Uganda Journal of Agricultural Sciences, 2003, 8 : 339 - 344 ISSN 1026-0919
Printed in Uganda

Improving forage processing for smallholder dairy farmers in Uganda

Lubwama F., Candia A., Saasa R. and Ben E.
Agricultural Engineering and Appropriate Technology Research Institute,
P. O. Box 7144, Kampala, Uganda.

Abstract

Two types of improved forage choppers were developed to satisfy the fine chop requirement of materials used for animal feed and improve on labour use efficiency. The two types were set to address the economic differences among farmers, giving a range to choose from depending on ones' affordability: the motorised one and the manually operated chopper. The choppers have been extensively tested on elephant grass, guatermala, corn stoves and calliandra with both female and male adults, boys and girls operators. The engine speed for the motorised chopper was varied during the tests between low (1000 rpm) and high (1500 rpm). Using the improved choppers on elephant grass, a clean fine chop was obtained with a capacity of between 150 - 480 kg/hr and length of cut between 25 – 45 mm for 65% of sample. For corn stoves, the capacity and length of chop were between 110 to 312 kg/hr and between 25 – 45 mm for 55 % of sample respectively. Guatermala grass registered between 170 – 394 kg/hr and between 25 – 45 mm for 60% of sample while calliandra gave between 130 to 410 kg/hr. Fuel consumption of the motorised chopper was approximately 0.89 - 1.2 lt/hr. Comparative tests for the traditional manual chopping with a machete gave 37 – 101 kg/hr for elephant grass, 45 – 95 kg/hr for maize stoves, 44 – 112 kg/hr for guatermala and 69 – 119 kg/hr for calliandra. Besides the lack of uniformity in the length of cut, results show a significant difference in the capacities attainable with the traditional manual chopping with a machete and the improved forage choppers. The cost of the improved forage choppers is off set by the economic gain realised by the increased feed consumption which in turn improves the livelihoods of dairy farmers through the increased milk yields.

Key words: Improved forage processing, Smallholder dairy

Introduction

In Uganda, livestock production contributes about 9% of the GDP and 30% of the total agricultural GDP. There are estimated 5.2 million cattle, approximately 96% of which are indigenous breeds, the rest are imported breeds and their crosses (Kabirize et al, 1998). Over 60% of the country's livestock are kept by smallholder farmers to provide milk, meat, income, manure and draught power. Women play key roles in raising animals and in harvesting and processing livestock feeds and products both for home consumption and for sale. Although men are often the owners of large livestock, it is the women who perform most of the household labour devoted to animals. The processing of animal feed has dominantly become a women's role and very often assisted by the children. Since women's roles are increasing within the livestock sector, it is imperative to enhance their access to appropriate technologies and any information related to livestock husbandry.

Feed materials for zero grazing animals require chopping for ease of consumption by the animal and increase consumption of the feed. Hand tools and head portage are common human powered activities that characterise forage chopping and haulage from fields often located far from the cattle stalls. These high labour demanding farm activities are followed by forage chopping tasks prior to feeding the cattle. Hand chopping is the common practice by most farmers. Besides its low output capacity and lack of uniformity in length of cut, the method is tedious, time consuming and quite dangerous to the operator. Data from an

AEATRI survey under the Livestock Systems Research Programme (LSRP) shows that three out of ten zero grazing families in Masaka district of Uganda have had a member loose a finger through manual chopping of fodder. In order to improve on labour use efficiency, a number of improved forage chopper designs ranging from electric and diesel powered types, manual crank wheel and fixed knife have been developed.

In an efforts to address some of the constraints highlighted above, AEATRI developed two types of improved forage choppers, motorised and manual, that are reasonably priced, versatile and ergonomically safe for the small-scale and medium scale farmers and farmer groups. The improved forage choppers are able to cut grass and legume biomass as well as other feed supplements like banana peelings into small pieces more conveniently and quickly. This increases feed intake of the animals. In addition, it makes the process of mixing forage with high energy and nitrogen ingredients like calliandra leaf and maize bran easier. By so doing the consumption of feeds and consequently milk yields are increased which in turn highly improves the livelihood of dairy farmers.

Methodology

Until very recent, agricultural research and development has largely ignored the need of women, yet their contribution is relevant and essential to agricultural development (NARO, 1991). Achieving agricultural development goals of efficiency, sustainability and equity can be successfully attained by targeting both men and women needs in technology development. Moreover, technological innovations can be turned into opportunities to boost women's production potential and improve their quality of life and that of their families. This weakness in research was also noted during the AEATRI stakeholders planning and review workshop of 1999.

Therefore, in a bid to respond to farmers needs, AEATRI undertook the development of improved forage choppers that are versatile and ergonomically safe. Two chopper types have been developed so far to address the farmer economic difference: the motorised and the manually operated forage choppers.

Chopper description and mode of operation

a) Motorised forage chopper

The inclined feed chopper forage chopper was developed drawing from some earlier work by Pasikatan (Pasikatan et al, 1993 and 1996). The chopper has ergonomic and safety features of a compact low-centre-of gravity frame, an inclined housing and a wide-mouth hopper. The machine has a counter blade bolted onto the chopper housing and two rotating reversible blades, angled at 10° to facilitate cutting as well as serving as a blow off mechanism for the chopped material. The knife assembly is tightly mounted on a belt driven shaft. The blades are manufactured from leaf spring material. The machine is driven by a 5 hp gasoline engine with a single B56 V-section belt twisted at 45°.

b) Manually operated forage chopper

The manually operated forage chopper was developed drawing from the mechanics of cutting plant materials (Person, 1987). This chopper has a metal frame lined with a sheet material hopper to guide the forage towards the knife during operation. A machete is fixed using a bolt at the opposite end of the frame to swing through a slot as it chops, with a flat adjustable sheet to control the length of chop. A metal square bar is fitted about six inches from the machete to prevent the operator's hand reaching the knife.

Variables and measurements

The power requirement for the motorised forage chopper was measured using an electronic tachometer that recorded the revolutions per minute. The feed rate was determined using the weight of the fodder before chopping and the time taken to chop that weight. Capacity was measured by weighing the chopped material output over time. Analysis of length of chop was done through the frequency distribution of three replications of 100 randomly selected chopped pieces. In the case of the manually operated forage chopper, the length of cut is pre-set at the start of the experiment, but its analysis is still important to check the effeciency of the machine. The fuel consumption for the motorised forage chopper was obtained by measuring fuel at the start and end of chopping a given weight of feed material.

Test procedure

The choppers were tested on freshly cut elephant grass, guatemala, corn stoves and calliandra using both male and female adults as well as the youth. The forage was weighed and time taken to chop a given weight recorded for the different operators, men, women and the youth. The youth were not gender disaggregated because in most instances, it was the boys assisting with this operation. In the case of the motorised forage chopper, two engine speeds were used: low of 1000 rpm and high of 1500 rpm and the fuel consumption at the two speeds was recorded. A plastic sheet was place on the ground to collect the chopped forage which was then bagged and weighed to determine the capacity.

Table 1: Capacity and length of cut for the various tested materials at 1000 rpm

Fodder	Gender	Capacity, kg/hr	Cut length, mm
Elephant grass 75.4 – 80.1% mc, wb	Male Female Youth	210 - 430 180 - 380 244 - 450	25 – 45 f for 65% of sample
Maize stoves 60.5 – 77.0% mc, wb	Male Female Youth	270 - 309 223 – 289 250 - 311	25 – 45 for 55% of sample
Guatermala 70.3 – 75.7% mc,wb	Male Female Youth	256 - 360 211 – 348 250 - 388	25 – 45% for 60% of sample
Calliandra 60.3 – 77.4% mc, wb	Male Female Youth	331 – 395 298 – 384 320 - 401	NA

Table 2: Capacity and length of cut for the various tested materials at 1500 rpm

Fodder	Gender	Capacity, kg/hr	Cut length, mm
Elephant grass 75.4 – 80.1%	Men Women Youth	241 - 439 214 - 399 254 - 480	25 – 45 for 65% of sample
Maize stoves 60.5 – 77.0% mc, wb	Men Women Youth	293 - 312 249 – 297 261 - 311	25 – 45 for 55% of sample
Guatermala 70.3 – 75.7% mc, wb	Men Women Youth	253 - 377 242 – 371 289 - 394	25 – 45% for 60% of sample
Calliandra 60.3 – 77.4% mc, wb	Men Women Youth	329 – 410 311 – 390 331 - 395	NA

Results

a) Motorised forage chopper

The capacity and length of chop for the different feed materials are shown in Table 1 and Table 2 for the two operating speeds for the different gender groups.

The fineness of chop for the tested feed materials improved with the quality of fodder. The fresh (75 – 80% mc, wb) or completely dried elephant grass, guatermala and calliandra gave finer chops than the wilted ones and, completely dried maize stoves had a finer chop than the partially dried one. The wilted feed material tended to twist around the blades leading to choking of the chopper and milling of the fodder instead of chopping it.

Considering the daily average consumption of an animal of 50 - 70 kg of fodder with supplements or 65 – 90 kg with very limited supplements, the results in Tables 1 and 2 imply that the motorised forage chopper can adequately handle a herd size of 25 – 50 animals operating the machine for 6 – 8 hrs daily. In addition, the ease of consumption and palatability of the fodder increases with the fineness of chop. The length of cut released by the machine satisfies the animal feed nutritional requirement for the tested feed material. The fuel consumption ranged between 0.89 – 1.2 lt/hr for both speeds of the machine, with hourly chopped fodder quantities as shown in Tables 1 and 2.

Table 3: Capacity and length of cut for the manually operated forage chopper for the various tested materials.

Fodder	Gender	Capacity, kg/hr	Cut length, mm
Elephant grass 75.4 – 80.1% mc, wb	Men Women Youth	161 - 180 150 - 168 165 - 198	25 – 45 for 65% of sample
Maize stoves	Men Women Youth	145 - 160 110 – 148 139 - 155	25 – 45 for
Guatermala for 70.3 – 75.7% mc, wb	Men Women Youth	78 - 203 170 – 198 185 - 201	25– 45% 60% of sample
Calliandra 60.3 – 77.4% mc, wb	Men Women Youth	130 – 155 149 – 167 153 - 179	NA

The ease of feeding was enhanced with the "leaves-first" mode of feeding other than the "stems-first" mode. With the "leaves-first" mode of feeding, the knives easily get hold of the material and pull it freely relieving the operator of the hold-on bit of the feeding. The hard stems of calliandra and the over grown stems of both the elephant grass and guatermala grass had to be removed before feeding to avoid choking the machine in the process of crushing them since they cannot be chopped. Similarly, the corn ears had to be removed as they could

not be chopped. For the tests run without removing them, the ears were thrown out unchopped or partially crushed.

a) Manually operated forage chopper

For the manually operated chopper, the capacities and lengths of chop for the different feed materials is given in Table 3 for the different gender groups. Like in the case of the motorised forage chopper, the fineness of chop for the tested feed materials improved with the quality of fodder, i.e., improved with high moisture content fodder.

The capacity/output of the fixed knife forage chopper is better than that of traditional manual chopping with a machete as shown in Table 4. These results imply that for the required daily consumption of 50 - 70 kg per animal of fodder with supplements or 65 – 90 kg per animal with very limited supplements, the manually operated chopper can adequately handle a herd of 18 – 22 animals, operating the machine for 6 – 8 hrs/day as opposed to 7 – 11 animals (Table 4) that can be served by the traditional manual chopping with a machete for 6 – 8 hrs/day but changing operators. Besides, the operator risks are highly minimised with the manually operated forage chopper and it is labour and time saving. The length of cut for this machine is pre-set to conform to the recommended length for better nutritional requirements but, measuring it after chopping helps in evaluating the efficiency of the machine. The length of cut released by the machine too guatermala grass had to be removed to save the edges of the machete from denting. The corn ears too had to be removed since they could not easily be chopped.

Table 4: Capacity of ordinary manual chopping

Fodder	Gender	Capacity, kg/hr
Elephant grass 75.4 – 80.1% mc, wb	Men	60 - 101
	Women	37 - 48
	Youth	65 - 95
Maize stoves 60.5 – 77.0% mc, wb	Men	79 - 95
	Women	45 – 62
	Youth	50 - 86
Guatermala 70.3 – 75.7% mc, wb	Men	55 - 112
	Women	44 – 67
	Youth	69 - 111
Calliandra 60.3 – 77.4% mc, wb	Men	77 – 103
	Women	69 – 87
	Youth	85 - 119

The ease of feeding in this case was enhanced with the "stems-first" mode of operation other than the "leaves-first" mode. Similarly, the hard stems of calliandra and the over grown ones for both the elephant grass and guatermala grass had to be removed to save the edges of the machete from denting. The corn ears too had to be removed since they could not easily be chopped.

Comparison between fixed knife chopper and traditional manual chopping with machete

The manual chopping with a machete may seem cheaper for a farmer with only one animal, but it presents potential risks to the operator. Besides its low output capacity and lack of uniformity in length of cut, the method is tedious, time consuming and quite dangerous to the operator. On-station results of chopping with a machete in Table 4 clearly show a significant difference in the quantities chopped by the machete in comparison to results in Table 3. No attempts were made to estimate the length of cut due to lack of uniformity.

Information on feeding requirements further shows that it requires a lot of time before the required amounts of feed can be realised with the machete which makes this method inappropriate for a farmer with several animals. Therefore, the advantages of operators' safety, efficiency, reduction of chopping–induced drudgery, ease of flexibility to integrate the entire household and capacity to release labour for other farm activities make the fixed knife superior to the traditional chopping with a machete.

Farmers experiences

Information from some contact farmers shows that for a cross breed of 430 kg body weight, the daily consumption of chopped material is between 55 – 70 kg with supplement of 3 kg (dry matter) of lab lab and some concentrates of Ugachick while milking. For a herd comprising of a lactating pure heifer, one pure heifer of about 1 year, a crossed heifer of about 1 year and a calf of less than a year, the consumption of chopped material was over 200 kg during the wet season. The cost of the improved forage choppers was certainly found to be high for some farmers but, those using the technology certainly found the economic gain worth the investment. Manual chopping with a machete proved expensive in the long run as supplements/additives were constantly required to improve the acceptability and palatability of the fodder. Commonly used by farmers for this kind of feeding is the brewers mash.

Discussions

1. The capacity of the forage choppers was significantly influenced by blade speed, feeding style and material properties (moisture content). High capacities were obtained at 1500 rpm for the motorised chopper and with either freshly cut of completely dried feed

material. At this speed, suction and throw were sufficient to ensure clog-free operation. High performance rates were also obtained with the "leaves-first" mode of feeding.

2. The length of cut was also influenced by the speed of the blades, in the case of the motorised chopper, as well as the moisture content of the forage, the rate and mode of feeding. The length of cut improved with high moisture content, just a hand full of feed material and with "leaves-first" throw-in mode of operation for the case of the motorised, but "stems-first" mode of operation for the fixed knife one.

3. The feeding value of the material is very important to attain good acceptability of the fodder, as animals do not particularly like overgrown material. Feeding with the right quality of fodder also minimises the need for additives to improve the acceptability of feeds.

4. There was a significant difference in the capacity/ output realised with the improved forage choppers as compared to that of the traditional manual chopping with a machete. In addition, uniform length of cut was obtained with the improved forage choppers. No efforts were made to estimate the length of cut with the traditional manual chopping with a machete due to lack of uniformity.

5. Although the cost of the improved forage choppers is considerably higher than that of a machete, the economic gain that is realised with the increased consumption of the feeds, off sets this cost. An increase in feed intake was realised with the finely chopped feed material leading to reduced wastage of feeds and consequently increased milk yields hence improving the household income. Also the time spent on chopping is tremendously reduced, hence allowing farmers to engage in other income generating activities.

Recommendations

Farmers' proposals

1. The motorised forage chopper should be made more portable by fitting it on some movable base to ease its mobility, especially for the female headed households and homes with limited human help.

2. Forage chopper sizes should take into consideration that children take part in forage chopping. Child friendly designs, which are smaller and cheaper, should be considered.

3. Low cost materials like wood and scrap metal should be considered as a way of further reducing the cost of the choppers.

Research aspects

1. The slot through which the fixed machete moves during chopping requires modification to eliminate the current clogging constraint without compromising on the chopper capacity.

2. Research should consider the possibility of chopping other feed material used by some dairy farmers like potato vines and banana leaves without crushing them.

Conclusions

1. The time required for chopping using the improved choppers was tremendously decreased hence freeing labour for other farm operations.
2. The ergonomic safety aspects of the operator were clearly addressed to minimise the chopping related accidents.
3. The quality of the chopped material improved with the controlled length of chop.
4. Wastage of feed material was tremendously reduced.
5. There was significant decrease in the drudgery associated with chopping, easing the whole operation.

References

Kabirizi, J. M. L. and Nanyeenya, W. 1998. Improving Feed Material for Smallholder Dairy Farms in Mukono District (unpublished research proposal for FARMESA funding).

NARO, 1991. National Agricultural Strategy and Plan, Vol. 1. Prepared by Uganda Agricultural Policy Committee Working Group 9A, with assistance of ISNAR, 1991.

Pasikatan, M. C. and Quick, G. R. 1996. Development and Evaluation of a FINE (Flywheel, Inclined, Non-clogging, Ergonomic) chopper. Phillippine Technology Journal, Volume XXI, Number 1, Jan – March, 1999, pp 3 – 18.

Pasikatan, M. C. and Quick, G. R. 1993. A low Cost Straw and Forage Chopper. Proceedings of the International Conference on Agricultural Machinery and Process Engineering, KOEX, Seoul, Korea. October 19-22, 1993.

Person, S. 1987. Mechanics of Cutting Plant Material. ASAE Monograph No7.