Utilisation of conserved forage to improve livestock production on smallholder farms in Asia and Africa

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Abstract. Ruminant livestock are essential to the livelihoods of smallholder farmers in many developing countries. Livestock production on these farms is characterised by low milk production, low live weight gain and poor reproductive performance because of poor nutrition. Access to high quality forage has been identified as key to improving livestock health and productivity. Conservation of surplus forage as hay or silage provides the opportunity to ensure livestock have access to high quality forage year-round. This paper reports on forage conservation in select countries in Asia and Africa.

Keywords: Forage conservation, silage, hay, smallholder, livestock.

Introduction

Livestock are an important livelihood strategy in most developing countries (Otte *et al*. 2005; Otieno *et al*. 2006; Rao *et al*. 2009) by providing meat, milk, manure, hides, draught power and collateral (financial asset, insurance). Smallholder cattle farming is the major source of livelihood for over 54% of poor people in sub-Saharan Africa (IFPRI 2007) and over 70% of the population in Pakistan is directly involved with livestock as a primary source of food and/or income (Devendra and Thomas 2002; Thomas *et al*. 2002). Furthermore smallholder livestock farms are the major meat and milk producers in developing countries of Asia and Africa. Despite their importance, livestock are usually undernourished due to lack of feeds of sufficient quality and quantity; the consequences of which are low production, increased disease susceptibility, higher mortality rates and reduced fertility (Xue *et al*. 2005). This is typical of livestock production systems on smallholder farms in developing countries where traditionally farmers have been livestock keepers/users.

Lack of high quality forage, which is influenced by seasonal supply and competition with neighbouring farmers for the available forage resource is the major challenge faced. The majority of livestock are part of integrated crop/livestock systems and low quality crop residues represent a significant proportion of the total annual diet, particularly where livestock are tethered for all or most of the year. In regions dependent on grazing, access to high quality feed is seasonal and dependent on rainfall and temperature. Opportunities for improvement involve forage production and conservation as well as efficient use of local feed resources. This paper outlines experiences with forage conservation and using conserved forage to improve livestock production on smallholder farms from some countries of Asia and Africa with a diverse range of environments and situations.

China

The Qinghai-Tibetan Plateau is one of the three most important livestock production areas in China. It has a harsh environment and insufficient feed supply during the long cold season (November to June). With an area of 129.3 million ha, it accounts for 32.5% of China's total grassland area and supports about 41.5 million sheep and 13 million yaks.

Year-round survival of the Tibetan livestock is largely dependent on the native alpine pastures, which are characterized by high altitude (> 3,500 m), very low annual average temperature (-5 to -1°C), a short growing season (from June to September), low productivity, without an absolute frost-free period, and extensive seasonal variation in feed supply. Animals in the traditional grazing system often suffer from poor nutrition, health-related problems, low production and low fertility, and losses of up to 30% have been reported during some extended cold seasons (Xue *et al*. 2005). Moreover, severe degeneration of the native alpine pasture has extended the gap between forage supply and animal feed demand in recent decades.

Conservation of forage and feed supplementation are important strategies to sustain animal farming systems in the cold season. Hay of cultivated forage, generally oaten (*Avena sativa*), and straw residues from crops, such as oat and barley (*Hordeum vulgare*) have been used as winter supplements by local farmers since the China Reform of 1978 (Wu 1996). In the agro-pastoral areas of the plateau, hay making is a universal and traditional way for fodder conservation. In purely pastoral areas of the plateau, herders normally buy oaten hay or highland barley straw from the agro-pastoral zone. However, only limited amounts of oaten hay are providedto lactating and weak animals throughout winter or to the whole herd during a severe snow disaster (Cai and Wiener 1995) when losses due to starvation frequently exceed 20% of a household's herds or flocks (Zhang and Zhang 2002); and most animals are not given any supplements during the cold season (Long *et al*. 1999). Local herders also harvest grasses from fenced winter pastures and conserve this as hay. Research has shown that supplying oaten hay or barley straw to yak herds during winter time could improve calving rate by 19 to 25%, and considerably reduce body weight loss compared to unsupplemented yaks (Long *et al*. 1999).

Silage with high nutritive value and palatability has been made by local farmers from either native grasses or crops. However, temperature during harvest in most regions is only 10 to 15°C and commercial inoculants do not produce well fermented silage (Zhang and De 2007). Local farmers have been asked to spray several indigenous inoculants *e.g.* diluted yak milk yoghurt, onto the wilted and chopped forage at ensiling in order to make high quality silage in this unique environment. Research has shown that feeding oaten silage to pregnant Tibetan sheep grazing pastures increased ewe body weight and lamb birth weight (Hua *et al*. 2012). Another study showed that supplementation of a native grass (*Elymus nutans*) silage to finishing Tibetan sheep is an economical and efficient way to improve daily weight gain on the Tibetan Plateau (Feng *et al*. 2009). Forage conservation or feed supplements in the growing season or in the winter/spring is a promising technology for many areas, and especially for those areas where snowstorms frequently occur.

Indonesia

Small holder farming, with average areas of 0.5 ha, is the predominant system in Indonesia. Small holder farms use a mixed cropping strategy, involving first sowing subsistence food crops (mainly paddy rice) in the rainy season, followed by cash crops (*e.g.* peanut, bean, maize) in the early dry season. As part of their farming system, farmers also raise a small number (2-5) of cattle. Indonesia's traditional beef production sector makes an important contribution to the country as the second largest contributor to meat supply (19%) after broiler chickens, as well as providing employment and income for over 4.57 million rural families.

Smallholder farmers rely on natural grass as the major component of cattle feed using the 'cut and carry' feeding system, which is time-consuming for farmers. High quality forage has become less available because previously uncultivated land is now being used for crops. When forage is scarce and of low quality *e.g.* during the dry season, cattle are under nutritional stress and low quality straw and locally purchased, available, cheap agricultural waste and by-products are often fed. Only a small number of farmers practice forage conservation. Various approaches to fodder conservation have been trialled and a number of forage conservation technologies including silage, urea-ammonia treatment of straw and hay production have been delivered to the small holder farmers in Indonesia. Both silage and urea-ammonia treatment of straw pose problems for farmers and are not widely used. A survey of 96 smallholder farmers in the district of Bulukumba, South Sulawesi showed that while the majority of farmers (56.25%) understand the principals of forage conservation, a sizeable proportion (43.75%) do not know how to conserve forage effectively.

Hay is the most promising technology that smallholder farmers have for cattle or buffalo feed, mainly in Java and some outer islands. Farmers commonly collect dry straw, mainly rice straw, and store it in a stall near their house. Priyanti *et al*. (2012) reported that about 74% and 80% of farmers in lowland and upland East Java, respectively collected rice straw from their own and other fields, while 24% of farmers purchased from other farmers or agents. Farmers also collect peanut, mungbean, and corn stover. Farmers often fed the straw plus other supplements such as rice bran, tofu waste, or tree legumes to meet animal nutrient requirements. This is in line with current findings that supplementation strategies improve the utilization of low quality forage by animals. For example, Syahniar *et al*. (2012) reported that supplementation with tree legumes at a level of 2.8 g DM/kg BW per day was sufficient to meet the maintenance energy requirements of Ongole cows fed rice straw *ad libitum*. Morever, Marsetyo *et al*. (2012) suggested that addition of Gliricidia or a mixture of copra meal and rice bran increased feed digestibility and live weight gain of Bali calves given Elephant grass hay or corn stover as a basal diet. Such integration between animal and crop production is a traditional practice in the villages but could be improved through education on how to create more nutritious diets.

There has been no economic evaluation of the impact of forage conservation practices on beef cattle smallholder farmers. The only observation in Central Sulawesi and South Sulawesi on forage management indicated that conserved forages, mainly hay making of straw (rice, peanut, mungbean, corn stover), have led to a substantial labour savings by decreasing time feeding from 4-6 hours down to 1-2 hours/day. With better feeding management, the body condition of cattle improves, which leads to a better price when sold. The additional income is used to purchase goods such as motorbikes that are then used to take children to school, and for carrying forages, thus saving even more time, or in some cases, allowing small holders to take off-farm work. Hay making has led to an increase in the price of straw which also potentially provides a source of additional income to farmers.

Kenya

Kenya has a national dairy cattle herd estimated at about four million (MoLD 2011) and about 80% (Friesians, Ayrshires, Guernseys, Jerseys and their crosses with local zebus) are found on small-scale farms and produce about 80% of the marketed milk. Kenya experiences a bimodal rainfall pattern and the distribution of livestock feed closely follows this pattern resulting in periods of feed shortage between the rainy seasons. The situation is worsened with to frequent droughts. Therefore, there is a need to conserve the excess feed produced during the rainy season to stabilize feed supply throughout the year.

Forage conservation is done as standing hay (particularly in the Arid and Semi-Arid Lands (ASALs)), baled hay or silage. There are certain feeds available on these farms which would be more suitable to conserve as silage than as hay; maize stalks, surgarcane (*Saccharum officinarum*) tops, Napier grass (*Pennisetum purpureum*) and sorghum (*Sorghum bicolor*) stover. However, the major limitation to the use of these methods by small-scale farmers is the lack of simple and appropriate technologies for hay baling and ensiling.

In Kenya, drying as the means of conserving grass species has been a common practice, but currently, ensiling of various forages is being promoted by several government agencies and other development partners. Production of high quality hay, by harvesting at full maturity, increases yield of grass per unit of land. The technology of ensiling forage in nylon bags has been taken up in some smallholder production systems but there are various constraints to adoption These include the high cost of the bags, lack of suitable choppers and inappropriate storage resulting in losses of ensiled material to rodents. Ensiling using large plastic bags placed horizontally can be an alternative for medium and large scale farms, but small scale farmers find this a challenge. For the small holder farmers, tube silage is recommended especially where the farmer has a small quantity of material to ensile. One tube can hold up to 500 kg, however smaller tubes are also available and the size chosen largely depends on the quantity of material to be ensiled. Where a farmer has a larger quantity of forage to ensile the above ground (silage bun) method of making silage is preferred.

Smallholder farmers in Kenya are increasingly making tube silage, a low cost procedure which requires high quality fodder, a silage tube (polythene tube 1000' gauge), molasses and polythene sheet gauge 500. One tube may contain from 350-500 kg of silage or compacted material and therefore becomes difficult to move. When the tube is full and tied at both ends, the farmer has a large cylindrical airtight bag in which the forage mixture ferments, turning into silage. The technology works with a wide range of green fodder. The ensiled material will be ready for use in the dry season after 3 months and can be conserved for even 30 years without losing quality provided the airtight seal remains intact.

Pakistan

Pakistan has an estimated 160 million ruminant livestock, comprising of buffalo, cattle, goats, sheep and camels, but is not self-sufficient in milk, meat and other products of animal origin. More than 90% of all ruminant livestock are integrated with small-scale mixed farming systems (Devendra and Thomas, 2002; Thomas *et al*. 2002). Pakistan is the fourth largest milk producer in the world (34 billion litres per annum), but productivity is low due to poor nutrition, poor management and neglect of health problems which results in late maturity, extended calving intervals and low milk production (Farooq, 2011). More than half (51 %) of total revenues from dairy sales are accrued by smallholders having 1-4 animals, with each of these house-holds generating a monthly income of US$60 to $240. Approximately 60% of the milk produced by smallholders is consumed at home, and the remaining 40% is marketed (FAO 2011).

Fodder scarcity is the core constraint, with current supply 40% less than demand and there are two periods of severe scarcity each year; May to June and October to November. Farmers rely heavily on low quality crop residues (Thomas *et al*. 2002); approximately 40 million tons (46% of the total animal feed resources) of crop residues are fed annually. Yields of traditional forage crops are less than half to a quarter of potential for improved hybrid varieties when grown with traditional agronomic practices. Improved varieties grown with recommended farming practices have a yield increase of around 75% (Din 2008).

Silage technology was introduced into Pakistan almost two decades ago by different government and international agencies, and also private sector companies like Nestlè Pakistan and Pioneer Seeds. However, despite heavy inputs in terms of time and money, uptake of silage technology has been less than hoped for in traditional livestock feeding and production systems. This is because, in many parts of the country, smallholder farmers are still able to feed crop residues and agricultural by-products during the dry season. However, more recently maize and sorghum silages have become more popular with a key group of smallholder farmers that have the necessary skills and are able to routinely produce well-fermented silage. Berseem silage making is also getting acceptance in the farming community though the high moisture content at the time of silage making can be problematic.

Silage making systems include Little Bag Silage (LBS), where forage is ensiled in strong plastic bags with a capacity of 5 kg of chopped green forage (Lane 1999). LBS allows conservation of available fodder in small quantities over a long period of time and is suitable for the small farms producing only a couple of bags over a 100 day growing season. Silage making in small (1.2 m x 0.7 m) drums was extensively promoted by Pakistan Dairy Development Company (PDDC) to a group of model smallholder farmers during 2007-2008 with training provided. Chopped maize, sorghum and berseem were ensiled successfully and produced excellent results when fed to livestock. Milk production remained steady throughout the year, was better than for neighbouring farmers, and with surplus silage being available for sale. Farmers are now prepared to buy silage, indicating a willingness to feed silage, but a lack of awareness on how to make it. Smallholders could now engage in entrepreneurial activity and produce silage as a marketable commodity.

Rwanda

Agricultural production in Rwanda is based on mixed crop-livestock production (Rutamu 2004) and feed resources remain a major constraint to livestock development. Grazing lands are sharply shrinking because of encroachment of crop cultivation with increasing human pressure (Mutimura and Everson 2011). As landholdings are small, with over 60% of households cultivating less than 0.7 ha, livestock owners practise zero-grazing (cut and carry). Napier grass (*Pennisetum purpureum*), introduced in the 1970s, is adapted to the cut-and-carry system, and it constitutes 95% of animal feed resources (Staal *et al*. 1997; Kamanzi and Mapiye 2012). Herbage production is high but its nutrient concentration is too low for dairy cows.

Other feed resources like fodder trees (*e.g. Leucaena* sp., *Calliandra* sp.) are used to supplement the Napier grass. Grasses including *Chloris gayana*, *Brachiaria* sp. and *Cenchrus ciliaris* are also used by large and smallholder farmers (Lukuyu *et al*. 2009), as are crop residues such as sweet potato vines, banana leaves and banana pseudo stems, stovers and straws. Except for Napier grass (*Pennisetum purpureum*) which is conserved as silage, other grasses eg. *Chloris gayana*, *Cenchrus ciliaris*, *Brachiaria* sp. are conserved as hay (Mutimura *et al*. 2007, unpublished). Farmers rely heavily on these feeds as a strategy to cope during the dry season (Kamanzi and Mapiye 2012).

Forage conservation has been challenging for farmers in Rwanda, especially smallholder farmers who have limited land size. For example, when ranking feed resources in central and southern plateau areas of Rwanda, Kamanzi and Mapiye (2012) found that conserved feed was the feed resource least used by smallholder dairy farmers. However, in peri-urban areas, dairy farms (small or large) use silage to feed their dairy cows (Nyiransengimana and Mbarubukeye 2005).

Lack of technical skills has been identified as the cause why farmers fail to adopt forage conservation and this stops farmers from coping with feed shortages, especially during the dry season (Lukuyu *et al*. 2009). Except for isolated research results, Rwanda has very limited experience with the treatment of crop residues to improve quality, especially digestibility and intake. However a recent experience in Rwanda proved that ammoniated straw based rations for feedlot beef production is economically feasible even when using indigenous Ankole steers (Mpangwa *et al*. 2010).

A seed bank of improved forage has been developed in Rwanda to increase quality forage production. The use of improved forages was adopted by at least 5,000 dairy farmers, and subsequently imports of protein-rich concentrates were reduced by 30% (Ndabikunze 2004). About 50 farmers are generating income from sales of hay in the Eastern Province of Rwanda while more than 200 farmers in the Western Province get income from sales of fresh Napier grass to dairy farms who use it to make silage (Mutimura and Ebong 2010, unpublished data). This technology has been coupled with the use of conserved crop residues as roughage to satisfy to ruminant feed supply. Different technologies for conserving forage/feeds are available in the country, and improved forage cultivation and conservation, including hay and silage making technologies have been disseminated to smallholder and commercial dairy farmers. Farmers' capacity to apply the introduced technologies has been enhanced through a series of training workshops and practical on-farm training sessions (Ndabikunze 2004).

Discussion

Growth in the agricultural sector in developing countries has been identified as the key to poverty alleviation (Cervantes-Godoy and Dewbre, 2010). Improving livestock productivity through improved nutrition is a critical component of this growth. Access to more and better quality forage provides the resource needed for improved livestock nutrition on smallholder farms. Given the constraints of land, water and the need to produce food for human nutrition this will require access to improved, higher yielding and adapted forage varieties combined with better management to achieve potential yields. In addition, access to high quality forage year round by smallholder farmers will require production of surplus forage that can be conserved as either hay or silage, and stored for use when forage quality or quantity is limiting.

Smallholder farmers still need to be encouraged to adopt better forage production, conservation and feeding technology to improve animal production. This will require targeted extension services with clear goals. Forage conservation systems will need to be tailored to the specific needs of the different farming systems, be low cost and provide safe storage methods that are without risk of damage *e.g.* from rodent attack.

In areas where hay making is difficult due to wet weather or low temperatures, and for certain crops *e.g.* maize, the preferred means of conservation will be ensiling ('t Mannetje 2000). Farmers making silage will need additional skills because a number of factors influence fermentation quality. Fermentation quality is important because poorly fermented silage is unpalatable and, even if high in energy and protein will only support low intakes. As a result milk production or liveweight gain will be low.

Conclusion

Despite a diverse range of environments and situations, experiences in production of high quality forage, forage conservation and developing local feed resources have been proved as an efficient way to increase livestock productivity, and the livelihoods of smallholder farmers, in developing countries.

Acknowledgments

The authors wish to thank their respective organisations and all partner organisations that have been involved in research and extension of the strategic utilisation of forage production and conservation technologies with the goal of increasing livestock productivity on smallholder farms. – Australian Centre for International Agricultural Research; Kenya Agricultural Research Institute; Lanzhou University, China; New South Wales' Department of Primary Industries, Australia; Pakistan Dairy Development Company; Rwanda Agriculture Board and Tadulako University, Indonesia.

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