROL OF WEEDS

- It involves the use of living organisms against them/weeds.These living organisms called **biogents** could be insects,plant pathogens, herbivorous fish,snails,or even competitive plants

16.

INTEGRATED WEED MANAGEMENT(IWM)

- According to FAO,
  "the integrated campaign against pests is a method whereby all economically, ecologically and toxicologically justifiable methods are employed to keep the harmful organisms below the threshold level of economic damage, keeping in the foreground the conscious employment of natural limiting factors".
- Its also called system approach

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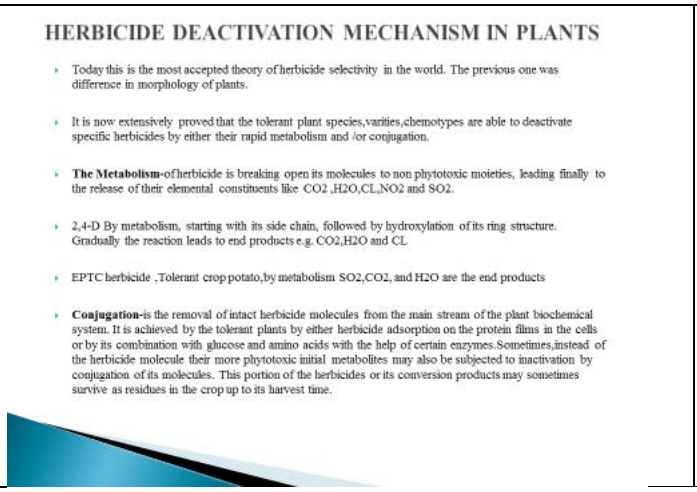

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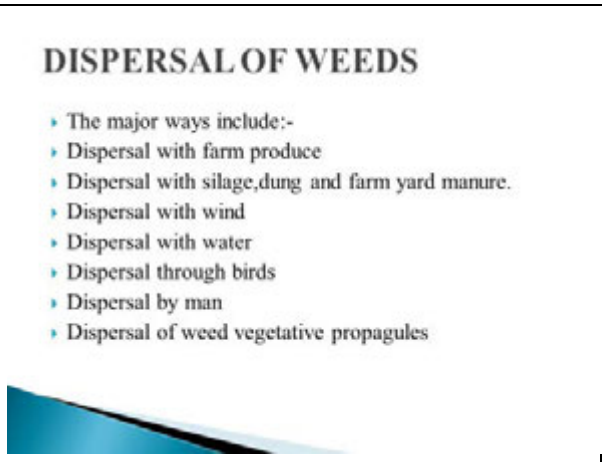

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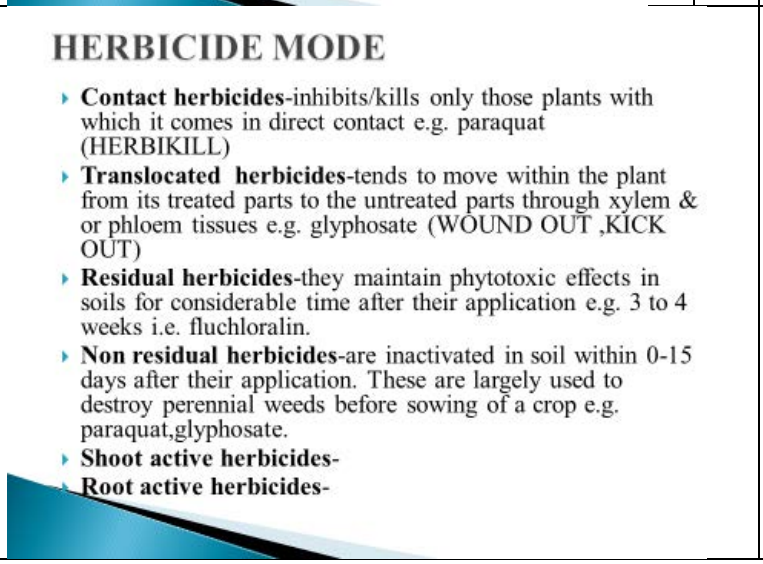

Questions and answers

Que. Some weeds are eaten by the animals and would you advise they be fed instead or throwing them?

Ans. Yes some weeds are liked by cattle e.g. wandering Jew, MacDonald's eye and they could be fed. However, depending on the crop field they are competing for nutrients with, they should not be allowed to thrive.

Dairy supplementation and animal health –Kimathi

The focus was on mineral supplementation of cattle. After feeding on roughages and supplemental feeds, animals do not get all the required minerals and in enough quantities. As a remedy, animals should be supplemented with minerals licks *adlibitum*, and essentially a mature cow should consume about 100g on minerals daily. A key element P (phosphorus) is associated with fertility and the cow returning on heat, deficiency of which could mean poor reproduction. Essentially a good cow should parturate yearly and milked for 305 days allowing only 60 days (two months) since calving-date to return on heat and conception. Other minerals are also essential including calcium for bone formation and milk synthesis, including minor element like zinc (Zn) responsible for integrity of keratin that lines up the teat canal.

Deworming and acaricides application control parasites that would otherwise cause diseases and reduce productivity. Dewormers are available that expel internal parasites that include, roundworms, tapeworms, liver flukes. Dewormers from Osho include; Starzol, Aniverin, Endact and Prazidol for dogs. Always remember to read and use the manufacturers' instructions. Acaricides are for external use only to tackle ectoparasites including; ticks e.g. red legged ticks (*Rhipicephalus appenduculutus*) responsible for the notorious East coast fever (ECF), blue tick (*Boophilus decoloratus*) that cause red-water or cattle fever.

One of the most import dairy production disease is mastitis. The disease affects the mammary glands and not only reduce the benefits of quality milk yields but also one of the most common disease that affect most dairy herds reducing profitability. It presents at two levels, of clinical and sub-clinical mastitis with the sub-clinical being the most difficult, as milk tools okay only to be rejected at the milk collection center. Poor hygiene is the key driver underpinning this problem and observing all aspects of clean milk production, should start with the cow itself being healthy. Cleanliness in the cow sheds is paramount especially where the animals lay down. Use of disinfectants is important around the milking parlor, including udder cleaning and milking equipments. Some products are available that could be used to address mastitis concern e.g. *mastrite* and other antibiotics.

California mastitis test kit is available from Osho where each udder quarter should be tested separately, as quarters may not be infected at the same time.

Mr. Sabana during training session

Livestock insurance – Kenya Orient - by *Mr. Robert*

Kenya Orient is sister to family Bank

Insurance cover was explained including when the benefits could be claimed. On Cattle, are insured and incase of loss under unavoidable circumstances, compensation would be effected. However, losses due to human error are never accepted i.e. loss due to a disease that is treatable. Usually veterinary doctor report guides on diseases. If the animal is sold out, the new owner bears the responsibility. The insurance is effective within a radius of 25km from where the household of the owner is.

If your cow is lost/stolen, you should report to the insurance immediately. The security of your animal prior to loss is key and the insurance would not accept to insure if your animal is vulnerable.

Question: if my cow dies of lightning strike, can I be compensated?

Answer: Lighting is a natural cause and you will be compensated but cannot be compensated to conditions that are avoidable e.g. neglecting a disease that could have been treated.

Question: if my cow dies and was using it to pay my loan through milk sales what happens?

Answer: you need to inform the bank so that a different arrangement can be made.

Day 2

Fodder conservation- by *Solomon Mwendia*

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2.

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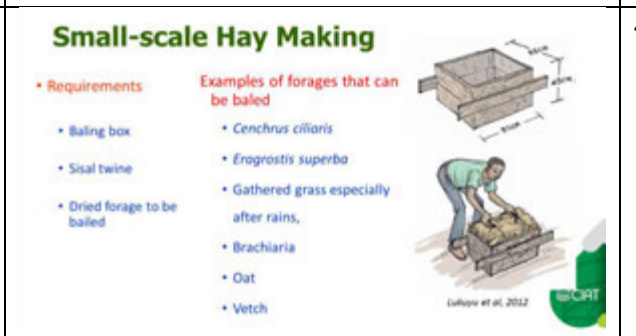

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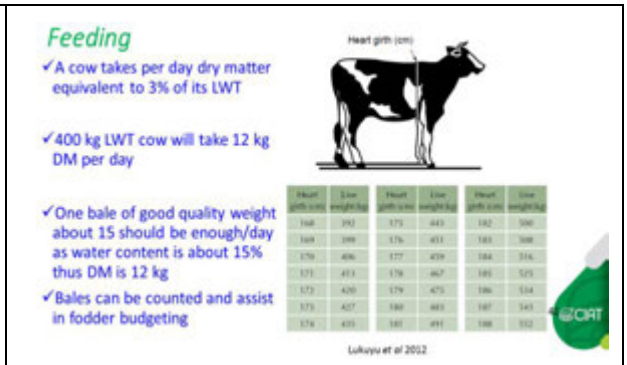
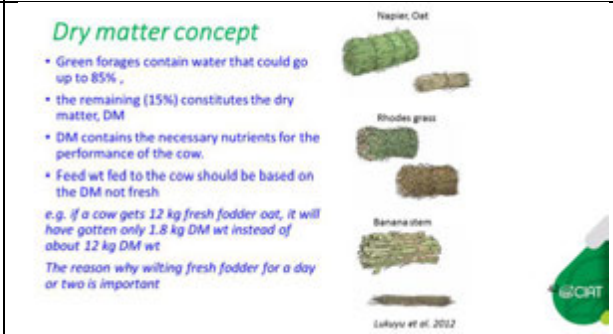
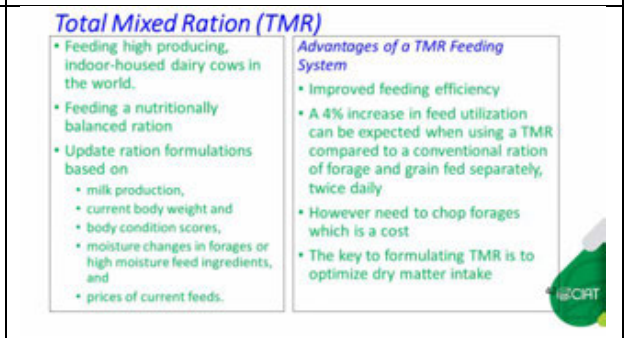
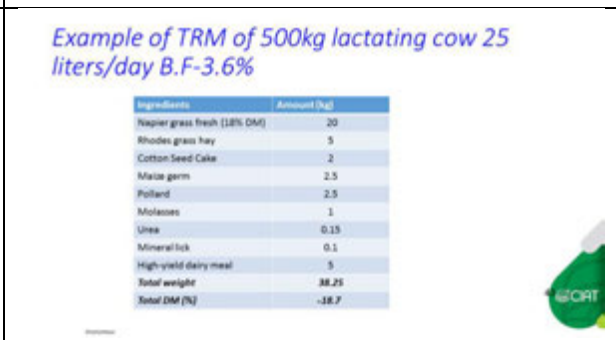
5.

6.

7.

8.

9.	**Silage** • Fodders that can make silage - Sorghum forage - Green maize stovers - Sugar cane tops - Napier grass - Oat - Maize thinnings 	10.	**Qualities of good silage** • Made from material when crude protein is optimal and at grain formation • Maize dough stage • Sorghum at grain formation • Napier grass 1m • Smell –sour milk • Colour- bright or light green-yellow • pH- 4.2 • Course texture- (not slimy)
11.	**Tube silage** • **Requirements** • 2 m length 1000 gauge polytube (1.5 m width) • Molasses • Sisal twine • *Chandarua* or polythene sheet • Material to be ensiled • Watering can	12.	• **Step 1** • Chop forage to about 1 inch (Panga chaff-cutter) • On *Chandarua* or polythene sheet place 1 bag of the chopped material (50 -70Kg) • Spread it into a thin layer  
13.	• **Step 2** • Dilute 1 liter of molasses (about 1 kg kasuku-tin –full with 1 -3 litres of water • This is enough to sprinkle on to the 50-70 kg chopped material. • **Step 3** • Sprinkle the diluted molasses on to the chopped forage as evenly as possible • Turn and mix the forage repeatedly to ensure even spread.   Lukuyu et al 2012	14.	• **Step 4** • Tie one end of the 2m tube to make a plastic bag • Place the 50-70 kg forage already mixed with molasses into the plastic bag • Compact as much as possible   Lukuyu et al 2012
15.	**Step 5** • Repeat steps 1 -3 twice • Each time compact thoroughly after adding forage into the plastic bag. **Step 7** • Store away from direct sun-light • Place some weight on the tied sack to maintain compacting **Step 6** • Tie the top of the plastic bag tightly ensuring no air remains in the bag   Lukuyu et al., 2012	16.	• Within 21 days the material will be silage • The silage can keep for years so long as anaerobic conditions are maintained!

17.		18.	
19.		20.	
21.		22.	

Que. For how long can the silage keep and remain in good condition?

Ans. As long as anaerobic conditions are maintained silage can keep well for years without going bad

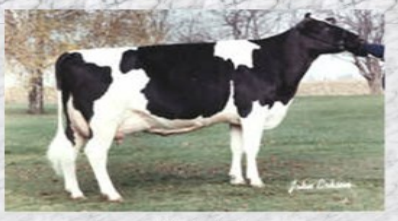
Ques. When and how much silage do you feed?

Ans. Feed silage when there is forage scarcity especially following dry spell. To avoid milk tainting, feed cows after milking or at least 3 hours before milking. A cow could be given about 30 kg of silage

Breeds and breeds selection- *by Simon Mutoru*

1.

Major Breeds of Dairy Cattle



Holstein

- Black and White or Red and White color pattern
- Large sized
- Heavy milk producers

2.

Major Breeds of Dairy Cattle

Jersey

- Color varies (light gray to a dark fawn being darker around the head and hips)
- Medium sized
- Produces more pounds of milk per body weight than any other dairy breed.

3.

Major Breeds of Dairy Cattle

Guernsey

- Red (Fawn) and White in color
- Medium sized
- High milk production to feed intake ratio
- Milk is high in betacarotene

4.

Major Breeds of Dairy Cattle

Brown Swiss

- Solid brown, varying from very light to dark
- Large sized
- Light colored band around the muzzle
- One of the oldest Dairy breeds

5.

Major Breeds of Dairy Cattle

Ayrshire

- Red and white in color (amount varies)
- Medium sized
- Purebred Ayrshires only produce red offspring
- Average milk production

6.

Dairy Breeds and Selection
Traits and Selection (Dairy Evaluation System)

1. Stature (measured at withers) points are awarded from 99 to 50 points - very tall 99 to very low set 50 points.
2. Chest and body (considering age and stage of lactation) points are awarded from 99 to 50 points - wide chest, deep rib, long body 99 to extremely narrow and frail 50 points.

7.

Dairy Breeds and Selection
Traits and Selection (Dairy Evaluation System)

3. Dairy character (independent of performance) points are awarded from 99 to 50 points - extremely sharp 99 to extremely thick 50 points.
4. Foot and shape (angle) points are awarded from 99 to 50 points - extremely steep angle 90 to extremely low angle 50 points.

8.

Dairy Breeds and Selection
Traits and Selection (Dairy Evaluation System)

5. Rear legs (side view) points are awarded from 99 to 50 points - extremely sickled 99 to extremely posty or overextended 50 points.
6. Pelvic angle points are awarded from 99 to 50 points - severe slope from hooks to pins 99 to pins clearly higher than hooks 50 points.

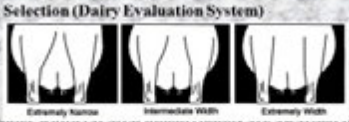
9.

Dairy Breeds and Selection
Traits and Selection (Dairy Evaluation System)

7. Rump width points are awarded from 99 to 50 points - extreme width of pelvic area 99 to extremely narrow pelvic area 50 points.
8. Fore udder attachment points are awarded from 99 to 50 points - extremely tight attachment 99 to extremely broken 50 points.

10.

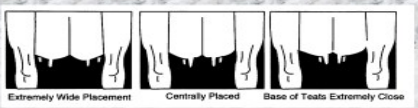
Dairy Breeds and Selection
Traits and Selection (Dairy Evaluation System)



9. Rear udder width (at attachment) points are awarded from 99 to 50 points - extremely wide 99 to extremely narrow 50 points.
10. Rear udder height (at attachment) points are awarded from 99 to 50 points - extremely high 99 to extremely low 50 points.

11.

Dairy Breeds and Selection
Traits and Selection (Dairy Evaluation System)



11. Teat placement (rear view) points are awarded from 99 to 50 points - base of teats extremely close 99 to extremely wide placement 50 points.
12. Suspensory ligament (cleft) points are awarded from 99 to 50 points - extreme cleft 99 to broken 50 points.

12.

Dairy Breeds and Selection
Traits and Selection (Dairy Evaluation System)

13. Udder depth (relative to point of hock) points are awarded from 99 to 50 points - extremely shallow, udder floor well above hock 99 to extremely deep 50 points.

13.

Dairy Breeds and Selection
Traits and Selection

Milk Production Facts

Breed	Percent Butterfat	Pounds Butterfat	Pounds Milk Prod
Holstein	3.66	703	19,185
Ayrshire	3.95	569	14,398
Jersey	4.75	618	13,020
Brown Swiss	4.03	606	15,062
Guernsey	4.57	611	13,363

Think about this?

1. Which breed produced the most total pounds of milk? Why do think this is so?
2. Why would butterfat be important to milk?
3. What breed produced the lowest total pounds of butterfat?
4. What would you think the most popular breed of Dairy cattle would be judging from this data? Why?
5. What is the definition of milk production? Why would a cow be lactating?

14.

Dairy Breeds and Selection
Traits and Selection Terms

- balance of symmetry - proper proportions and blending of parts.
- clean - free from fat
- cow-hocked - rear legs turned so that the hocks are close together and feet point out when viewed from the rear.
- body capacity - total amount of volume exhibited by a cow and indicated by a combination of depth of fore and rear rib, length of barrel, spring of rib and depth of flank.
- quality - overall smoothness, blending of shoulders, and refinement of head and bone.
- spring of rib - amount ribs arch out from the backbone.
- type - combination of characteristics that make an animal most useful for a specific purpose.
- sickle-hocked - rear legs too curved when viewed from the side.

What other terms might you use?

15.

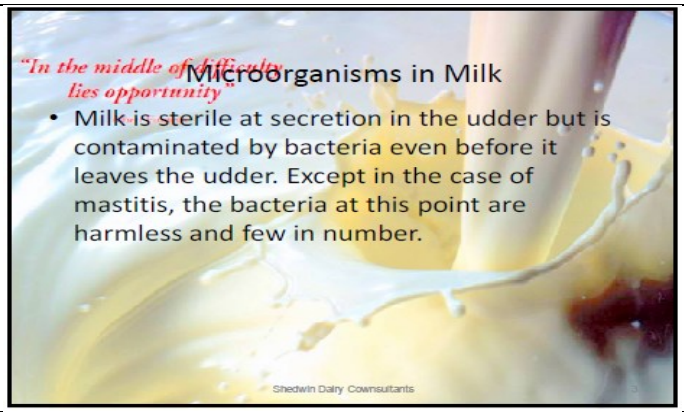
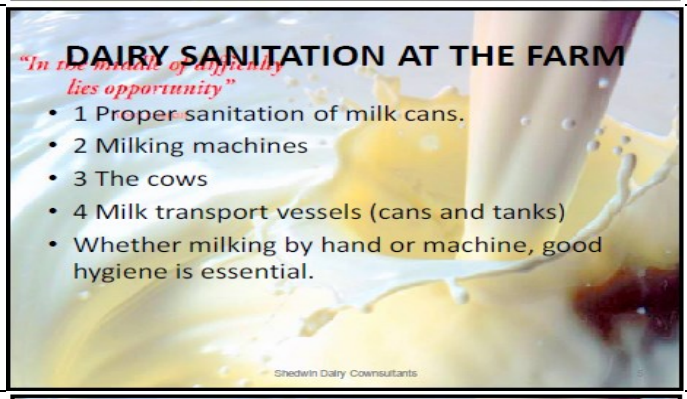
Dairy Breeds and Selection
"Use What you have learned"

- Which animal would be considered desirable?
- What terms would you use to describe the differences?
- Which animal shows the best general appearance?
- Are these cows or heifers? Why?

16.

Dairy Breeds and Selection
"Use What you have learned"

- Which animal would be considered desirable?
- What terms would you use to describe the differences?
- Which shows more dairy character? What are the indicators?
- What about the udder?

	Ques. Where can one buy these breeds? **Ans.**		
1.		2.	
3.		4.	
5.		6.	
7.		8.	

9.

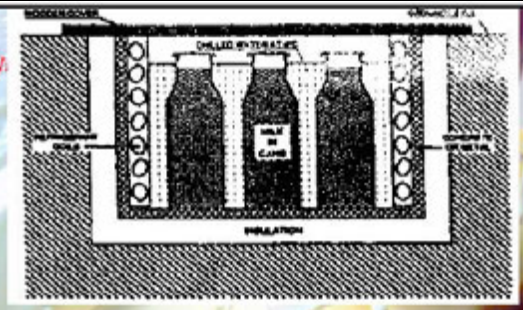
"In the middle of difficulty lies opportunity"

Cooling

- Immediately after milking, the milk must be cooled preferably to 4° C. This requires mechanical refrigeration or milk cooling tanks. These are expensive and can usually be afforded by large scale commercial farms

Shedwin Dairy Cownsultants

10.



Milk cooling by immersion in a trough with cool water

11.

"In the middle of difficulty lies opportunity"

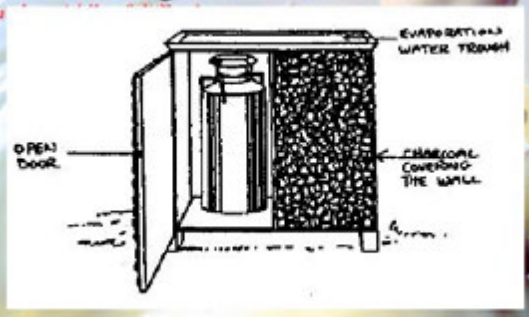
Milk delivery

- For small scale dairy farmers, setting up a milk cooling centre centrally may be the ideal solution.
- Where farmers bring their milk to a cooling centre through a co-operative, they should do so as soon as milking is completed.

Shedwin Dairy Cownsultants

12.

Using a surface milk cooler



Surface milk cooler

13.

"In the middle of difficulty lies opportunity"

In-can milk transport

- Alternatively, such milk may be filled in cans and transported in milk cans. This has, the advantage that a farmer's can of POOR quality milk will not be mixed with other farmers' GOOD quality milk and spoil the lot!
- Since the cans are not insulated, the transport to the factory must be efficient enough to enable milk reach the factory in acceptable condition.

Shedwin Dairy Cownsultants

14.

"In the middle of difficulty lies opportunity"

- In the case of farmers delivering milk via pick-up (collection) points it is advisable that the milk cans are placed in a shaded area while awaiting pick-up by a milk transport vehicle.

15.

"In the middle of difficulty lies opportunity"

Provision of shade at pick up-points is important

16.

"In the middle of difficulty lies opportunity"

- Bad milk will be rejected at the dairy plant.
- The farmer will lose money, the milk transporter may lose money if the fault is his.
- The nation will suffer because its people will not have the high quality food.
- To avoid all these bad things happening, hygienic milk handling is essential at each stage; the FARM, COOLING CENTRE AND DURING TRANSPORT.

17.	All microorganisms require water but the amount necessary for growth varies between species. "In the middle of difficulty lies opportunity" • Milk has a pH of 6.6 which is ideal for the growth of many microorganisms. • The water activity of fluid milk is approximately 0.98 aw. • Physical barriers such as skin, rinds, feathers, etc. have provided protection to plants and animals against the invasion of microorganisms Shedwin Dairy Cownsultants	18.	"In the middle of difficulty lies opportunity" Cont. • Further infection of the milk by microorganisms can take place during milking, handling, storage, and other pre-processing activities. • Lactic acid bacteria: this group of bacteria is able to ferment lactose to lactic acid. • They are normally present in the milk Shedwin Dairy Cownsultants
19.	Significance of microorganisms in milk: "In the middle of difficulty lies opportunity" • Information on the microbial content of milk can be used to judge its sanitary quality and the conditions of production • If permitted to multiply, bacteria in milk can cause spoilage of the product • Milk is potentially susceptible to contamination with pathogenic microorganisms. • Precautions must be taken to minimize this possibility and to destroy pathogens that may gain entrance. Shedwin Dairy Cownsultants	20.	"In the middle of difficulty lies opportunity" Cont. • Certain microorganisms produce chemical changes that are desirable in the production of dairy products such as cheese, yogurt. Shedwin Dairy Cownsultants
21.	Spoilage Microorganisms in Milk "In the middle of difficulty lies opportunity" • The microbial quality of raw milk is crucial for the production of quality dairy foods. • Spoilage is a term used to describe the deterioration of a foods' texture, colour, odour or flavour to the point where it is unappetizing or unsuitable for human consumption. Shedwin Dairy Cownsultants	22.	Pathogenic Microorganisms in Milk "In the middle of difficulty lies opportunity" • Hygienic milk production practices, proper handling and storage of milk, and mandatory pasteurization can decrease the threat of milk-borne diseases such as tuberculosis, brucellosis, and typhoid fever. • There have been a number of food-borne illnesses resulting from the ingestion of raw milk, or dairy products made with milk that was not properly pasteurized or was poorly handled causing post-processing contamination. Shedwin Dairy Cownsultants
23.	"In the middle of difficulty lies opportunity" • Improving product quality and assuring consumer health is important for milk and dairy producers, in all phases of the production chain, from the livestock diet to the quality control of the finished product. Shedwin Dairy Cownsultants	24.	 Shedwin Dairy Cownsultants

25.		26.	
27.		28.	
29.		30.	
31.			

Day 3

Farm visit

The participants visited *Feska Dairy* farm (Pictures below) on the 3rd day before departure. Trainees were able to see underground silage, housing structure for the zero-grazed animals. Further, the traits of good dairy cow that were taught the previous day were demonstrated by the live animals, including alcohol test for milk adulteration. A demonstration on treatment of hay with yeast before feeding for improved digestibility was also done.






Way forward

Trainees were provided with all the training materials that were covered by different presenters to enable them undertake subsequent trainings adequately. IFDC to follow-up and get reports on the secondary trainings implemented, including any challenges and/or recommendations.

Five ABC clusters were identified, model farms proposed and a visit by Shedwin Agribusiness to the model farms to verify factors of eligibility. These farms will host fodder demos to include; Sorghum, Lupin, vetch, Lucerne, which will be established before December, 2016

Field-day would be conducted when the demo fodders are at prime stage, further there would be an educational exchange visit possibly to farmer groups in Nyahururu

One biogas demo-would be established before the end of the year (2016)

Reference

Agricultural Sector Development Support program –ASDSP (2013). Government of Kenya (GoK) http://asdsp.fastlinksystem.com/

(i) Forage seed- linkage workshop- KAGURU ATC NKUBU, Meru County

REPORT ON SEED LINKAGE WORKSHOP HELD AT MERU 25-27TH MAY 2017

Report by

Solomon Mwendia and David Njenga

Introduction

The objective of the workshop was to link farmer group leaders to sources of forage seeds. One of the major problem that has been highlighted and contributing to low livestock productivity is lack of forage seeds and planting materials. To contribute towards addressing this, seed companies and animal production experts were invited to the workshop to share with the farm farmer leaders on formation on the same. Previously, farmers have also cited lack of capital as a major impediment and financial institutions were also invited to share information and borrowing opportunities that may be existing at the disposal of the farmers. The famer leaders were expected to train other farmers they lead in their groups.

Training

Various topics were covers by invited resource people as stipulated in Table 1, touching on livestock production, forages and agronomy requirements, and forage seeds available and their sources. The thrust of the workshop was on linking farmers to forage seed sources and the following section puts emphasis on this, presented by Advantage Crops Limited and Advata Limited

Table 1. Topics covered and resource persons involved

Topic	Institution	Resource person
Brachiaria grass farming and conservation	Advantage Crops Limited	Solomon Mwendia on behalf of Dr. Charles Wasonga
Fodder management- weeds, pests and fertilizer application	Osho Chemicals	Kiogora
Financing commercial fodder production and Agro-input dealers	Equity Bank	Karani
Dairy supplementation and Animal Health	Osho Chemicals	Dr. Kimathi
Soil testing and soil correction	Soil care Meru farmers Centre	Dennis
Fodder training- land preparation, soil testing, fodder management	CIAT	Solomon Mwendia
Nutrifeed and Sugar graze	Advanta limited	Subra
Digital Cow Technology	Farming Tech Solutions limited	Wanjiku

Advantage Crops Limited

It is a new company based in Homabay, in Kenya. Currently dealing with forages seeds only and specifically *Bachiaria* Hybrids namely; Mulato II, Cobra and Cayman. The lines have been

cleared by plant health inspectorate service in Kenya and are allowed in Kenyan market. The company has been granted rights to trade on behalf of Tropical Seeds, a company based in Brazil, where a big industry on forage seeds exist.

Mulato II

Mulato II is Brachiaria hybrid cv CIAT 36087. Mulato II is a three-way hybrid (*Brachiaria ruziziensis* x *B. decumbens* x *B. brizantha*). Mulato II is the result of three generations of crosses by Grupo Papalotla in 2004. It is an apomictic hybrid that is genetically stable and screening carried out by CIAT's tropical forages project. Mulato II was developed at CIAT in Colombia from an original *B. ruziziensis* x *B. decumbens* cross, followed by 2 generations of hybridization by open exposure to *B. brizantha* pollen in the field and was commercially released and does not segregate or divide from one generation to the next.

Morphology: Mulato II is a leafy, vigorous, semi-decumbent perennial grass of medium height, growing to between 80-100 cm without inflorescences. It is a very leafy plant, with 5-8, long (40-60 cm), broad (8-7mm) leaves per stem. The intense green leaves are strongly pubescent on both sides of the leaves. Pubescence on the cylindrical stems is weak.

It is a unique perennial grass to improve beef and milk production in tropical and subtropical regions. It is recommended for regions with acid soils of medium and low fertility, prolonged periods of drought, high temperatures.

Main characteristics:

- More meat and more milk with improved quality
- Higher stocking rates
- Highly palatable
- Tillered, with semi-decumbent growth
- Resistant to diseases and pests (spittlebug)
- Greater tolerance to drought and heat stress

Characteristics	
Common name	Mulato grass
Scientific name	Brachiaria hybrid cv. CIAT 36087 (*B. ruziziensis* x *B. decumbens* x *B. brizantha*)
Growth habit	Tillered, semi-decumbent
Palatability	High
Digestibility	High
Protein potential	Up to 17%
Tolerance to waterlogging	High
Tolerance to drought	High
Planting density	5–10 kg/ha; zero tillage
Days to first grazing/cut after germination	60–90 days on average
Time in rotation	25–30 days
Maximum height for animals to exit the paddock	30 cm
Soil fertility requirement	Intermediate to high
Adaptation in m above sea level	0–1200 m above sea level
Adaptability to soils with acid pH	High
Resistance to spittlebug attack	High
Uses	Grazing, hay, fresh in feeding trough; its quality and production also make it adequate for use as silage

Cayman

Cayman is another Brachiaria hybrid variety (CIAT BR02/1752) and is a unique perennial grass to improve beef and milk production in tropical and subtropical regions. It is Apomictic clone BR02/1752 resulted from the crossbreeding of the species *B. ruziziensis*, *B. brizantha* and *B. decumbens*.

Cayman has a tillered growth habit and produces abundant stolons. Additionally, under high moisture conditions, this variety modifies its growth habit and develops, early during its growth cycle, a large number of decumbent stems, which produce tillers and roots at the nodes, a characteristic similar to that of *Brachiaria humidicola*. These superficial roots give the plant support, absorb nutrients, and supply oxygen to the plant in these adverse conditions of poor drainage.

Unique characteristics

- It is an apomictic hybrid
- It is drought tolerant
- It has a high persistence and has been shown to maintain over 85% soil cover even four years after establishment.
- It has a high regrowth capacity.
- It produces high biomass (fodder). In one study it was documented to have produced up to 15 tons of fodder per hectare every ten weeks during the rainy season. This also underscores its high regrowth capacity.
- It has a high tolerance to flooding conditions, a characteristic that is only rivaled by *Brachiaria humidicola*
- Produces fodder that is high in nutritional quality

Establishment: Similar to that of Mulato II

CHARACTERISTICS	
Commercial name	Cayman grass
Scientific name	Brachiaria hybrid cv. CIAT BR-02/1752
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Palatability	High
Digestibility	High
Protein potential	Up to 17%
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Days to first grazing/cut after germination	60–100 days on average
Time in rotation	25–30 days
Maximum height for animals to exit the paddock	30 cm
Soil fertility requirement	Intermediate to high
Adaptation in m above sea level	0–1200 m above sea level
Adaptability to soils with acid pH	High
Resistance to spittlebug attack	High
Uses	Grazing, hay, fresh in feeding trough; its quality and production also make it adequate for use as silage

- Establishment: Can be either planted in rows, 40-50 cm apart, or broadcast sown at 10-12 kg/ha. For drilling the seed through seed drills, be very careful not to bury the seed more than 2 cm in depth. Roller drills are preferred because they do not bury the seed too deeply, but instead press the seed just below the soil surface. For broadcast sowings, seed can be spread mechanically or hand sown. The seed must be covered after sowing by harrows. On small areas, tree branches or large brooms can be used to lightly cover the seeds with soil. Be careful not to bury the seed no more than 1-2 cm under the soil. Mulato II seed is acid scarified to give seed high viability (90%+), high germination (80%+) and high purity (98-99%). This good quality ensures rapid establishment of pastures.

- To maximize DM production, Mulato II grows better on medium to high fertility soils. Annual fertilizer applications of between 250-300 kg/ha of NPK fertilizer are recommended. Mulato II will also grow well on low fertility soils but with lower levels of production. Higher and more frequent fertilizer applications are necessary on low fertility acid soils.

- Grazing and cutting management: Can be either rotationally grazed or set stocked. Management depends on the farmer's experience. However, because of its superior forage quality and excellent forage production, Mulato II is very suitable for intensive rotational management. Mulato II is a sturdy and robust plant that tolerates trampling and has a rapid recovery rate following grazing. During the wet season, 30-40 day rest periods between grazings are recommended depending on soils and fertilization. During the dry season, without irrigation, longer rest periods of 50-60 days are recommended. Some farmers especially smallholders in East Africa and Southeast Asia prefer cut-and-carry, feeding their cattle in stalls. Cutting to about 5 cm above ground level every 40-45 days in the wet season and 60-70 days in the dry season is recommended. On good soils with fertilizer applied, quicker recovery periods between grazings (25-30 days in the wet season) and more frequent cutting can be practiced. Mulato II is very suitable as a high quality forage to make hay and silage.

Currently seeds of Mulato II, Cobra and Cayman are available from Advanatge Crops and upon request they can be sent to the client

Brachiaria hybrid grass varieties (Mulato II, Cayman and Cobra)

1) Planting, management and utilization instructions

Land preparation

- Clear the land during dry season. Plough and harrow land to a fine tilth before the onset of the rains

Planting

- This can be done in through direct planting through seeds or through seedlings raised in a nursery bed. In both cases the seed should be sourced well in advance of the planting season.
- If planning to establish from seedlings, source the seed well in advance of the planting season. Prepare to a fine tilth a nursery bed. Apply organic manure (farmyard or compost) to the nursery bed and mix well with the soil. Inorganic fertilizer such as DAP or TSP can also be applied by broadcasting at a rate of 200kg/ha (approx. 0.18kg for 9 m2). Mix the fertilizer or manure with the soil using a rake. Broadcast the seed uniformly over the bed and cover by brushing soil over the using a rake or tree branches. Water the nursery area if there is no rain. Weed if necessary. At about 4-5 weeks of age seedlings are usually large and strong and can be uprooted for transplanting
- For direct planting or transplanting into the field mark the rows at 60cm apart (inter row spacing) using strings and pegs.
- Make holes 30cm apart within the rows along the string. When establishing directly from seed make holes that are 2 cm deep using a stick.
- Apply DAP or NPK fertilizer at the rate of 200 kg/ha (one teaspoonful per hole) or decomposed FYM in each hole and mix well with the soil.
- Plant Mulato II seeds in each hole at the rate of 4-5 seeds per hole (pinch using two finger tips). If establishing from seed, do not place seed at more than 3/4 of an inch (2cm) in depth to avoid problems of low seedling emergence. Thin and leave only 2-3 plants per hill 3-4 weeks after emergence.
- If transplanting seedlings, plant 2-3 seedlings per hole and trim off the leaves at the top.

Management of field plot

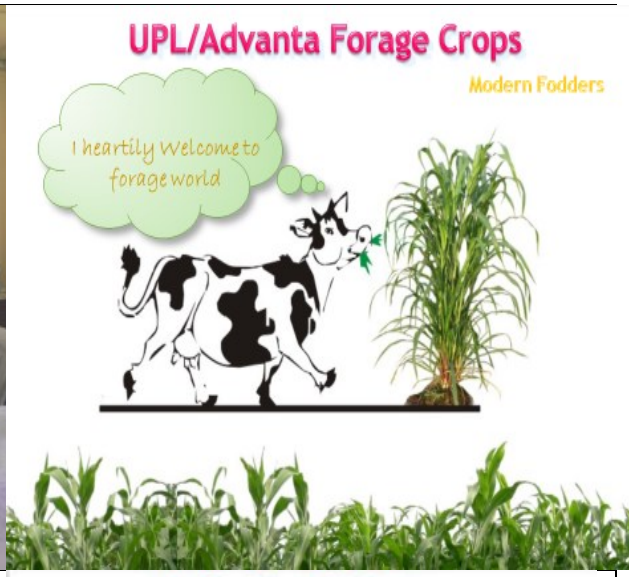
- For hills with missing plants, fill gaps by reseeding or using seedlings thinned from the other hills.
- The plot should be kept weed free. Early weeding is preferred for the farmer to get good harvest

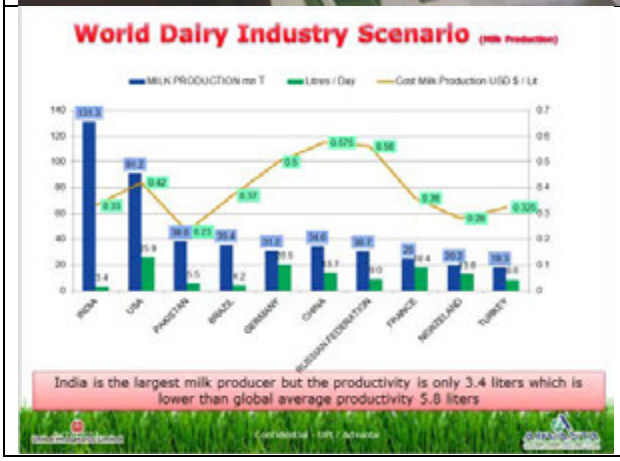
Harvesting and utilization

- Mulato II has high growth vigor and will establish with than 80% coverage at 2-3 months after planting.
- Mulato II can be first cut and utilized as livestock at about 60-70 days (8-10 weeks) after transplanting or when the plants reach about 60-80 cm in height. To harvest for livestock feed, cut the forage down at 5-10 cm above the ground. It may advisable to cut and carry the forage to the livestock feeding area for the zero grazing system otherwise direct grazing can also be done
- After the first cut, Mulato II can be cut/harvested every 40-45 days during the wet season and every 60-80 days during the dry season. To maximize regrowth apply organic manure or nitrogenous inorganic fertilizer after every harvest.

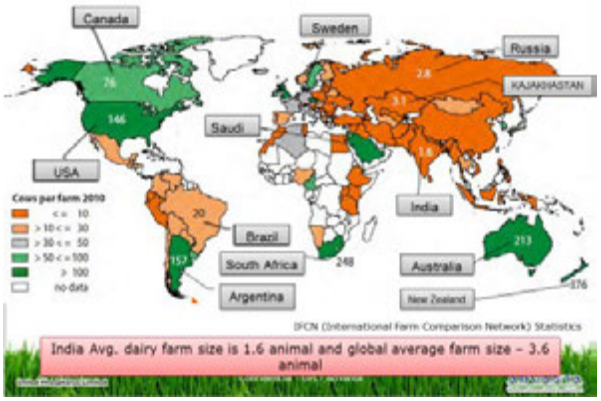
Advanta

Forage Crops





Global Dairy Farm sizes



India Avg. dairy farm size is 1.6 animal and global average farm size – 3.6 animal

Dairy Industry in Kenya

Dairy Industry in Kenya

Status - 2014-15

- No. 32 in the world milk production - 4.4 mill Tons
- No. of Dairy farms - 1690002 (1.7 mio)
- Milk Price: -23% to world market
- Feed Price: +8% to world market

Key development over past 5 Years

- Milk Production Growth: +7.4%
- Farm number: +1% per year
- Big change in 2009-10 with 30% growth in milk production
- Every Year 3% CAGR in milk production
- Milk price and Feed prices still no change

Source - IFCN

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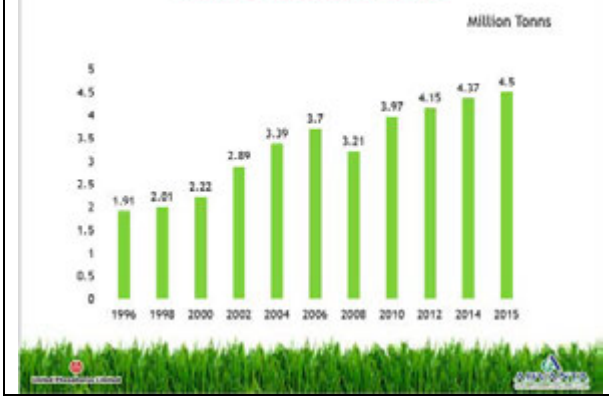
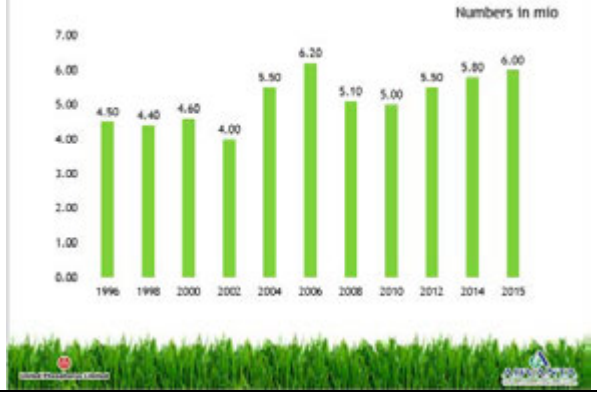
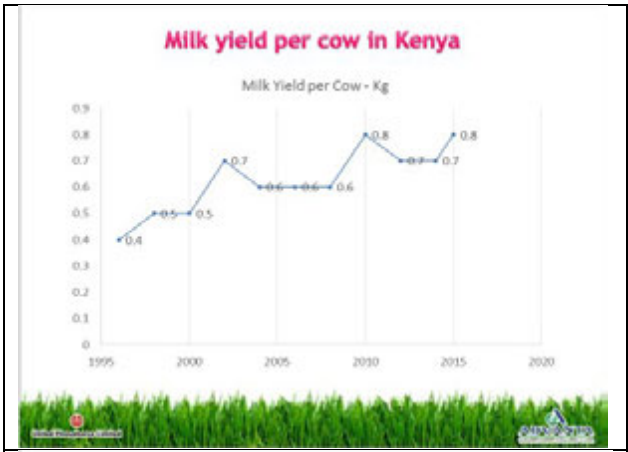
Source - IFCN

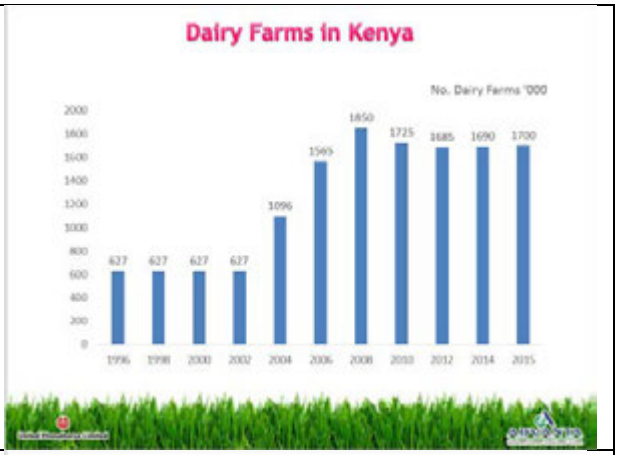
Milk Production in Kenya

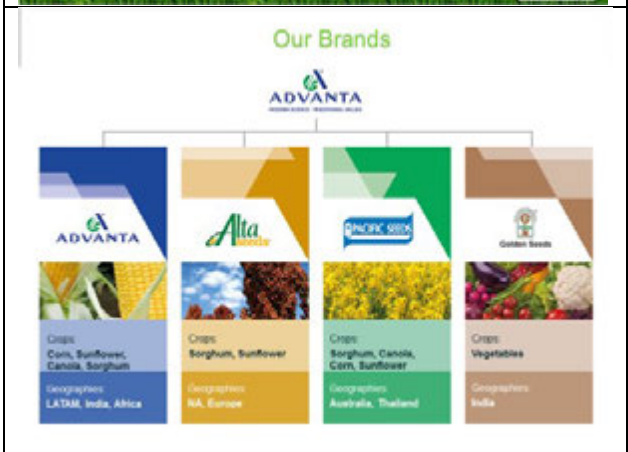


Cow population in Kenya



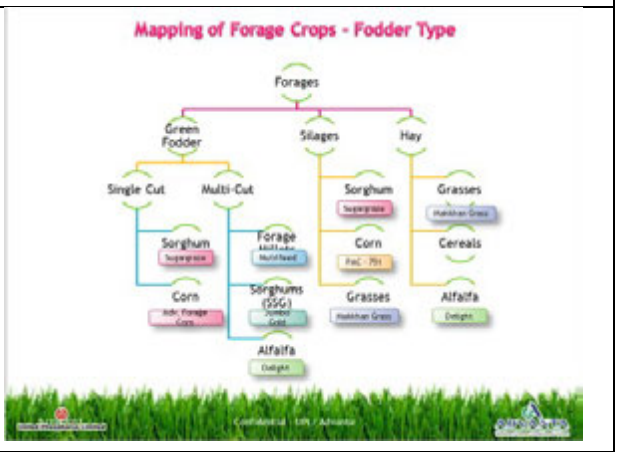

Milk yield per cow in Kenya
Milk Yield per Cow - Kg
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.4
0.5
0.5
0.7
0.6
0.6
0.6
0.8
0.7
0.7
0.8
1995
2000
2005
2010
2015
2020

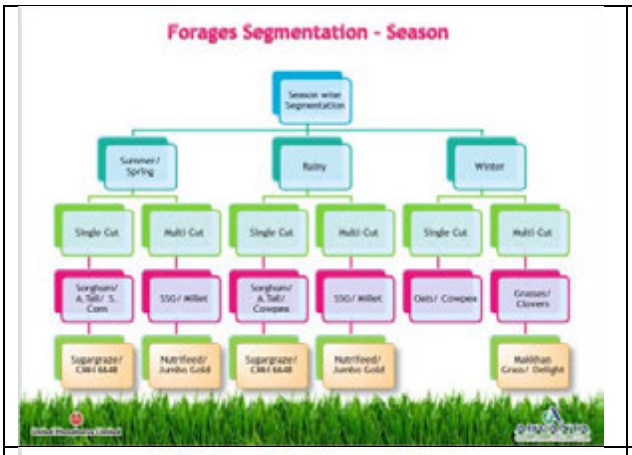

Dairy Farms in Kenya
No. Dairy Farms '000
2000
1800
1600
1400
1200
1000
800
600
400
200
0
627
627
627
627
1096
1593
1850
1725
1685
1690
1700
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2015


Our Brands
ADVANTA
ADVANTA
Alta
PACIFIC SEEDS
Golden Seeds
Crops
Corn, Sunflower, Canola, Sorghum
Geographies
LATAM, India, Africa
Crops
Sorghum, Sunflower
Geographies
NA, Europe
Crops
Sorghum, Canola, Corn, Sunflower
Geographies
Australia, Thailand
Crops
Vegetables
Geographies
India

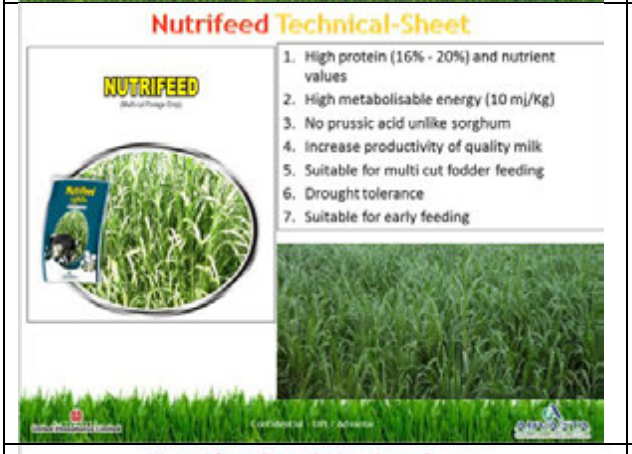

Animal Feeding Solutions by ADVANTA

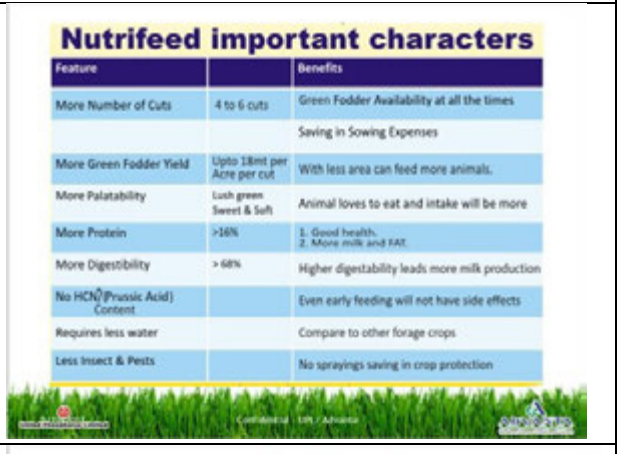

Benefits from good Forages
Milk Production
Milk Productivity
Lactation Days
Reduced milk prod. Cost
Reduced concentrate Expenses
Timely Calving, Reduced dry period
Healthy – Reduced Methane Emission

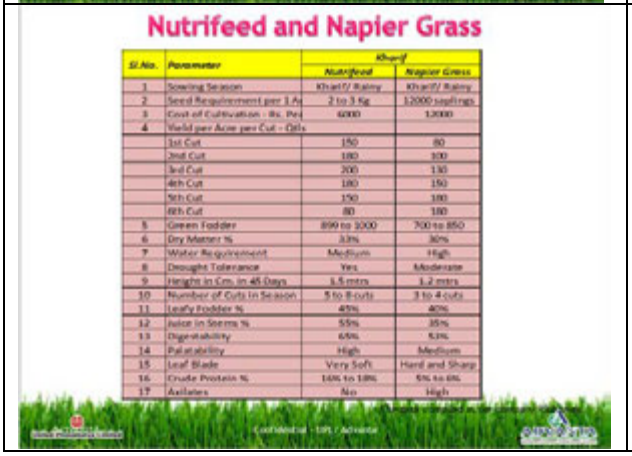

Mapping of Forage Crops - Fodder Type
Forages
Green Fodder
Silages
Hay
Single Cut
Multi-Cut
Sorghum
Grasses
Forage
Corn
Cereals
Sorghum
Corn
Sorghums (SSG)
Grasses
Alfalfa
Alfalfa

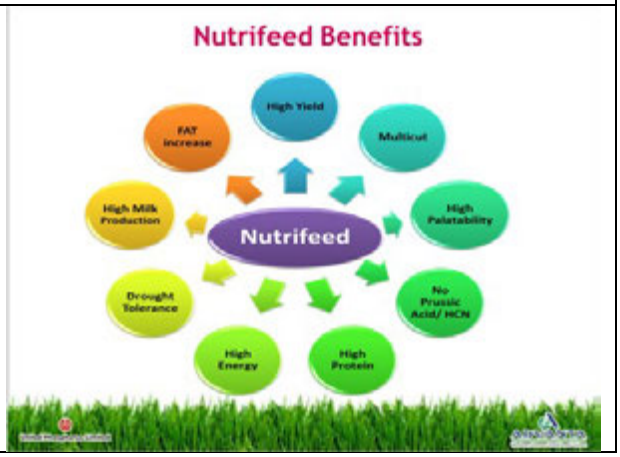

Forages Segmentation - Season
Season wise Segmentation
Summer/ Spring
Rainy
Winter
Single Cut
Multi Cut
Single Cut
Multi Cut
Single Cut
Multi Cut
Sorghum/ A. Tall/ S. Corn
SSG/ Millet
Sorghum/ A. Tall/ Cowpea
SSG/ Millet
Oats/ Cowpea
Grasses/ Clovers
Sugargraze/ CMH 6648
Nutrifeed/ Jumbo Gold
Sugargraze/ CMH 6648
Nutrifeed/ Jumbo Gold
Makhan Grass/ Delight


UPL/ Advanta Forage Crops
A high nutritional and high yield hybrids
CMH 6648


Nutrifeed Technical-Sheet
NUTRIFEED
1. High protein (16% - 20%) and nutrient values
2. High metabolisable energy (10 mj/Kg)
3. No prussic acid unlike sorghum
4. Increase productivity of quality milk
5. Suitable for multi cut fodder feeding
6. Drought tolerance
7. Suitable for early feeding


Nutrifeed important characters
Feature
Benefits
More Number of Cuts
4 to 6 cuts
Green Fodder Availability at all the times
Saving in Sowing Expenses
More Green Fodder Yield
Upto 18mt per Acre per cut
With less area can feed more animals.
More Palatability
Lush green Sweet & Soft
Animal loves to eat and intake will be more
More Protein
>16%
1. Good health. 2. More milk and FAT.
More Digestibility
> 68%
Higher digestability leads more milk production
No HCN (Prussic Acid) Content
Even early feeding will not have side effects
Requires less water
Compare to other forage crops
Less Insect & Pests
No sprayings saving in crop protection


Nutrifeed and Napier Grass
Sl.No.
Parameter
Kharif
Nutrifeed
Napier Grass
1 Sowing Season Kharif/ Rainy Kharif/ Rainy
2 Seed Requirement per 1 Ac 2 to 3 Kg 12000 saplings
3 Cost of Cultivation - Rs. Per 6000 12000
4 Yield per Acre per Cut - Qtls
1st Cut 150 80
2nd Cut 180 100
3rd Cut 200 130
4th Cut 180 150
5th Cut 150 180
6th Cut 80 180
5 Green Fodder 890 to 1000 700 to 850
6 Dry Matter % 33% 30%
7 Water Requirement Medium High
8 Drought Tolerance Yes Moderate
9 Height in Cm. in 45 Days 1.5 mtrs 1.2 mtrs
10 Number of Cuts in Season 5 to 8 cuts 3 to 4 cuts
11 Leafy Fodder % 45% 40%
12 Juice in Stems % 55% 35%
13 Digestability 65% 53%
14 Palatability High Medium
15 Leaf Blade Very Soft Hard and Sharp
16 Crude Protein % 16% to 18% 5% to 6%
17 Axillaries No High


Nutrifeed Benefits
Nutrifeed
High Yield
Multicut
High Palatability
No Prussic Acid/ HCN
High Protein
High Energy
Drought Tolerance
High Milk Production
FAT Increase

Sugargraze

1. 2 cut Sweet Stem Jowar Crop
2. Brix 16% to 18%
3. Soft Stems with soft internodes
4. Suitable for silage and Hey Making
5. Drought tolerance
6. 2.5 mts height with no lodging
7. Highest yield capable up to 100 Mt per hector

Fodder Quality in Sugargraze

Sugargraze 'Silage' Vs Corn Silage

Yields

- High fodder yield than corn
  - Green Fodder - Dry Fodder
- Productive even on marginal soils
  - Good performance in light soils & low fertility soils
- Stress tolerance
  - Heat & Drought & Salinity
- High yields on less water
  - Yields similar to corn with 30%-50% less water
  - Yields of 1.75 to 2.5 tons of biomass per inch of water Vs. corn yields of 1 ton per inch of water
  - Lower energy & water pumping costs
- Versatility for multiple harvests
  - Green Fodder - Hay - Graze
- Economics
  - Lower fertilizer use than corn, especially N
  - Efficient water use
- Silage
  - No need of mixing Jaggery/ Molasses

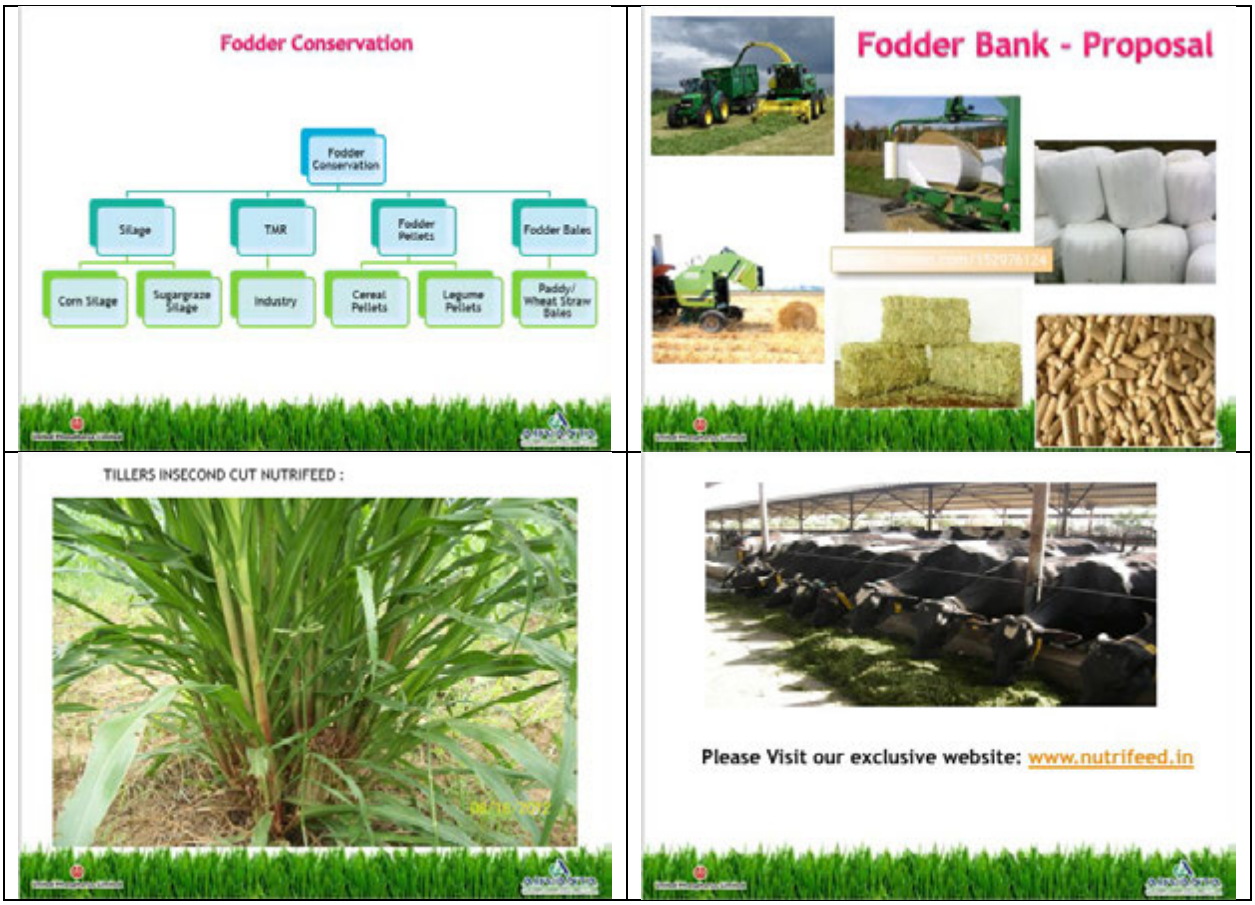
Jumbo Gold

1. 4 to 5 Cuts with 50 Days interval
2. High leafy fodder
3. Soft Stems with soft internodes
4. Drought tolerance and high adoptability
5. Minimum height with good standability
6. Highest yield capable up to 70 Mt per hector

Delight - new gen. Lucerne

- Delight is a perennial Lucerne F1
- Delight is very good in dry matter
- Delight is good in palatability
- Delight is good in Digestibility
- Delight is good in all nutritive values
- 6 Kg seed rate - very good tillers
- Stem rot resistant.

Advanta activities in Kenya



Advanta has the two forages undergoing National Performance Trials (NPT) supervised by Kenya Plant Health Inspectorate Service and in the second and final year. Seeds will be available in the market once the release is gazetted. The grasses could do well in many areas even at high altitudes except that they are not cold and frost tolerant.

DigiCow Dairy Application

While keeping records by farmers has been very poor, smart ways to assist the farmers on the same are coming to the light and in this case by Digi Cow as presented below

Benefits to farmers

Progress Update

- Launched in **Feb 2017** in Githunguri Kiambu County
- Over **500 farmers** have downloaded the app
- 15% of the farmers are active
- Continuous upgrade to the app

Challenges faced so far

- Farmers don't have smartphones but very interested in the app- working on a partnership with dairy cooperative offer smart phone loans and Samsung supply the phones
- Farmers too busy to enter data - we are simplifying the app further to make it easy for farmers to enter data and enabling farm hand to enter data
- Need for personalized training which is expensive-Development of innovative ways such as tutorials.

Areas of collaboration

- Awareness Creation
- Financing through check off
- Communication to farmers through the platform

Fodder training (land Preparation, Soil testing and fodder management)

CIAT International Center for Tropical Agriculture

Topic: *Forage growing and feeding*

Training of trainers

April, 2017

Meru, Kenya

Solomon Mwendia

Outline

- Introduction and background
- Feed categories
  - Roughages (Basal diet)
  - Supplementary
- Examples (Roughage + supplementary)
  - Establishment and agronomy
- Fodder conservation
  - Feeding – dry matter concept

Introduction and background

- *The Cost of Feeding Dairy Animals*
  - Livestock feed is the highest cost for most dairy farmers.
- To increase income farmers either;
  - Sell more milk
  - Obtain a higher price per litre of milk or
  - Reduce their costs for cattle, feed and other expenses

Approaches

- *Maximum Production*
  - Buy large amounts of feed and concentrates at market
  - effective if the price of milk

- *Least Cost*
  - feed on naturally occurring pasture, crop residues
  - not always plentiful and usually not very nutritious

Growing Forages

- One cost-effective approach for feeding dairy cattle is cultivating forage crops on your farm.

✓ Roughages (grasses)
- source of energy
- contain only low or medium levels of protein

✓ Supplementary (Legumes)
- greater amounts of protein and other nutrients

Especially for lactating and pregnant cows and growing calves

Climate Zone	Grasses	Legumes
Semi-Arid Semi-Arid land typically has an **elevation of 1000 to 1800 metres** and receives **less than 650 millimetres of rainfall** each year.	Cenchrus ciliaris Eragrostis superba, Enteropogon macrostachyus	Lablab purpureus
Warm, Wet, Medium Altitude This includes areas with an **elevation of 1200 to 1850 metres** that receive **1000 to 2500 millimetres of rainfall** each year.	Oats Rhodes Grass	Callandra Desmodium Leucaena
Cool, Wet, Medium Altitude This would include areas with an **elevation of 1850 to 2400 metres** that receive **1000 to 2500 millimetres of rainfall** each year.	Napier Grass Oats Rhodes Grass Signal Grass Sweet Potato (Dual Use)	Desmodium Lucerne
Cold, Wet, High Altitude This would include areas with an **elevation of 2400 to 3000 metres** that receive **1000 to 2500 millimetres of rainfall** each year.	Oats Ryegrass	Vetch Lupin Lucerne

Climate zone	Areas in Kenya
Semi-arid	Northern Kenya, Parts of eastern
Warm, wet , medium altitude	Taita Hills, Meru, Embu, Kirinyanga, Muranga, Kiambu and Nyeri districts in eastern and central Kenya. In western Kenya, the region covers Bungoma, Kakamega, Busia, Siaya, Kisumu, Kisii and South Nyanza districts.
Cool wet medium altitude	Trans Nzoia, Nandi, Kericho, Kisii and Narok districts, Nyandarua, upper Kiambu, Nyeri, Kirinyanga, Muranga, Embu and Meru districts in Central Kenya
Cold, wet high altitude	Mau Narok in the Rift Valley, the upper Cherangani hills and upper Mt. Elgon in Western Kenya, and the upper Nyandarua, Nyeri, Kiambu, and Aberdare Range in Central Kenya

Land preparation

✓Land preparation

✓Well before start of rains

✓Plough/dig seedbed to a fine tilth

✓Harrow if necessary

Soil testing

Why test?

- Acidity and alkalinity
- Nutrient deficiency esp. P and N
- Most crops require neutral soils
- Nutrients may be there but if the soil is to acidic will not be available to the plants especially Phosphorus
- Take soils samples from your farm (20cm depth)- most roots in this region for crops

Remedy

- Liming
- Manure –ameliorate the soil pH

Table 1. Soil properties (0-20cm depth) at out trial sites in OljoroOrok.

Farmer group	Host farmer	pH	% Clay	% Sand	% Silt	% Total N	% Total C	Bray P mg/kg
Nyamaruru	Francis Mburu	5.0	34.8	31.9	33.3	0.32	3.6	16.2
Nyamaruru	Gilbert Gacheri	5.6	37.5	34.5	28.0	0.27	2.9	12.9
Hilltex	Peter Njihia	6.1	43.2	31.2	25.5	0.35	3.7	7.3
Kangoo	Peter Mwangi	5.2	42.1	35.9	22.0	0.19	2.1	8.3
Kangoo	James Karuga	5.4	47.7	34.3	18.0	0.18	2.1	2.6

Bray P levels
Very low <5
Low – (6 – 12)
Medium – (13 -25)
High - >25

Total N (%)
Very low < 0.05
Low (0.05 – 0.15)
Medium (0.15 – 0.25)
High (0.25 – 0.5)
Very high > 0.5

Planting -Example oat

- ✓Drill seeds in rows at 20cm apart and 3-6cm depth (100kg/ha i.e. 40kg/acre) or
- ✓Broadcast (Increase seed rate slightly 1.e. 10%)
  - ✓ Disadvantage- loose soil contact
- ✓Fertilizer rate -50 kg N/ha i.e. 216 kg of 23:23 :0 /ha (Approx. 100 kg/acre)

Weed control

- ✓Herbicide
- ✓Uproot weeds /weeding
- *Herbicide:*
  - *When the intended fodder crop is a grass e.g. oat, spray broadleaf*
  - *When intended fodder is broad leaf or pinnate- spray herbicide that kills grass-based weeds.*

Osho Chemicals

- ✓In case of minimum tillage- Could spray weeds once they die, then plant

Harvesting

- ✓Boot stage (first head appear in fodder field)
  - ✓ Quality of good (protein high approx. 20%)
- ✓Cut slightly (5cm) above the ground
- ✓A regrowth will occur (oat)
- ✓Hay making (150-200 bales/acre)

Rye grass and festulolium

- Land preparation applies
- Ideal for cold and tolerant to frost
- *Seed rate* 20 kg/ha or 8kg/acre
- 90 kg N/ha or 36 kg N/acre at planting
- Broadcasting applicable
- DM t/ha yield
  - ryegrass 14.7–18.0
  - Festulolium14.3–20.2
- CP (16.3–19.0%),
- Could be grazed directly

Sorghum E6518

- Seed rate: 8kg/acre, spacing: 75 cm x drill
- Soils: Medium fertile soils
- High yielding, drought resistant crop good for silage making.
- Propagation: By use of seeds.
- Planting: Fine soil tilth is best for seed drilling. Use planting fertilizer at the rate of 50 kg per acre. Thin plants when 15 cm high to 10 cm intra plant.
- Maturity: 7 - 8 months (dough stage) for silage making.
- Yields: 28-40 tons / per acre of silage material. Up to 3 ratoons (re-growths) are possible.
- Feeding: Ensiling destroys chemical subsistence present in fresh material which may cause death. DM 32, CP 9, CF 27

Vetch

- Land preparation applies
- Seed rate 20 kg/ha or
- Seed rate: 8 kg per acre in pure stand
- Drill in shallow (3-6cm) furrows 30 -45cm apart
- Weed by uprooting or use pre-emergence herbicide for grass-based weeds before panting

Vetch

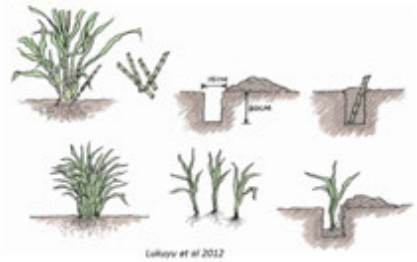
- Will be ready for feeding or hay making at about in about 4 months
- For vetch leave a portion to harvest seeds- for planting
- Soils - Should be well drained and not acidic. Neutral of pH 6-7 is preferred.
- Feeding value: - CP 17-22, DM 89, CF 30
- Yields: Average hay yields is 150-300 bales/acre of pure vetch

Napier grass

- Most planted fodder crop in Kenya by small holder farmers in Kenya
- Does not perform well in cold and frost prone areas
- Can grow from sea level up to 2000 m
- Yield variable depending on management up to 40t/ha under irrigation.

Napier grass

- ✓ Can be established from canes or splits
- ✓ Spacing 1 x 1 m



Lukuyu et al 2012

Napier grass

- Fertilization- Use DAP (100 kg/acre) or manure at planting-depending on availability e.g. 2 spades/ hill
- Weeding- when necessary especially after harvesting
  - Don't heap soil at the base- leave soil uniformly spread
  - Intercropping with Desmodium reduce on weeding costs
- Manure application
  - Make small furrows between the Napier rows and burry manure. Why?

Napier harvesting

- With good rains can be harvested up to 3 times in a year
- Harvest at 3ft height or waist height
- Crude Protein- (8- 10%)
- Can be fed as green chop (Wilt) or conserved as silage.

Napier grass challenges- diseases

- Smut
  - Smut-1998 – has spread
  - Reduce harvestable yield
  - Infection spread- planting material, farm tools, manure-feeding infected material, Mechanically
  - Remedy- use tolerant cultivars: Kakamega I & II
- Stunt
  - Stunt 2004- Has spread
  - Reduce harvestable yield
  - Infection spread- insect vector (tiny hoppers)
  - Remedy- Use tolerant cultivar: Ouma and South Africa I and II

Utilization

- Feed the silage during dry season when you have fodder shortage.
- A grade cow could eat 30kg of silage per day
- Feed after milking or 3 hours before milking to ensure milk is not tainted.
- After removing the amount to feed always remember to tie the tube and place back the weight on top.

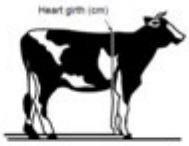
Feeding

✓A cow takes per day dry matter equivalent to 3% of its LWT

✓400 kg LWT cow will take 12 kg DM per day

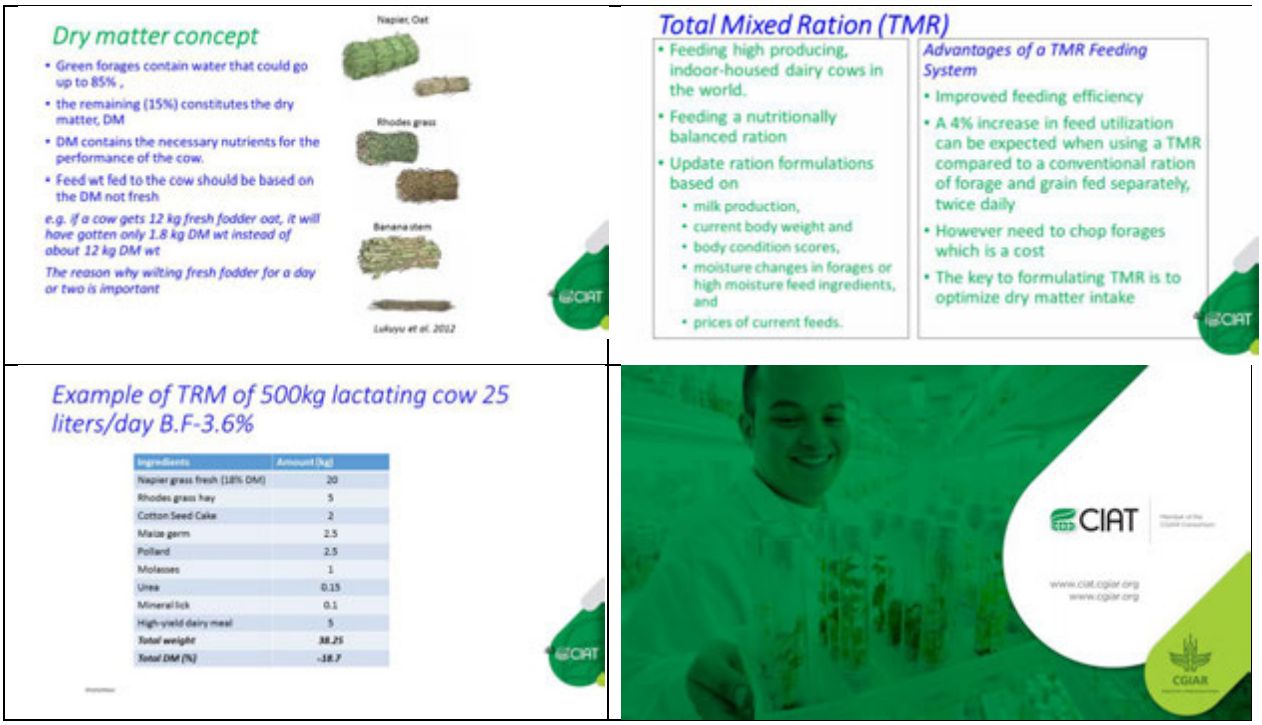
✓One bale of good quality weight about 15 should be enough/day as water content is about 15% thus DM is 12 kg

✓Bales can be counted and assist in fodder budgeting



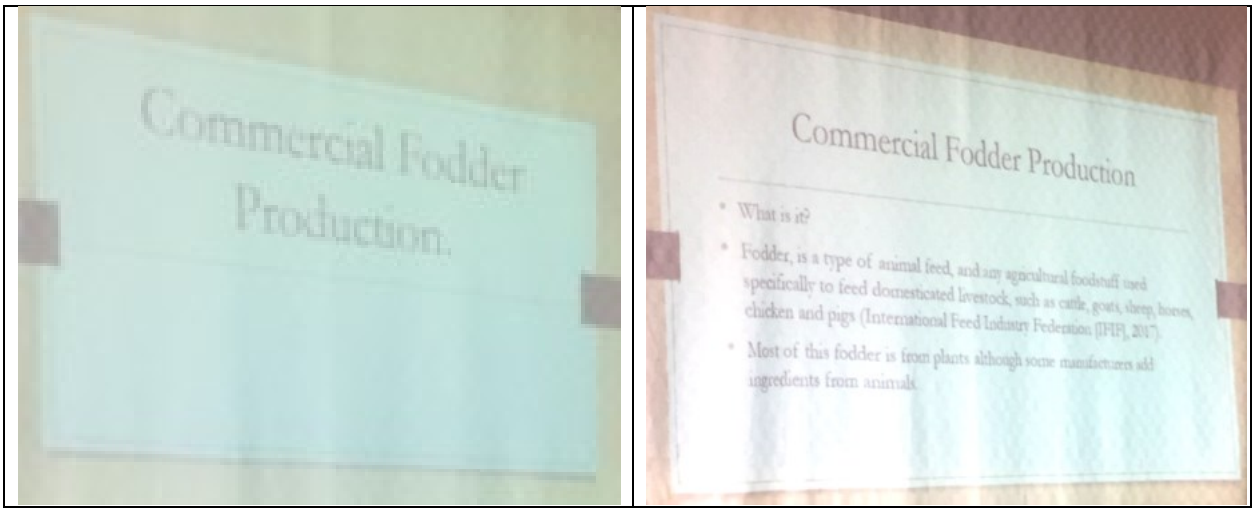
Heart girth (cm)	Live weight (kg)	Heart girth (cm)	Live weight (kg)	Heart girth (cm)	Live weight (kg)
168	392	175	443	182	500
169	399	176	451	183	508
170	406	177	459	184	516
171	413	178	467	185	525
172	420	179	475	186	534
173	427	180	483	187	543
174	435	181	491	188	552

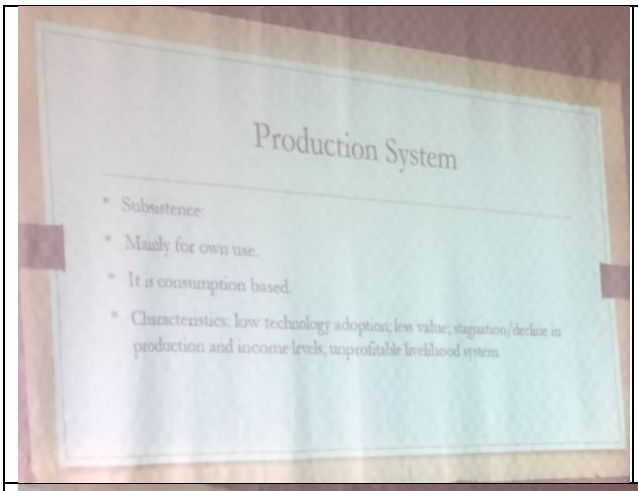
Lukuyu et al 2012

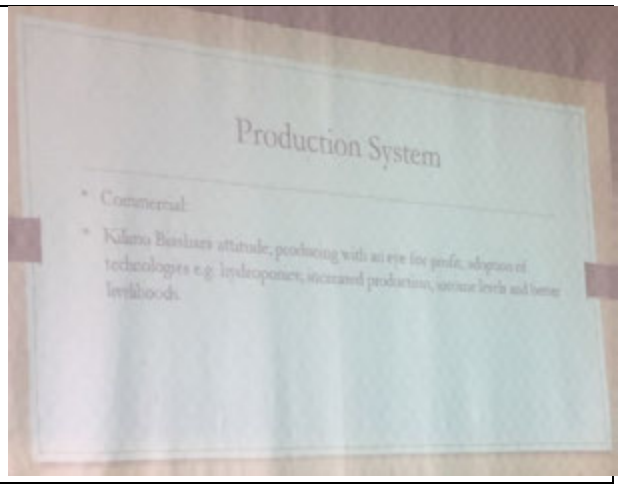


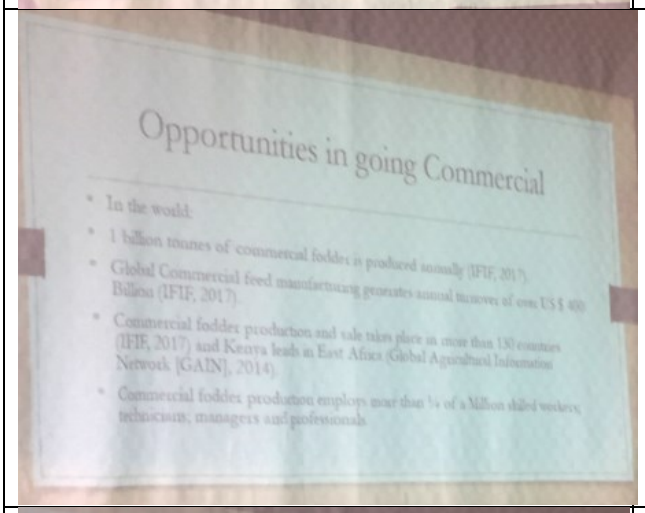
Equity Bank

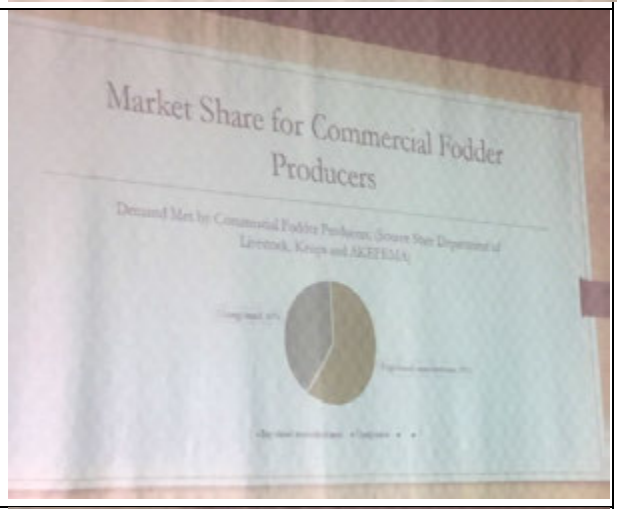
Delivered on importance of doing dairy and forages as a business and importance of banking money that would allow to borrow as bank transactions help evaluate borrowing strength.

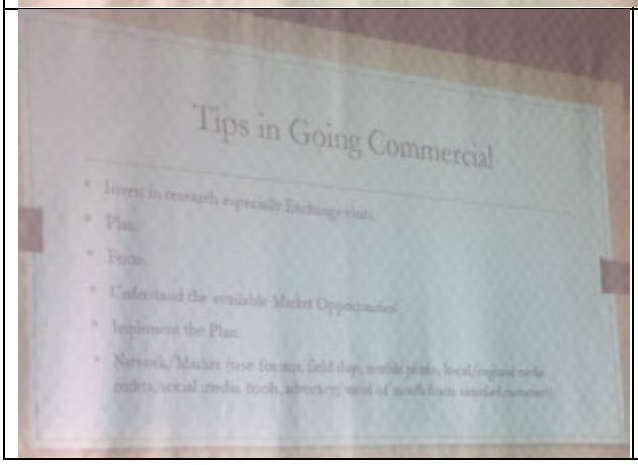


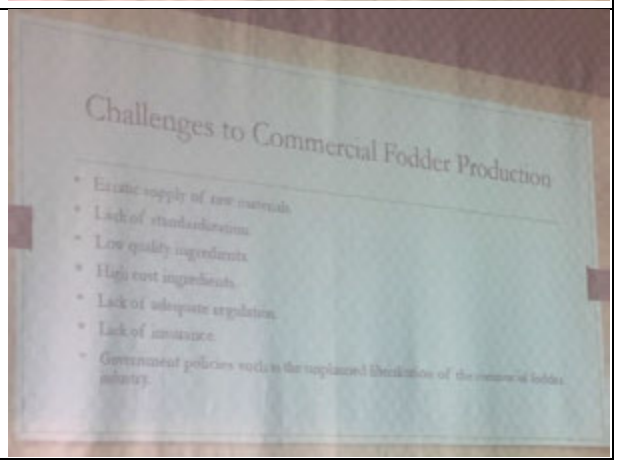

Production System
Subsistence:
Mainly for own use.
It is consumption based.
Characteristics: low technology adoption; less value; stagnation/decline in production and income levels; unprofitable livelihood system.

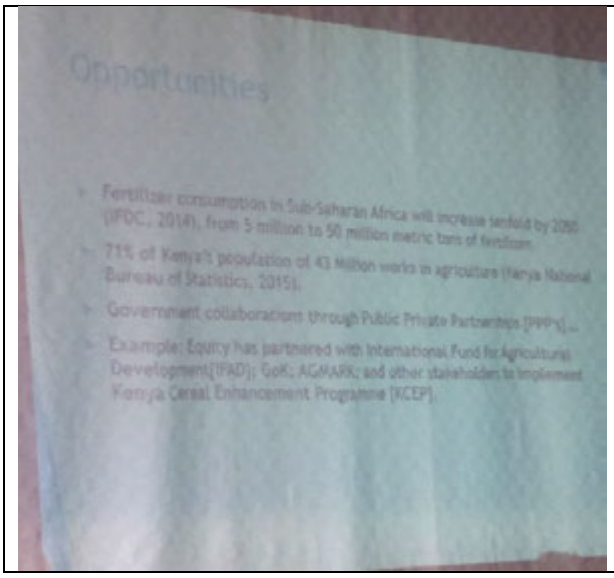

Production System
Commercial:
Kilatu Bieshara attitude; producing with an eye for profit, adoption of technologies e.g. hydroponics, increased production, income levels and better livelihoods.


Opportunities in going Commercial
In the world:
1 billion tonnes of commercial fodder is produced annually (IFIF, 2017).
Global Commercial feed manufacturing generates annual turnover of over US$ 400 Billion (IFIF, 2017).
Commercial fodder production and sale takes place in more than 130 countries (IFIF, 2017) and Kenya leads in East Africa (Global Agricultural Information Network [GAIN], 2014).
Commercial fodder production employs more than ¼ of a Million skilled workers, technicians, managers and professionals.


Market Share for Commercial Fodder Producers

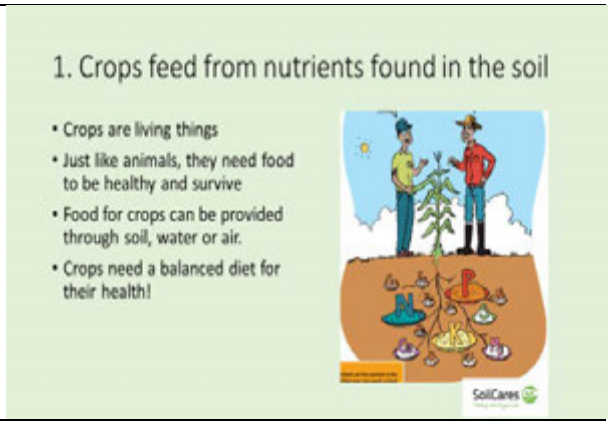

Tips in Going Commercial
Invest in research especially Exchange visits.
Plan.
Focus.
Understand the available Market Opportunities.
Implement the Plan.
Network/Market (use forums, field days, mobile phone, local/regional radio outlets, social media tools, advertisers, word of mouth from satisfied customers).


Challenges to Commercial Fodder Production
Erratic supply of raw materials
Lack of standardization
Low quality ingredients
High cost ingredients
Lack of adequate regulation
Lack of insurance
Government policies such as the unplanned liberalization of the commercial fodder industry.

	*Tips* Always maitain quality Ensure agro-inputs meets the need of the consumers Obey taxation law Attend knowledge and capacity building trainings Follow necesasary regulations

Soil Care

To understand what your soil requires in order to support the performance of your intended crop, it is important to know the nutrient status in your soil. Soil testing will establish what soil amendments are necessary including what fertilizer applications will be important. The trainers were taught of collecting representative soil samples for proper interpretation and recommendation. If for example a farmer has two separate land parcels, it is important to have two samples representative of each farm.



2. Every crop needs different types of food to be healthy

- Some require more for roots… root crops
- Some require more for fruit
- Some food is required for taste development, leaf formation
- Take time to ask what type of crops the farmers grow and those grown in the region. Also those they would wish to grow

SoilCares

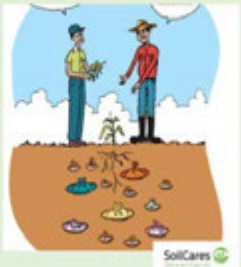
3. With every harvest, various foods are taken away from the soil

- Many farmers have been farming the same crop for years. This means that they have been removing certain foods from the soil year in, year out!

SoilCares

4. If the right type and amount of food is not replenished, your crop becomes weak

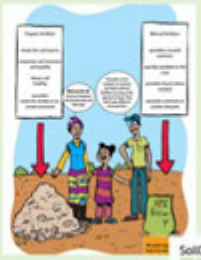
- Weak crops are susceptible to diseases and infection
- Other have only been adding one kind of food. This is ok ONLY if this food is what the crop requires and in the right amount required. Other things such as acidity are affected and change over time. It is therefore practically impossible to be sure you are giving the right food



SoilCares

5. The right fertilizers and organic matter provide the required food for your crop

- Emphasis should be on the right type of food. One can not guess what is in the soil and what is required.
- A soil test is important



SoilCares

6. A soil test helps you know the right amount and type of food for your crop

- Without a soil test, a farmer is guessing and leaving a lot to chance

SoilCares

Review and way forward

After consultations among the trainees, having forage demonstrations (4 grasses, 4 legumes) and in strategic farms representative of the areas was found acceptable. The trainers would use the same to train at least 60 farmers each on what they had learnt during the workshop. The target translates to about 3 trainings assuming each with a group of 20 farmers. It was also agreed the trainers will keep records of all the farmers trained including their contacts, against which, once presented to FESKA, reimbursement will be paid to the trainers to cater for expenses incurred during trainings. Training locations were agreed on the geographical spread in the area and the villages with their representative trainers are in Table 2.

Table 2. Location areas of training and trainers responsible

Area	*Trainers*
Mitunguu Upper	Mutembei
Abogita West	Purity Mugambi, Patrick Kimathi,
Abogita East	Jane, Miriam, Joyce
Nkuene	Maingi Purity, Murathe
Mitunguu Lower	Kirigia

Appendices

Program

ITINERARY

SEED LINKAGE WORKSHOP FOR

Extension Team, Agro dealers and Group Officials

VENUE: KAGURU ATC NKUBU.

Date: 2017 APRIL 25 to 27th

Time	Content	Responsible	Moderator	Resources
25th April 2017 (7:30am)	**Participants (ToTs, Extension team, Agro-dealers and group officials) check in @Kaguru ATC**			
Day 1:(25th) Session 1:	**Workshop introduction and Fodder training.**			
8:00-8:30	Registration,	Feska -		Registration sheet
8:30-9:00	Welcome, Introduction, Expectations 1. Participants 2. IFDC	David Njenga - IFDC	Dr. Solomon Mwendia	Laptop/LCD/ Flip chart
9:00-10:30	Fodder Training - Land Preparation, Soil testing, Fodder management	CIAT- Dr. Solomon Mwendia	David Njenga	Laptop/LCD
10:30-11:00	**Health break**	Feska		
Session 2:	**Commercial Fodder Training cont'**			

Time	Content	Responsible	Moderator	Resources
11:30– 12.30	Fodder management- Weed, Pest and Fertilizer application.	Osho Chemicals -	Patrick Boro	Agro Chemical samples / Laptop/LCD
12:30-1:30	**Lunch Time**	- Feska		
Session 3:		**Fodder management**		
1:30-2:30pm	Commercial fodder production and Agro-Input Business	Equity Bank- Karani	Patrick Boro	Flit chart / ppt /Laptop/LCD
2:30-3:30	Dairy supplementation and Animal Health	Osho Chemicals –	David Njenga	Agro Chemical samples/ Laptop/LCD
3:30-4:00	**Health break**	Frank - Feska		
4:00-4:30	Financing- Commercial fodder production and Agro-Input dealers	Equity Bank- Karani	Patrick Boro	Laptop/LCD
Day 2:(26th) **Session 1:**	**Certified Fodder Seeds and Fodder**			
8:00-8:30	Recap	Patrick Boro - IFDC	David	
8:30-9:30	Soil testing and soil correction	Dennis – Soil care Meru Farmers Centre	Solomon	Flip chart
9:30-11:00	Brachiaria Grass farming and Conservation	Charles- Advantage	Solomon	Seed Catalogue/ Laptop/LCD
11:00-11:30	**Health break**			
Session 2:				

Time	Content	Responsible	Moderator	Resources
11:30-1:00	Leguminous Seeds and Hybrid Sorghum	Kenya Seed	Patrick Boro	Seed Catalogue/ Laptop/LCD
1:00-2:00	**Lunch break**	David Njenga		
Session 3:				
2:00– 3.30	Nutrifeed and Sugar Graze	Advanta- Subra.	David	Laptop/LCD
3:30-4:00	**Health break**	Frank-Feska		
4:00-4:30	Digital Cow technology	Shiko- Farming Tech Solutions Ltd.	Patrick Boro	Laptop/LCD /Flip chart.
Day 3: **(27th Oct)**	**Review and planning.**			
7:00-8:00	Break fast	Frank - Feska		
8:30-11:00	Review of Dairy Activities- Feska	Patrick - IDFC	David	Flip chart.
11:00-11:30	**Health break**			
11:30-12:30	Way forward	David, Simon, Solomon	Patrick	Laptop/LCD /Flip chart.
12:30-14:00	Lunch and Departure	David.		

The list of attendance

2SCALE-Toward Sustainable Clusters in Agribusiness through Learning in Entrepreneurship

ATTENDANCE LIST

	ACTIVITY: FESKA SEED LINKAGE WORKSTHOP			DATE: 25th April 2017		VENUE: Kagumo ATC	
No.	NAME	Gender	Company/Group	POSITION	Email	Mobile	SIGN
1	FELIX MEME	F	IGOKI DAIRYSHG.	MEMBER		0723866462	
2	FRANCIS MAINGI	M	MIKUMBUNE	MEMBER		0720310626	
3	MARTIN MUGAMBI	M	MIKUMBUNE	MEMBER		0712761134	
4	MARY GUNTAI	F	NIBARAGA	MEMBER		0729037983	MGM
5	Honest malkena	F	MIKUMBI	member		0701 564718	
6	FLORENCE NGUGI	F	KAIRUNC-	member		07.0317286	Ngugi
7	Joyce muriuki	F	IGOKI Dairy	Member		0723535184	
8	Jane Nyambu	F	Gracia	Member		079 0113414	
9	MIRIAM MBABU	F	Kururu	Leader		0724045123	MIRIAM
10	PATRICK MURITHI	M	KIGANE	MEMBER		0714557647	
11	MARTIN MWIRIGI	M	IGOKI Dairys	MEMBER		0714725142	
12	PATRICK KIMATHI	M	IGOKI	member	Mugambi Patrick@gmail	0726780306	
13	FRANKLIN MUTUGI	M	FESKA	STAFF		0711697468	
14	PURITY GACHERU	F	FESKA	MEMBER		0702358563	
15	DOREEN MWENDA	F	FESKA	MEMBER		0707794515	

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ATTENDANCE LIST

	ACTIVITY: SEED LINKAGE WORKSHOP – FESKA			DATE: 26th April 2017		VENUE: Kenguru ATC	
No.	NAME	Gender	Company/Group	POSITION	Email	Mobile	SIGN
1	Jane Nyamu	F	Gaabia	Member		0720113444	
2	Joyce Nurioni	F	IGOKI	member		0723535184	
3	Florence Njugi	F	KAIRUNE	member		0700317286	
4	Hannah Makena	F	Nkumari	member		0701564478	
5	Miriam Mbabu	F	Kururu	Leader		0724045128	
6	Mary Gwantai	F	Baranga	Member		0729037918	
7	Purity Gaitheri	F	NKWICIA	leader		0702258563	
8	Humphrey Mugambi	M	Kairune	leader		0723118758	
9	Martin Mugambi	M	Mikumbune	Member		0712761134	
10	Patrick Muriithi	M	KIGANE	MEMBER		0714557647	
11	Martin Mwiraji	M	Kairune	Member		0711475161	
12	Patrick Kimathi	M	KAIRUNE	MEMBER		0726780306	
13	Amos Kaitira	M	mikumBUNE	MEMBER		0701776889	
14	Franklin Muturi	M	FESKA	staff		0711697468	
15	Johnson Mutembei	M	Kamuchege	Member		0746031750	

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ATTENDANCE LIST

	ACTIVITY: FESKA-SEED LINKAGE WORKSHOP			DATE: 27th April 2017		VENUE: Kegaru ATC	
No.	NAME	Gender	Company/Group	POSITION	Email	Mobile	SIGN
1	Jane Nyaru	F	Peacetia	member		0720113414	
2	Joyce Muriuki	F	Igoki dairy	Member		0723535134	
3	Purity Nkatha	F	CAATIA	member		0701107621	
4	Joseen mwendeu	F	CAATIA	member		0707394515	
5	FLORENCE NGUGI	F	KAIRUNE	LEADER		0700317286	Ngugi
6	Honest makena	M	Nkumari	Member		0701564718	
7	Miriam Mbabu	F	Yururu	leader		0724045123	
8	Mary Gwantai	F	Burunga	Member		0729037913	Mary
9	Purity Kaoneri	F	NKUNGA	Leader		0702358563	
10	Humphrey Mugambi	M	KAIRUNE	leader		0723118758	
11	Martin Mugambi	M	Nkumbune	Member		0712761134	
12	Patrick muriithi	M	KIGANE	Member		0714557647	
13	MARTIN MWIRIGI	M	IGOKI	Member		0714475148	
14	PATRICK KIMATHI	M	KAIRUNE	MEMBER		0726780306	
15	Jotham Mutembei	M	Kamachiege	Member		0716031750	

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