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Research Application Summary

Cost effectiveness of mechanized hay production for feeding beef cattle in the central and southwestern rangelands of Uganda

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Abstract

Significant decline in pasture productivity in the central and southwestern rangelands of Uganda in the past 20 years has led to rangeland rehabilitation interventions to sustain beef production. Here we report the results of a study conducted between October 2020 and June 2021 on selected farms to verify the cost-effectiveness of hay production using mechanized and manual methods. Chloris gayana planted in intervention sites was mowed using a Falcon F80/180 EV haymaker-Intermediate duty mounted on a TAFE 8502 4WD 80HP tractor and left in the field for 1 or 2 days to dry with occasional raking. Thereafter, a Fimaks 5690 small square baler was used to compress and package the hay. Manually cut Chloris gayana was left to dry in the fields for a maximum of 4 days and baled using a hay box. In both cases finished bales were collected and stored in locally constructed hay barns. Data was collected by direct observation and farmer interviews and analyzed using SAS version 9.4. The time taken for hay harvesting, baling and storage space requirements reduced significantly with use of machinery. The monetary benefits of machine harvested hay (CBR=0.75) and cattle raised (CBR=0.13) on this hay outweighed the costs of production. Economic benefits were only realized with sale of fattened cattle (CBR=0.39) in the manual system. Mechanized hay production has potential to increase economic benefits for beef farmers hence development interventions should mainstream provision of specialized feed production equipment which farmer can access through a cost sharing arrangement.

Key words: Beef cattle, cost effectiveness, hay, mechanization, rangelands, Uganda

Résumé

La baisse significative de la productivité des pâturages dans les parcours du centre et du sud-ouest de l'Ouganda au cours des 20 dernières années a conduit à des interventions de réhabilitation des parcours pour soutenir la production de viande bovine. Nous rapportons ici les résultats d'une étude menée entre octobre 2020 et juin 2021 sur des fermes sélectionnées pour vérifier la rentabilité de la production de foin à l'aide de méthodes mécanisées et manuelles. Chloris gayana planté dans les sites d'intervention a été fauché à l'aide d'une faneuse Falcon F80/180 EV - Service intermédiaire monté sur un tracteur TAFE 8502 4WD 80HP et laissé au champ pendant 1 ou 2 jours pour sécher avec un ratissage occasionnel. Par la suite, une petite presse à balles carrées Fimaks 5690 a été utilisée pour comprimer et emballer le foin. Couper manuellement Chloris gayana a été laissé sécher dans les champs pendant un maximum de 4 jours et mis en balles à l'aide d'une boîte à foin. Dans les deux cas, les balles finies ont été collectées et stockées dans des granges à foin construites localement. Les données ont été recueillies par observation directe et entretiens avec les agriculteurs et analysées à l'aide de la version 9.4 de SAS. Le temps nécessaire à la récolte du foin, à la mise en balles et aux besoins en espace de stockage a été considérablement réduit avec l'utilisation de machines. Les avantages monétaires du foin récolté à la machine (CBR = 0,75) et du bétail élevé (CBR = 0,13) avec ce foin l'ont emporté sur les coûts de production. Les avantages économiques n'ont été réalisés qu'avec la vente de bovins engraissés (CBR=0,39) dans le système manuel. La production mécanisée de foin a le potentiel d'augmenter les avantages économiques pour les éleveurs de bovins. Par conséquent, les interventions de développement devraient intégrer la fourniture d'équipements spécialisés de production d'aliments pour animaux auxquels les agriculteurs peuvent accéder grâce à un accord de partage des coûts.

Mots clés : Bovins de boucherie, rentabilité, foin, mécanisation, parcours, Ouganda

Introduction

For decades, pastoral communities that inhabit Uganda's vast rangelands practiced nomadic pastoralism and transhumance on communal lands to produce beef for local communities and beyond (Asizua *et al*., 2017). Over 80% of the total beef output is derived from livestock that depend on predominantly native pasture swards in Uganda's rangelands (Mugerwa and Nyangito, 2011). The beef cattle population in Uganda is dominated by indigenous breeds notably the Ankole and East African Zebu (SEZ) cattle breeds, that are characterized by considerably good tolerance to diseases, climatic shocks particularly drought, and have excellent abilities to walk long distances in search of forage resources. In terms of productivity, the indigenous beef cattle breeds are generally characterized by low daily body weight gains, low market live weight and consequently low carcass weights. In fact, the SEZ attains a market live weight of 250kg in a period of over four years (Nantongo *et al*., 2021). Given the low beef production potential of indigenous beef cattle breeds that dominate the beef cattle population, Uganda produces only 185, 709 metric tons of meat annually, translating into a per capita consumption of about 9 Kg, which is far below 50kg recommended by the Food and Agriculture Organization (FAO) and World Health Organization (WHO).

Although beef consumption in Uganda is expected to increase by 403% by 2050, production will only have increased by 17% within the same timeframe (FAO, 2019). This demonstrates a worrying gap in the domestic market demand which is further exacerbated by the desire for increased meat export to tap into the lucrative international markets, which has stimulated government investment in establishment of numerous meat slaughter and export abattoirs, each with a capacity to process 400 heads of cattle of at least 300 kg of live weight, attained in at most two years. Currently, the export abattoirs are operating at below capacity.

Beef production in Uganda's rangeland ecosystem is heavily reliant on availability of natural pastures. Availability of these pastures during the wet season across rangeland ecosystems often exceeds animal requirement (Selemani *et al*., 2013). However, during the dry seasons, pasture dry matter availability significantly reduces and is often insufficient to meet the nutritional requirements of cattle to sustain high daily weight gains. Relatedly, studies by Mugerwa *et al.* (2012) revealed that the mean pasture dry matter yield in the wet season across different rangeland sites was 2895 kg/ha, and was 23% higher than the yield (2349kg/ha) recorded in the dry season. The low pasture dry matter availability during the dry seasons is further compounded by the fact that as tropical forages mature, they quickly get lignified, resulting into significantly decline in nutritive quality. More to this, subterranean termites pose stiff competition for pasture dry matter in many rangeland habitats hence aggravating the feed scarcity problem (Mugerwa and Nyangito, 2011; Mugerwa *et al.*, 2014; Mugerwa and Emmanuel, 2014; Mugerwa, 2015a, 2015b). As such, beef cattle that predominantly depend on native pasture resources are deprived of both adequate and nutritive feed resources, resulting into negative daily weight gains, loss of body condition, and eventually delayed attainment of market weight.

In order to sustain high daily weight gains of beef cattle during periods of feed scarcity, deliberate efforts have been directed towards building farmer institutional capacities in forage production and conservation. Relatedly, European Union funded a project called "Market-Oriented Beef Improvement Project (MOBIP)" which among other interventions, focused on improving feed availability through promoting pasture production and conservation innovations. However, promotion and stimulating adoption of new innovations is often constrained by paucity of information on the cost-effectiveness of feed conservation innovations to support decision making by the farmers. Therefore, this study sought to evaluate the cost- effectiveness of mechanized hay production on selected farms in the central and south western rangelands of Uganda to support informed decision making on the use of scarce resources by the livestock farmers.

Materials and methods

Study area. The study was conducted between 26th October 2020 to 15th June 2021 on selected farms in 9 districts in the central and southwestern rangelands of Uganda's cattle corridor (Figure 1).

Nine districts were selected on account of the extent of rangeland degradation over the past 20 years as shown in Figure 2. These areas receive a bimodal-seasonal type of rainfall where the first season rains occur from March to May and the second rain season occurs from August to November. The mean daily temperatures range between 18 to 35°C while the annual rainfall ranges between 750 and 1200 mm (Nimusiima *et al*., 2013).

Selection of farms. Two categories of farms were purposively selected for the verification exercise. Farms selected for mechanized hay production were those that benefited from the MOBIP project interventions. These farms were supported to establish varying acreage of mixed Chloris gayana and Centrosema pubescens gardens for hay production. Farms selected for manual hay production opportunistically recruited if they had established similar pastures under other development interventions either by government of non-government organizations (NGOs). In total 28 farms were purposively selected for the study.

Mechanized and manua**l harvesting and baling of hay**. Grasses for hay making were cut prior to the flowering stage in order to obtain the highest nutritive value and conserved as hay for dry season feeding and for bull fattening (Figure 2 (a)). The grass was mowed using a Falcon F80/180 EV haymaker- Intermediate duty mounted on a TAFE 8502 4WD 80HP tractor.

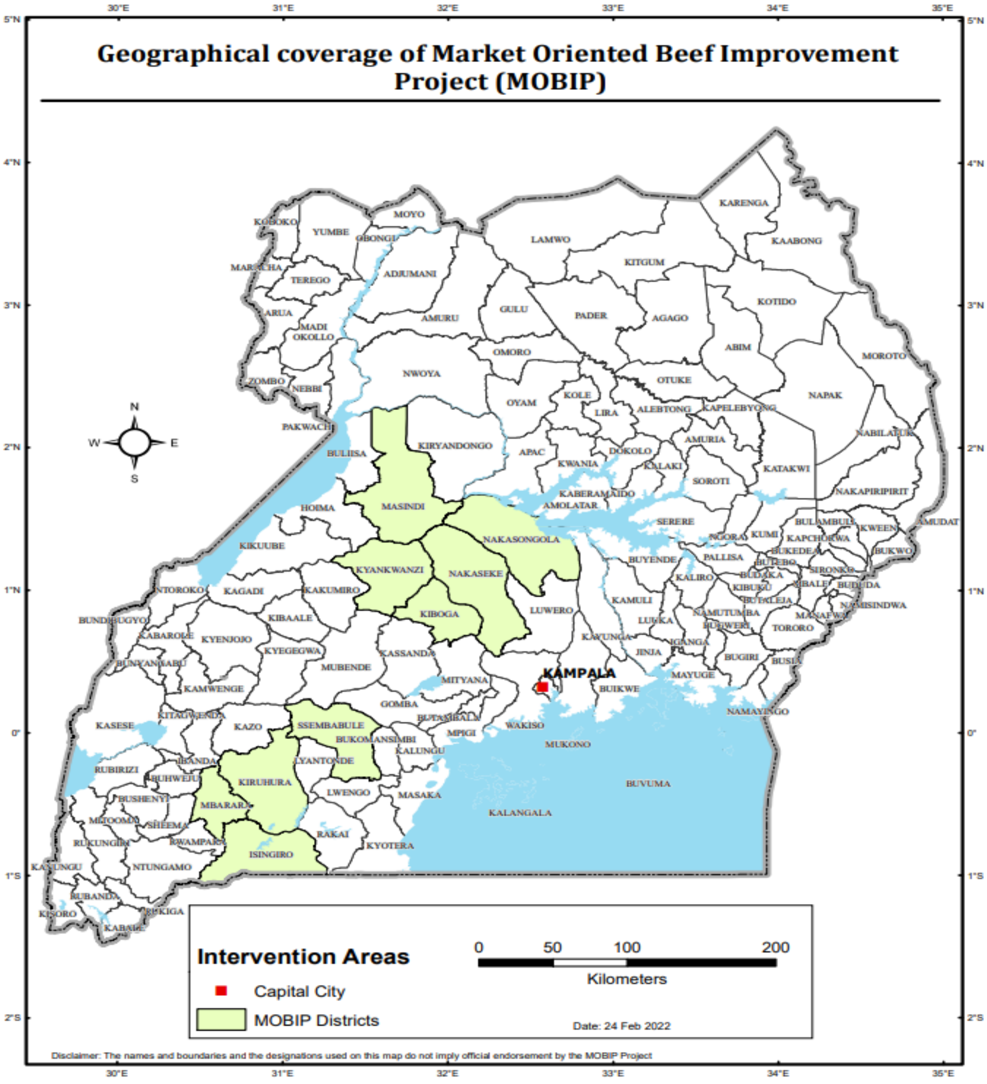

Figure 1. Map showing the study districts within the central and southwestern rangelands of Uganda

(a) (b) (c) (d)

Figure 2. Mechanized hay harvesting and baling process

To ensure quick drying raking was performed to turn the swathes and roll them together for easier pickup by the baler. A day or two of drying for finer grasses and more for the high growing grasses was considered. After drying, hay was baled using the Fimaks 5690 small square baler to compress and package hay. The baler was configured to produce small rectangular bales of 36 by 46 cm in cross-section1, 30 cm long and 25kg of weight (Figure 2(b)). Finished bales were loaded onto trucks and transported for storage in locally constructed hay barns that allowed adequate air circulation (Figure 2 (c) and 2 (d)). In some cases, excess hay was sold to dairy and beef farmers to yield extra income. In addition, seed from these pastures was harvested, processed and sold to yield more income for the farmers.

Grass for manual hay production was harvested manually under favorable weather conditions by cutting with a sickle or panga (Figure 3 (a)) and drying it in the fields for a maximum of 4 days.

(a) (b) (c)

Figure 3. Manual Hay harvesting, baling and storage process

Upon drying bales were made using a hay box measuring 2 feet and 2 inches long, 2 feet and 2 inches wide and 1 foot and 9 inches deep. The bales were secured with sisal strings and kept in locally constructed hay barns (Figure 3 (b) and 3 (c)).

Data collection and analysis

Data on farm profile and characteristics was collected using a predesigned questionnaire. The cost of fuel, labor, baling strings and other associated costs were determined either by interviewing farmers or reviewing farm records where they existed. The average acreage harvested under the 2 systems was determined by summing the total number of acreages harvested under each system and dividing by the number of farms. The average number of days taken to harvest the above acreage was determined by dividing the total number of days by the number of farms under each system. After each harvest ten bales were randomly sampled and measured to determine the average weight. Storage space requirements were estimated by multiplying the area of occupied by one bale of hay in both cases by the number of bales harvested. The average cost of constructing a square meter of a hay barn was estimated to be 35,000UGX from the cost provided by individual farmers and verified by the production extension staff. This was used to estimate the total cost of hay barn construction. In all cases, hay barns were constructed using wooden poles, timber and iron roofs.

Total costs were determined by summing up all the costs. The total farm gate value of hay was estimated by multiplying the average weight of hay produced in both systems with an average cost of 400UGX per kilo (Wamai, 2018). The available Dry Matter was estimated by multiplying the total weight of harvested hay by the dry matter content of Chloris gayana hay (0.8%) as reported by Naji, 1974.

The number of animals supported by the harvested hay for 60 days was calculated by dividing the total available Dry Matter (DM) with the DM requirement for a standard tropical livestock unit (250kg) for the same period. A daily Dry Matter Intake (DMI) of 3% was used. We made an assumption that the animal will entirely depend on the Chloris gayana-Centrosema pubescens hay for nutrition without any grazing. The total value of animals was estimated using a standard market price of 1,300,000UGX (Agriterra, 2012). Data was analyzed descriptively using SAS Version 9.4. Cost benefit ratio was calculated using the formula below.

CBR=Cost of production (UGX)/Economic benefits (UGX). A cost benefit ratio greater than one, indicates that the costs are greater than the benefits. However, when the cost benefit ratio is less than one, then the economic benefits outweigh the costs. Students t-test was used to test for significant differences between the two groups of farmers, who either used manual or mechanized harvesting of hay.

Results

The number of farms selected were fairly distributed across the 9 districts and majority were male owned (78.6%), mostly keeping cross breed animals (57.1%) mainly for bee production (46.4%) although dairy and dual-purpose farms were also included. On 60% of the farms mechanized hay production was conducted while manual hay production was being practiced on the rest (Table 1).

Hay production performance under the mechanized and manual harvesting systems. The acreage of Chlrois gayana harvested under the 2 systems did not vary significantly (P=0.1018). The hay yield in terms of weight did not vary significantly (P=0.30) with harvest methods (Table 2). However, the number of days taken to harvest the same acreage were much lower under the mechanized than the manual system (P<0.0001).

Table 1. Farm profile and characteristics (n=28)

Variable	Category	Frequency (%)
No of farms per district	Isingiro	3(10.7)
	Kiboga	4(14.3)
	Kiruhura	4(14.3)
	Kyankwanzi	3(10.7)
	Masindi	2(7.1)
	Mbarara	3(10.7)
	Nakaseke	4(14.3)
	Nakasongola	2(7.1)
	Sembabule	3(10.7)
Sex of farm owner	Male	22(78.6)
	Female	6(21.4)
Breed	Indigenous	12(42.8)
	Crosses	16(57.1)
Purpose	Beef	13(46.4)
	Dairy	8(28.6)
	Dual purpose	7(25.0)
Method of feed conservation	Manual	11(39.3)
	Mechanized	17(60.7)

Table 2. Production performance under mechanized and manual harvesting systems

Parameter	Manual	Mechanized	P-value
Average acreage harvested	16.05	18.7	0.1018
Average no of days needed to harvest and bale	16.18	5.05	<0.0001
Variable costs			
Labor, transport (A)	6,361,708	1,610,000	-
Total cost of baling strings (B)	418,000	310,588	-
Storage /space requirement (SqM)	88.13	65.65	<0.0001
Fixed costs			
Cost of construction/ 35000UGX/sqm (C)	3,084,550	2,297,750	-
Total cost (D): (A+B+C)	9,864,258	4,218,338	-
Bales harvested	1071.4	701.4	0.2759
Average weight of hay (kgs)	10714	14028	0.3000
Estimated value of hay (E)	4,285,600	5,611,200	-
Average DM available (80%)	8571.2	11223.0	0.8421
No. cows supported for 60 days (Daily DMI 3% of 250Kg body weight)	19	25	0.7726
Total value of cows (F)	24,700,000	32,500,000	-
CBR-1(D/E)	2.3	0.75	-
CBR-2(D/F)	0.39	0.13	-

The DM yield from both harvesting systems did not vary significantly (P=0.8421). However, the storage space requirement for harvested bales was much more in the manual compared to the mechanized system (P<0.0001). The CBR for value of hay (0.75) and value of animals (0.13) was lower than 1 in the mechanized system implying that the economic benefits of using mechanized hay conservation outweigh the costs involved. The CBR for value of hay (2.3) in manual hay conservation indicates that the costs of manual hay conservation are greater than the economic benefits. However, the CBR for value of animals (0.39) using manual hay conservation indicates that the economic benefits are greater than the costs involved.

Discussion

The central and southwestern cattle corridor of Uganda has undergone severe degradation over the past 20 years significantly reducing vegetation cover and available forage resources for beef production (Figure 2). The degradation has been occasioned by overgrazing, intense termite activity, tree felling for charcoal production, severe erosion and prolonged droughts (Walsh *et al*., 2006; Mpairwe *et al.,* 2011; Mugerwa and Nyangito, 2011). Therefore, several interventions aimed at improving rangeland productivity have been implemented to ensure availability of adequate high-quality pastures for beef production to meet the current and future demands. One of such interventions was to introduce drought tolerant pastures that were established either through reseeding or over sowing practices (Twinamatsiko *et al.,* 2020). Traditionally these interventions have been carried out manually, due to challenges associated with cost and availability of machinery. However, to provide adequate forage especially in the prolonged drought periods experienced in the central and southwestern rangelands it is prudent to mechanize the process of feed production. Mechanization offers several benefits over manual production methods. These include extended scale of production, consistent quality of hay, minimal wastage, reduced drudgery and minimal hazardous health effects (Rotz, 2001; Muhammad *et al.,* 2018). Despite the well-known advantages that mechanized feed production offers, there has been limited uptake of these technological innovations. The main reasons are availability of machines and costs involved. Besides farmers do not have adequate information to guide decisions on adoption of the technologies. Our findings indicate that mechanized harvesting is three times faster in terms of the time required to harvest comparable acreage of Chloris gayana. The faster harvesting with machines also offers added advantages in terms of hay quality as a result of 2 main aspects. Faster harvesting ensures faster drying and hence reduces the chances of exposure to adverse weather elements which could potentially spoil the hay. Secondly due to lesser time taken to harvest, the fiber and lignin content of the grasses are kept at a minimum since the grasses are not allowed to over grow before harvesting is completed as recommended by (Lacefield *et al.,* 1999). This ensures that the protein content, digestibility and acceptability of the hay are not compromised. Our findings also showed that mechanized hay harvesting significantly reduced storage space requirements and therefore the cost of construction by almost 2-fold (Table 2). The compression power of the Fimaks 5690 and other baler types, yields smaller but heavier hay bales (Rotz, 2001). This is also the reason why the estimated value of hay was much higher in the mechanized than in the manual harvesting system because of the heavier weight of the bales harvested made by the hay baler.

Overall, the monetary value of both manual and machine harvested hay outweighed the costs of production. Moreover, these were realized from a comparable acreage of Chloris gayana. This implies that if the acreage is expanded (which is only feasible with the use of machines), more monetary benefits could be realized by the farmers. The monetary value of the beef cattle supported by the hay only outweighed the costs of hay production only with the mechanized methods, implying that farmers can only break even by using the hay for fattening beef cattle and only sell the excess to avoid wastage.

Conclusions and recommendations

Despite the costs involved in acquiring and utilization of machines for hay production, this system offers monetary benefits in the long run. These benefits are related to reduced cost of hay barn construction, reduced time taken for hay harvesting, baling and storage, higher quality and therefore higher value of hay, more animals fed and therefore more income realized from their sale and additional income from sale of excess hay. Government and other development partners should mainstream provision of specialized feed production equipment which beef farmers can access in a cost sharing arrangement. This will ensure production of adequate high-quality hay for beef production in the cattle corridor. Increased beef production will contribute to eliminating hunger, malnutrition and poverty eradication by 2030.

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