



## **Drylands research in KALRO: addressing feed availability, livestock performance, climate smartness and business orientation challenges**

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### **Introduction**

The drylands in Kenya represents about 84% of land mass, hosts a ¼ of human population and >70% of livestock herd. Drylands experience below optimal livestock productivity, constrained by unavailability of quantity and quality feeds. Low availability of feeds is attributed to poor management of grazing resources in the natural systems leading to degradation and, limited adoption of improved pasture and fodder technologies leading to limited restoration and establishment of new pasture fields. Livestock in the drylands produce methane from enteric fermentation of low quality feed in the rumen. Manure also produce methane but to a lesser extent (Gerber *et al.* 2013). Enteric methane emission also represents a 2-10% loss of the dietary energy (Moraes *et al.* 2014). In the last couple of years, KALRO has been undertaking research aimed at enhancing feed availability, livestock performance, climate smartness of the production systems and profitability.

### **Methodology**

To address the feed availability challenge, KALRO adopted the innovative approach of developing and commercializing forage varieties, working closely with Kenya Plant Health Inspectorate Service (KEPHIS). Variety development entails germplasm collection, molecular and phenotypic characterization, selection and on station evaluation of promising candidates, the National Performance Trials (NPTs) in different agro-ecological settings and Distinctness, Uniformity and Stability (DUS). The trials culminate in registration and release of varieties by KEPHIS. To realize commercialization of the varieties, the certification process was done. Certification is about building the quantity of seeds available to marketable volumes. The process starts with planting of the nucleus seed to produce breeder seed, later planted to produce pre-basic while pre-basic is planted to produce basic and so on to the certified seed generation 2. The pre-basic and basic classes are commercially produced by registered seed merchants. The basic, certified seed generation 1 and 2 goes to farmers for feed production.

To enhance livestock performance, existing forage technologies (crops) were transferred to farmers and the latter's capacity to use the technologies innovatively build using the Training of Trainers (ToT) – Demo plots methodology. About 20 forage technologies (crops) were transferred where trainer of trainees drawn from county governments of Taita Taveta, Kajiado, Narok and producer organizations were recruited and trained by KALRO

research team. The trained trainers (TTs) were each assigned a demo plot or 2 where they worked with farmers to establish the forage crops which included grasses and legumes. The TTs used a training curriculum to train 30 to 50 farmers at each demo plot on forage establishment, weeding, harvesting, conservation and utilization including feed ration formulation. The farmers did own evaluation of the different forages including biomass yield, tolerance to low moisture, attack by diseases and pests, palatability and acceptability by livestock using the Secret Ballot method and, effect on the milk yield of livestock. Chemical composition of the forages was determined and the results shared back with farmers. The training enabled farmers to select forage crops to adopt and grow on scale for their livestock. Feed rations were innovatively formulated using different combinations of grasses and legumes exposed to farmers through the demo plots in order to attain the energy-protein balance required for good livestock performance. The feed rations were also tested for capacity to finish beef. Sheep were used in the trials where 6 different rations were tested against control (pure grass diets) for 90 days where the trial animals were individually stall fed. During the trials, growth performance, nutritive value and cost data were collected.

To enhance climate smartness, KALRO introduced inclusion of legume in livestock feed. During the feeding trials, data on proximate composition of the feed rations (wet chemistry) and growth performance was collected and used to estimate enteric methane emission per kg of meat produced following Intergovernmental Panel on Climate Change (IPCC), 2019 equation shown below.

(1)

$$DMP (g / d) = \frac{(GE (MJ) \times Y_m(\%)/100)}{0.05565}$$

Where;

DMP is daily methane production; Y<sub>m</sub> is the methane emission factor of 6.7 %

GE is the gross energy of the rations, computed from the equation below;

(2)

$$GE = 0.0226CP + 0.0407EE + 0.0192CF + 0.0177NFE$$

Where; CP =Crude protein; EE= Ether extract; CF= Crude fibre; NFE = Nitrogen free extract

Cost data also collected during the feeding trials was used to determine average variable cost and profitability of each ration. Business cases were formulated based on the feed rations and promoted.

## Results and Discussion

The varieties: *Cenchrus ciliaris* (CECI) Var. MGD KBK, *Cenchrus ciliaris* (CECI) Var. TVT3 KBK, *Enteropogon macrostachyus* (ENMA) KBK, *Chloris roxburghiana* (CHROX) KBK4, *Brachiaria* KS1 and *Brachiaria* BS1 were registered and released in December 2021. The species including *Megathysus maximus* MK1, *Megathysus maximus* MK6 and *Eragrostis superba* are currently undergoing the NPTs with a view of having them registered and released by KEPHIS as well. On commercialization, about 3.2 tons of pre-basic class seed have so far been bulked and are in the process of being distributed to investors for commercial multiplication.

Forage technologies transferred to farmers are: *Cenchrus ciliaris* (African fox tail), *Enteropogon macrostachyus* (Bush rye), *Chloris roxburghiana* (Horse tail), Sugar graze, Nutrifeed, *Brachiaria* cayman, *Brachiaria* cobra, *Brachiaria* camello, *Panicum maximum*, cowpea M66, *Dolichos lab lab*, Lucerne, *Desmodium*, *Mucuna*, Purple vetch, among others. A 40% adoption of the forages was registered with the farmers. In the low rainfall areas, the grasses Sugar graze, *Brachiaria* camello and Masaai love grass were the most adopted while the same was true for Boma Rhodes in the high rainfall areas. The legumes, *Dolichos lablab*, Cowpea M66 and Sweet Potato vines, *Greenleaf desmodium* (*Desmodium intortum*). Adoption of the forage technologies by farmers was informed by; biomass yield, drought tolerance, acceptability and palatability by livestock and animal performance.

For the beef finishing trials, table 1 shows CP, Metabolizable Energy (ME) of the feed rations, initial live weight, Average Daily Gain (ADG), Final Weight, Net Weight, Dry Matter Intake per day (DMI/day) and DMI as a % of Live Weight (LWT).

Table 1: CP, ME, Average Initial Weight, Final Weight and Weight Gain for Goats Fed with Different Diets

Diet	CP (%)	ME (MJ/Kg DM)	Initial Weight (Kg)	ADG (g)	Final Weight (Kg)	Net Weight Gain (Kg)	DMI g/day	DMI as a % of LWT
Maiza grain+Lucerne hay+Wheat bran+Commercial ingredients	14	11	21.3	357 <sup>a</sup>	48.8 <sup>a</sup>	27.5	-	-
Brachiaria sp var cayman+Desmodium	8.7	8.6	15.5 <sup>a</sup>	317.5 <sup>b</sup>	44.1	28.6	593.2	3.29 <sup>a</sup>
Brachiaria spp var cayman +Lucerne	10.8	9.4	16.7 <sup>a</sup>	277.8 <sup>b</sup>	41.7	25.0	583.3	3.0 <sup>a</sup>
Megathysus maximus+Lucerne	7.5	7.9	16.7 <sup>a</sup>	238.1 <sup>b</sup>	38.1	21.4	643.1	3.3 <sup>a</sup>
Megathysus maximus +Desmodium	7.1	8.6	17.0 <sup>a</sup>	297.6 <sup>b</sup>	43.8	26.8	562.6	2.8 <sup>a</sup>
Megathysus maximus	3.1	6.6	17.0 <sup>a</sup>	119.0 <sup>a</sup>	27.7	10.7	686.3	
SEM	14	11	0.69	28.1	0.99	0.59		

Inclusion of legume in the diets enhanced nutritive quality, feed intake and the average daily weight gain of sheep. This was attributed to enhanced crude protein, digestibility and low fibre content in agreement with Krause *et al.* (2002).

Table 2 shows methane yield from other trialed feed rations.

Table 2: Methane Yield from Forage Based Feed Rations by Sheep over 91 Days in a Feedlot System

Parameter	C. ciliaris	C. ciliaris + Lucerne	C.ciliaris+ Desmodium	E.macrostachyus+Lucerne	E.macrostachyus+Desmodium	E.macro stachyus	SEM	P value
CP (%)	4.4 <sup>ab</sup>	12.1 <sup>b</sup>	7.1 <sup>a</sup>	8.1 <sup>bc</sup>	11.8 <sup>c</sup>	5.5 <sup>ac</sup>	-	-
*ME (MJ/Kg DM)	8.2 <sup>a</sup>	8.5 <sup>b</sup>	8.2 <sup>a</sup>	7.8 <sup>c</sup>	9.1 <sup>ab</sup>	7.1 <sup>c</sup>	-	-
DMI kg/day	0.87 <sup>c</sup>	0.84 <sup>c</sup>	0.68 <sup>a</sup>	0.71 <sup>b</sup>	0.81 <sup>bc</sup>	0.92 <sup>c</sup>	0.04	**
Daily Methane production (DMP g/day)	18.4 <sup>c</sup>	17.7 <sup>c</sup>	14.0 <sup>a</sup>	15.15 <sup>ab</sup>	16.94 <sup>b</sup>	19.36 <sup>c</sup>	0.81	**
CH <sub>4</sub> yield (g CH <sub>4</sub> /kg DMI)	21.2 <sup>c</sup>	21.2 <sup>bc</sup>	20.8 <sup>a</sup>	21.2 <sup>bc</sup>	20.8 <sup>ab</sup>	21.0 <sup>abc</sup>	0.13	**
Methane intensity (g CH <sub>4</sub> /kg LW	690.2 <sup>a</sup>	470.9 <sup>b</sup>	350.1 <sup>b</sup>	599.6 <sup>a</sup>	286.7 <sup>b</sup>	645.6 <sup>a</sup>	146.9	NS

<sup>a,b,c</sup> Mean values within a row with different superscript letter differ significantly at  $p < 0.05$ ; C – Cenchrus; E – Enteropogon; SEM – Standard Error of the Mean; NS – Not Significant; \*The asterisk indicates values obtained through computation. Column mean with different letter superscript are significantly different at  $p < 0.05$

A significant difference ( $p < 0.05$ ) was recorded on daily methane production from sheep fed on the six diets with inclusion of Desmodium in the *Megathysus maximus* diet reducing the DMP by 25%. This is tied to the fact that increased non fiber sugar content in ruminant feeds lead to a more propionate-based fermentation pattern which in turn decreased the amount of hydrogen produced (Archimède *et al.* 2014) and consequently led to lower methane emissions. Methane yields obtained in the present study ranged from 20.8 -21.2 g/kg DMI which was within the range found by other studies in tropical environment with tropical low quality forages (Archimède *et al.* 2018, Gera *et al.* 2022).

Table 3: Profitability Case for 100 units

Diet	TVC	Revenue	GM	BCR (>1)	ROI	Viability (V) & Ranking
Brachiaria+Desmodium	39,976.1	201,000.0	161,023.9	5.0	4.0	V-1
Brachiaria+Lucerne	55,249.8	174,000.0	118,750.2	3.1	2.1	V-3
Megathysus maximus	39,430.6	75,000.0	35,569.4	1.9	0.9	V-5
Megathysus maximus +Desmodium	39,976.1	189,000.0	149,023.9	4.7	3.7	V-2
Megathysus maximus +Lucerne	55,249.8	150,000.0	94,750.2	2.7	1.7	V-4

TVC – Total Variable Cost; GM – Gross Margin; BCR – Benefit Cost Ratio; ROI – Return on Investment

Brachiaria+Desmodium and *Megathysus maximus* +Desmodium returned the highest BCRs of 5.0 and 4.7 and ROI of 4.0 and 3.7, respectively. *Megathysus maximus* basal diet showed the least returns. The legume addition to grass-based diets returned high BCR, GM, low Break Even Quantity (BEQ) and high ROI confirming the importance of the protein rich ingredients in livestock feeds.

### Conclusion and Recommendations

KALRO is on course in terms of making available, certified range grass seed varieties for restoration of degraded rangelands and establishment of new pasture fields. This will contribute to the government effort to close the 56% livestock feed supply deficit experienced at the moment. Seed companies, farmer groups or individual farmers are encouraged to engage in commercial seed multiplication using the basic seed now available in KALRO. In so doing, the companies will help the country produce and meet the demand for certified grass seed. With a 40% adoption of forage technologies by farmers, the country is on course to significantly increase feed availability and by so doing increase livestock productivity. The KALRO team recommends that counties encourage farmers to continue adopting the improved forage crops in order to make more livestock feed available. Inclusion of the legume in the diets enhanced nutritive quality, feed intake and the average daily weight gain of sheep on the feed rations. It is therefore beneficial for sheep farmers to adopt growing of grasses and legumes for use in forage-based feed ration formulation to finish the sheep. The alternative is to ensure supplementation of the free grazing goats with cultivated protein rich feed material for the livestock finishing activities to make economic sense. Finishing of the sheep should start at between 4 to 6 months old to take advantage of the naturally fast growth at this stage and in a feedlot system. Legume addition to low quality roughage reduced daily methane emission and methane yield per unit of beef produced implying, the system is a good option for achieving the emission reduction goals for sustainable sheep production. The legume addition to grass-based diets returned high BCR, GM, low BEQ and high ROI confirming the importance of the protein rich ingredients in livestock feeds. The on-farm feed production was more cost proficient than buying from the market and thus more farmer profit maximizing.

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## References

- Archimède H, Martin C, Périacarpin F, Rochette Y, Etienne T S, Anais C, Doreau M (2014). Methane emission of Blackbelly rams consuming whole sugarcane forage compared with *Dichanthium* sp. Hay. *Animal Feed Science and Technology* 190, 30-37.
- Archimède H, Rira M, Eugène M, Fleury J, Lastel M, Périacarpin F, Silou-Etienne T, Morgavi D, Doreau M (2018). Intake, total-tract digestibility and methane emissions of Texel and Blackbelly sheep fed C4 and C3 grasses tested simultaneously in a temperate and a tropical area. *Journal of Cleaner Production* 185, 455-463.
- Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J, Falcucci A, Tempio G (2013). Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.
- Gera S, Kankuri E, Kogermann K (2022). Antimicrobial peptides–unleashing their therapeutic potential using nanotechnology. *Pharmacology & Therapeutics*, 2022 Apr 1. 232.107990.
- IPCC (2019). Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [PR Shukla, J Skea, E Calvo Buendia, V Masson-Delmotte, HO Pörtner, DC Roberts, P Zhai, R Slade, S Connors, R van Diemen, M Ferrat, E Haughey, S Luz, S Neogi, M Pathak, J Petzold, J Portugal Pereira, P Vyas, E Huntley, K Kissick, M Belkacemi, J Malley (eds.)]. In press.
- Krause KM, Combs DK, Beauchemin KA (2002). Effects of Forage Particle Size and Grain Fermentability in Mid Lactation Cows. II. Ruminal pH and Chewing Activity, *Journal of Dairy Science*, Volume 85, Issue 8, Pages 1947-1957, ISSN 0022-0302, [https://doi.org/10.3168/jds.S0022-0302\(02\)74271-9](https://doi.org/10.3168/jds.S0022-0302(02)74271-9). Sousa *et al.* (2018).
- [Morales AB](#), [Strathe JG](#), [Fadel DP](#), [Casper EK](#) (2014). Prediction of enteric methane emissions from cattle. First published: 21 November 2013 <https://doi.org/10.1111/gcb.12471>.