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Candidate fodder trees and shrubs for sustainable ruminant production in northern Ghana

Franklin Kodzo Avornyo, Robert Zougmore[1], Samuel Partey[1] and Kevin Tengan

Council for Scientific and Industrial Research, Animal Research Institute, P O Box 52, Tamale, N R, Ghana
favornyo@yahoo.com
[1] International Crops Research Institute for the Semi-Arid Tropics, Bamako, Mali

Abstract

A survey was done to document preferred browse plants and farmers' knowledge about them for sustainable ruminant production in northern Ghana. The study was done in Jirapa and Lawra Districts of Upper West Region of Ghana. A questionnaire was used to interview 50 farmers per district. Tables and graphs were drawn to summarize results.

Ruminant production was a predominantly male occupation (p=0.032). It was also in the domain of the lowly educated (p=0.003). Ninety-seven percent (97%) of the respondents had goats with about half of them having sheep and 17% owning cattle. The overriding (99%) reason for rearing ruminants was to serve as a source of income. In the dry season, ruminants were kept on free range. In the wet season, small ruminants were tethered with or without feed supplementation. A total of 34 browse plants were identified and the most frequently browsed were Fadherbia albida, Ficus sycomorus gnaphalocarpa, Afzelia africana, Pterocarpus erinaceus, Combretum molle and Annona senegalensis. Paramount among the challenges faced by the owners were limited grazing land, feed scarcity and theft. Apart from being fodder sources, the identified browse species were soil improvers, medicinal and human food sources. All respondents grew crops and the most frequently cultivated crops were groundnut, maize, cowpea, bambara groundnuts, sorghum, millet, rice and yam in this decreasing order. Ninety percent (90%) of the respondents fed crop residue to their animals, with the commonest, groundnut haulm, fed by about 80% of the respondents. Twenty-eight different types of trees/shrubs were identified on respondents' farms.

Keywords: *browse, climate change, feed, integrated systems, multipurpose*

Introduction

Livestock production employs over 60% of rural households in the three northern regions of Ghana (MOFA 2012; Panyan et al 2012), making investment in this industry critical for alleviating poverty and enhancing food security. Among other factors, Avornyo et al (2007) reported access to sustainable feed supply as one of the livestock industry's key constraints. As most livestock are kept on a free-range system, forage of fair nutritive value is normally scarce in the dry season due to prolonged droughts, continuous over-grazing and lack of range improvement interventions (Konlan et al 2016). As a result, highly palatable and productive perennial grasses, legumes and herb species have been replaced by unpalatable, low quality annual species, with a concomitant loss of soil fertility (Estell et al 2014). The nutritive value of the remaining predominant pasture species is very poor with an average crude protein (CP) content of less than 7%, and grazing livestock are deficient in about 50% of their required CP intake (Khan and Habib 2012). In addition, due to seasonal rainfall, the year-round feed availability and quality in these rangelands fluctuate substantially. For example, pasture abundance increases with a concurrent improvement in quality in the rainy seasons, whereas pasture abundance and quality generally decline in the course of prolonged dry periods. During pasture scarcity periods, livestock are fed on cereal crop residues and low-quality rangeland hay. These low quality forage based diets impede livestock productivity due to lower dry matter (DM) intake, and lower digestibility and nutritive value of ingested feed.

Research has established that supplementation of CP, minerals and energy-rich feeds optimizes microbial fermentation of low quality fibrous feeds in the rumen which in turn increases total DM intake and improves animal productivity (Khan et al 2009; Patra 2010). However, in the predominant small scale, subsistence farming systems in the northern regions of Ghana, most of the farmers cannot afford a continuous supplementation of concentrate feeds to their animals. Recent research is therefore directed towards the exploration of an affordable and abundant, alternate CP and energy-rich feeds. In this regard, tree leaves have received increasing attention, due to many advantages such as supply of good quality green fodder during the dry periods, and high CP and mineral contents (Khan and Habib 2012; Habib et al 2013). Recent findings show that tree leaves can be more efficiently utilized as a low-cost CP and mineral supplement to the low-quality fibrous diets in the tropics, particularly during the prolonged feed scarcity periods (Patra 2010). Considering this need, the Consultative Group on International Agricultural Research (CGIAR) Program on Climate Change, Agriculture and Food Security (CCAFS) has used Climate-Smart Village (CSV) models in Ghana to promote the adoption of Climate-Smart Agricultural (CSA) interventions such as agroforestry and farmer managed natural regeneration practices that promote the management of useful fodder tree and shrub species. It is envisaged that the adoptability and wider applicability of the aforementioned tree-based CSA practices will dwell on knowledge about priority fodder species in the CSV communities and evidence of their nutritive characteristics. While various authors have documented potential fodder species in the project areas, less is known about farmer perceptions of their use, priorities among livestock producers and the nutrient supply capabilities of the fodder species. Data on the above is crucial for strategic livestock farm technology development, feeding and supplementation to livestock ration in the region.

The study was designed to:

- Identify predominant livestock feeding practices in the study area
- Document priority fodder species and assess farmers' ethnobotanical knowledge about them
- Identify and characterize integrated tree/crop-livestock production systems in the study area

Methodology

Study location

The geographical focus of this study was Lawra and Jirapa Districts of Upper West Region of Ghana. Lawra District lies between latitude 10^{o} 35'-10^{o} 40' North and longitude 2 ^{o} 50' - 2^{o} 53' West while Jirapa District is located within latitudes 10° 25' and 11° 00' North and longitudes 2° 25' - 2° 40' West. The districts have mean annual temperatures ranging between 28°C and 31°C. During the months of June to October, the districts experience a single rainy season induced by the moist monsoon winds with an intensity of 1,000-1,100 mm per annum and relative humidity ranging between 70 and 90% but falling to 20% in the dry season. The area is occupied by one main indigenous ethnic group namely the Dagaaba who speak slightly varying dialects of the Dagare language.

Questionnaire administration

A combination of desktop review, questionnaire interviews and direct field observations were used. With the assistance of the staff of the Department of Agriculture of the two districts, 100 smallholder farmers were randomly selected such that 50 were from each district. For questionnaire interviews, data was collected on the types of ruminants reared by farmers, feeding practices, common and priority feed sources, feeding experience across seasons, ethno-botanical knowledge on prioritized fodder trees and shrubs and crop-livestock integration practices.

Data analysis

Chi-square was used to compare actual values against expected values. Paired T-Test was also used to separate means. Tables and graphs were plotted for summary of the results.

Results and discussion

Demographics

With 21% of the respondents being female, rearing of ruminants was predominantly a male activity ($p=0.032$) in the study area. Ansah and Nagbila (2011) made a similar observation in the Upper East Region of Ghana. However, Ogunlana et al (2006), in their study in South Western Nigeria, reported that most small ruminants were owned by women. Seventy-two percent (72%) of those who reared ruminants had no formal education. About 19% of them had primary education, 8% had secondary education and 1% had tertiary education. Long distance to school was cited as one reason for the low literacy rate. This was irrespective of gender.

Livestock production system

All the female respondents kept goats, but only 38% of them had sheep and none had cattle. For the men, 96% had goats, 61% had sheep and 22% had cattle. Generally, preference was for goats in the ratio of 3.4:3:1 for goat, sheep and cattle, respectively. Goats were cheaper to acquire, more difficult to steal and exercised better nutritional wisdom, for example, by avoiding the consumption of polythene material, when compared to sheep. While ruminant population worldwide has increased by about 48% in the past 50 years, that of goat has doubled in 30 years, mainly because of their increased production in Africa and Asia (Estell et al 2014). Goats have wide-ranging feeding habits and have a wide choice of feedstuffs including browse which characteristically are perennial and therefore available even in the dry season (Agrawal et al 2014; Preston and Gomez unpbl). They are also less sensitive to environmental changes, more resistant to dehydration and more efficient in fibre digestion (Agrawal et al 2014).

In the dry season, their sheep and goats were left on free range. Cattle were herded throughout the year occasionally with sheep. Semi-intensive system was not a common practice in both dry and wet seasons. The common practice in the wet season was tethering of sheep and goats on communal grazing land to graze soilage with or without feed supplementation.

The overwhelming reason (99%) for rearing ruminants was for storage of wealth and depending on it to settle school fees, hospital bills, buy farm inputs, clothing, housing construction, food ingredients particularly during the farming season, source of meat at festivities and during sacrifices, and also so as to reduce the need for farm families to sell food crops reserved for home consumption. The farmers rarely considered ruminant rearing a business enterprise even though most of their animals were sold. However, the younger respondents appeared to be more commercially-oriented than the older respondents. Compared to the women, the men appeared to be more commercially-oriented. Also respondents with a higher level of education appeared to be more commercially-oriented. When the different marital statuses were compared, it appeared that the widowed were more commercially-oriented, and families with 4 to 6 dependants seemed to be more commercially-oriented than the other family types (Figure 1). These values however were all not statistically different.

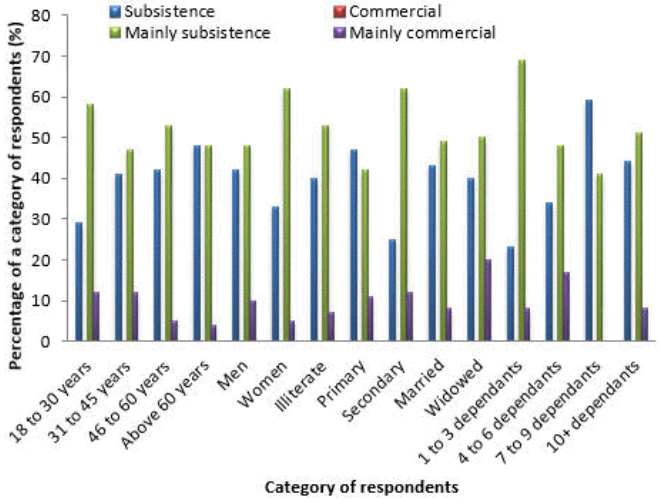

Figure 1. Ruminant production objectives of various categories of respondents

According to the respondents, the most frequently browsed plants on both free range and under intensive system included Faidherbia albida, Ficus sycomorus gnaphalocarpa, Afzelia africana, Pterocarpus erinaceus, Combretum molle and Annona senegalensis (Figures 2 and 3). All these species were indigenous (Table 1). Mulatu and Kassa (2001) identified F. albida as highly preferred by farmers in Ethiopia. Generally, exotic species such as Leucaena leucocephala and Albizia lebbeck tended to have higher crude protein content than their indigenous counterparts, and therefore might be more degradable (Larbi et al 1998). This notwithstanding, indigenous species appeared to have more uses (Mulatu and Kassa 2001). Apart from being fodder materials, the presence of anti-nutritive factors in these species confers some medicinal properties on them (Ansah and Nagbila 2011; Ziblim et al 2013; Saganuwan 2017) (Table 2). Also the presence of these factors could contribute to a reduction in the production of methane and ammonia gas when the plants are consumed by ruminants (Estell et al 2014; Maselema and Chigwa 2017). Studies on 15 fodder species in India however showed that they were suitable as ruminant feed as most of them contained less than 5% condensed tannin (Das et al 2010). Binh et al (2017) have demonstrated that brewers' grains, as additive, has the ability to enhance the capacity of rumen microbial populations and immune system to neutralize most anti-nutritive substances in browse plants. Feed residue resulting from supplementation of browse constitutes a suitable resource for the production of biochar which is able to adsorb microbial flora and fauna as well as plant nutrients and carbon by sequestering atmospheric carbon dioxide into the soil (Preston and Gomez unpbl). When tested on livestock, improvements in the growth of cattle were reported when biochar formed 1% of their diet (Sengsouly and Preston 2016). Apparently, biochar, like brewers' grains, has a detoxifying effect on browse plants.

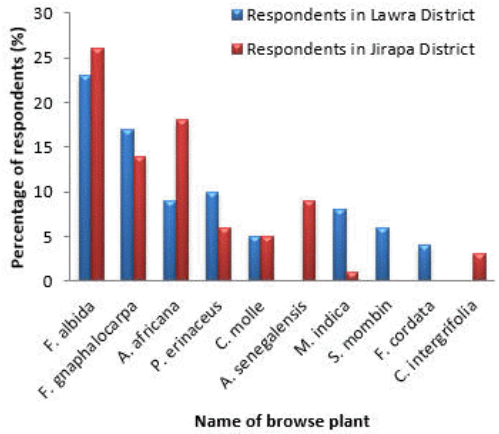

Figure 2. Ten most commonly browsed plants in the study area

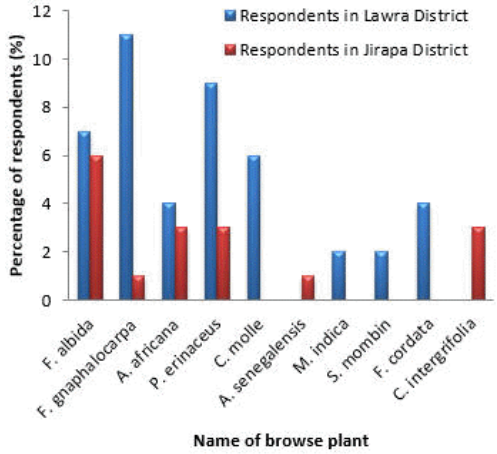

Figure 3. Common feeds offered under intensive system

Table 1. Identification of fodder species

No.	Scientific name	Common name	Local names (Dagare)	Characteristics
1	Faidherbia albida	White acacia	Gozanga/Gozan	Deciduous multipurpose tree that sheds its leaves in the wet season
2	Ficus sycomorus gnaphalocarpa	Mulberry fig	Kakanga	Semi-deciduous multipurpose tree; edible; medicinal
3	Ficus cordata subsp. lecardii		Kankantechira/Kankanwie	Multipurpose shrub or tree
4	Cordia myxa	Sapistan plum	Tongbo/Tangbon	Evergreen multipurpose shrub or tree; fruits eaten; for glue
5	Pterocarpus erinaceus	African kino	Nyaga/Neiga/ deega/Ligah	Deciduous multipurpose tree
6	Combretum molle		Lingbira/Damui	Evergreen to deciduous multipurpose shrub
7	Magifera indica	Mango		Evergreen multipurpose tree; edible
8	Blighia sapida	Akee	Kyiraa	Evergreen multipurpose tree
9	Hibiscus sabdariffa	Roselle	Biri	Annual to perennial multipurpose woody plant
10	Vitex doniana	Black plum	Haara/Agna Aanna /Oorna Leaves called banigbe/bornabe	Deciduous multipurpose tree
11	Afzelia africana	African mahogany	Kakala	Deciduous multipurpose tree; not used as fuelwood as it causes sickness; used in the establishment of sacred groves
12	Annona senegalensis	Wild/African custard apple	Baantang/ Bentaora	Deciduous multipurpose multi-stemmed shrub
13	Khaya senegalensis	Dry-zone mahogany	Kog/ko	Evergreen to deciduous multipurpose tree
14	Celtis intergrifolia		Kyeo/kio	Evergreen multipurpose tree
15	Anogeissus leiocarpus	African Birch	Siktre/sigtir	Evergreen multipurpose shrub to small/medium size tree
16	Diospyros mespiliformis	West African ebony	Gaa	Evergreen multipurpose shrub to tree
17	Adansonia digitata	Baobab	Tuo	Deciduous multipurpose tree
18	Sclerocarya birrea	Marula	Bunununa/Busina	Deciduous multipurpose tree; gives vitality; leaves & fruits eaten
19	Tapinanthus globiferus subsp. bangwensis	African mistletoe	Taanwiel/Liridaa/Singbon	Partial plant parasite, medicinal
20	Detarium microcarpum	Sweet dattock	Kpalaa/kpagra	Deciduous multipurpose shrub or small tree
21	Bombax costatum	Red-flowered silk cotton tree	Vagatie/varor/vara/ Vagaa	Deciduous multipurpose tree
22	Vitellaria paradoxa	Shea butter tree	Tantie	Deciduous multipurpose small to medium-sized tree
23	Anacardium occidentale	Cashew	Tian	Evergreen multipurpose shrub or small tree
24	Azadirachta indica	Neem	Datuo/flower tie	Evergreen multipurpose fast-growing long-lived tree
25	Strychnos spinosa	Kaffir orange/Green monkey orange	Papalore/Panpalure/Pompuloro/Punpunluura	Deciduous multipurpose multi-stemmed shrub or small tree; fruits in the rainy season but no leaves
26	Cussonia arborea		Kontie/Konkongtie	Deciduous multipurpose tree; ruminants feed on flowers; not used as fuelwood because it increases appetite
27	Parkia biglobosa	African locust bean	Duor/ Dawadawa	Deciduous multipurpose tree
28	Crataevia adansonii	None	Donkuma/Dungnakuna	Deciduous multipurpose tree; food/feed/medicinal
29	Acacia nilotica	Tomentosa babool	Gorgor	Tree; leaves/flowers/fruits; thorny; medicine for human anaemia/stomach ulcer
30	Lannea microcarpa		Sensigre/ Ansigne/ Suge/sugo/ansigne	Deciduous multipurpose tree
31	Tamarindus indica	Tamarind	Pootie/ Pooray/Pooretie	Evergreen to deciduous multipurpose long-lived tree
32	Saba senegalensis		Ora	Multipurpose shrub
33	Manilkara multinervis		Kultanga/ Katanga	Deciduous multipurpose tree
34	Dichrostachys glomerata	Sickle bush	Sunsule/Susugle	Deciduous/semi-deciduous multipurpose shrub or small tree; for making xylophone; flowers are the edible part; thorny

Source of some of the information: Forestry Services Division, Lawra, Ghana; Arbonnier (2004); Fern et al (2014); CSIR - Animal Research Institute; Dr. B. N. Baatuuwie, University for Development Studies, Nyankpala, Ghana

The male respondents harvested a wider variety of browse plants for their animals compared to the women (Figure 4). Harvesting of browse was more a preoccupation of the men than the women, probably because the trees were tall and their fodder was difficult to access (Ansah and Nagbila

2011). The women harvested F. albida, A. africana, Celtis intergrifolia and Azadirachta indica (neem). Harvesting of C. intergrifolia and neem seemed to be predominantly a female activity. Celtis intergrifolia and neem were often located near the house. In Jirapa District, harvesting of A. senegalensis for ruminants did not seem to be a common activity (Figure 3) even though its consumption at range was quite significant (Figure 2). Often it was grazed at a tender age before it could grow into a mature shrub in the project community. According to Franzel et al (2003), the use of calliandra shrubs as a supplement or substitute for dairy meal increased profit margins of dairy farmers in Central Kenya.

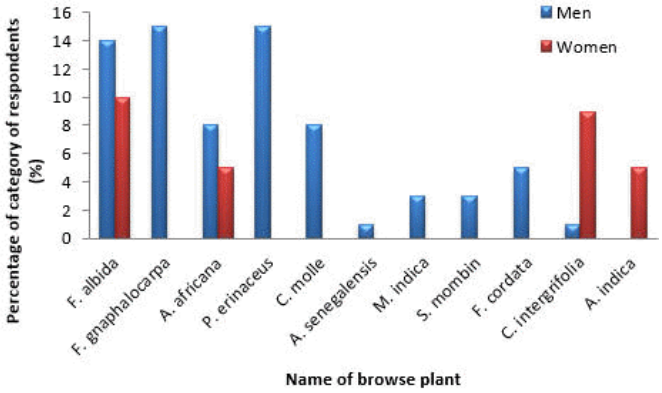

Figure 4. Common feeds offered by men and women in project communities

Paramount among the challenges mentioned was feed scarcity partly due to senescence of vegetation, limited grazing land, devastation by bush burning and heavy downpour interfering with grazing activity. Water scarcity, theft and drudgery were also highlighted. Women reported more theft/animal loss cases than the men ($P<0.005$).

Preferred fodder species and ethno-botanical knowledge

The leaves of A. senegalensis were used to bath newly born babies in order for them to develop strong bones and help babies to grow fat. It was also used to treat bone fractures (Table 2). The leaves of all 34 identified fodder plants were edible to ruminants. Apart from the leaves, the fruits of F. albida, Spondias mombin, F. gnaphalocarpa, C. myxa and V. doniana were also harvested and fed to ruminants. In some cases, the inflorescence was consumed as well.

Table 2. Additional knowledge on some of the identified fodder species

No.	Fodder	Additional knowledge
1	Faidherbia albida	Induces prolificacy in animals; medicinal/dewormer; enhances soil fertility; wood/fuelwood; fire resistant; seasonal and sheds its leaves in the wet season
2	Ficus sycomorus gnaphalocarpa	Pig feed; medicinal/dewormer; food; fuelwood; fire resistant; available year round
3	Cordia myxa	Food
4	Combretum molle	Medicinal/dewormer; fire resistant; seasonal; available in the wet season
5	Mangifera indica	Treatment of fever; food
6	Blighia sapida	Food
7	Vitex doniana	Medicinal; food
8	Afzelia africana	Induces prolificacy; dewormer; timber; fuelwood; fire resistant; available year round
9	Pterocarpus erinaceus	Induces prolificacy; medicinal/dewormer; for making xylophone; fuelwood; available year round
10	Annona senegalensis	Medicinal ; food; fire resistant
11	Celtis intergrifolia	Induces prolificacy; vegetable/food; fire resistant
12	Moringa oleifera	Medicinal
13	Spondias mombin	Gives vitality
14	Azadirachta indica	Feed tender leaves; fire resistant
15	Adansonia digitata	Medicinal
16	Detarium microcarpum	Induces prolificacy

Most of the aforementioned fodder plants were targeted for feeding to goats because most of the community members owned goats and fewer had sheep and cattle. Thapa et al (1997) have observed differential preference of fodder by the various ruminant species. According to Paterson (1993), while cattle show preference for soft-leafed fodder, goats prefer fodder with tough leaves, with sheep in-between these two. Respondents who claimed to experience feed shortage for their ruminants constituted 32% (a third) in the Lawra enclave but probably more at Jirapa (44%) (Figure 5). While the majority of those who experienced feed scarcity in Lawra District indicated that feed was relatively abundant in the wet season, the opposite was the case in Jirapa District. Fodder from F. albida and other fodder trees was abundant in Jirapa District in the dry season for feeding of ruminants.

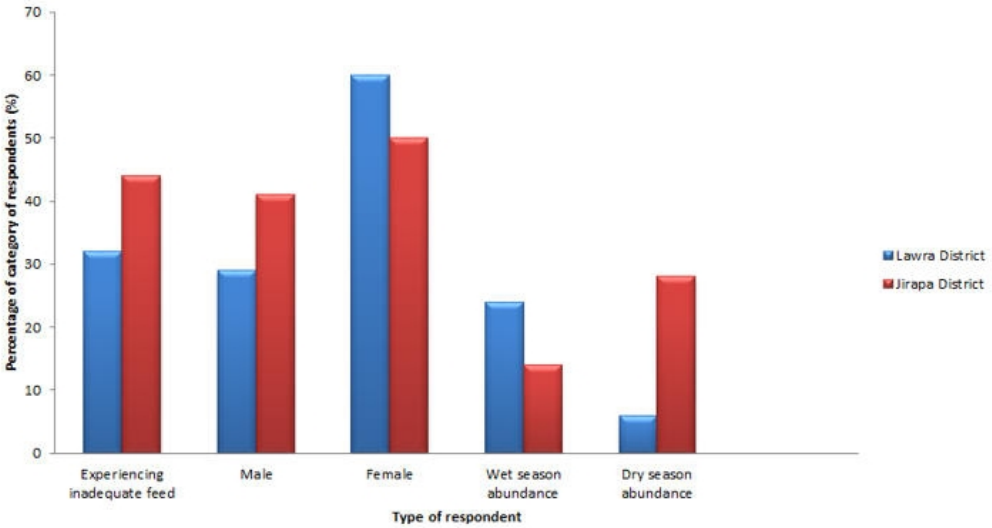

Figure 5. Extent of feed shortage in the project communities and periods of perceived abundant feed

Evidence of integrated production system

All one hundred (100) respondents grew crops alongside animal rearing. The more frequently mentioned crops were groundnut, maize, cowpea, bambara groundnuts, sorghum, millet, rice and yam listed in this decreasing order. Crops that were least mentioned were tomato, pepper, soybean, sweet potato, okra, cassava, Mucuna sp and Moringa oleifera. The most frequently cultivated crops by the female respondents were groundnut, maize, cowpea, bambara groundnuts, sorghum, millet and rice.

Ninety percent (90%) of the respondents fed crop residue to their ruminants. When the sample was separated into male and female groups, it was realized that 90% of respondents in each gender group fed crop residue. Feeding of crop residue might be an indication of increasing scarcity of feed at pasture for animals.

Groundnut haulm was observed to be the commonest crop residue given to ruminants in the study area, as it was fed by an average of about 80% of the respondents. Maize stover, mentioned by about 60% of the respondents was probably also offered to an appreciable extent. Crop residues which were fed by about 20 to 40% of the respondents included millet stalk, bambara groundnut vines, sorghum stalk and cowpea vines. Feeding of yam peel and potato vines was hardly mentioned because they were not commonly cultivated.

Management of trees on crop farms

Presence of trees on crop farms was very characteristic of the project areas. Declining availability of fodder trees and shrubs on communal lands as well as certain cultural practices would promote their availability and conservation on crop farms (Thapa et al 1997). Majority of the farmers did not have the capacity to cultivate a variety of tree species however awareness with regard to tending of multipurpose tree seedlings on farmlands, rangelands, around homes and fallow lands was imminent. This notwithstanding, there may be restrictions with planting of economic trees on leased lands (Ogunlana et al 2006). Solorio Sanchez and Solorio Sanchez (2002) reported that trees which were propagated by cuttings as opposed to seedlings tended to have shallow roots and therefore were more vulnerable to drought and wind.

Twenty-eight (28) trees/shrubs in total were listed as present on respondents' farms, and out of this number, 22 were ruminant feeds while 18 constituted foods for human beings indicating that some of these species were satisfying both needs. Actually, 15 species were characterized as both animal and human food sources (Table 3). These plant species served other needs as well, for example, soil fertility improvement, income source, timber, fuelwood, medicine, provision of shade, windbreaks, reducing soil erosion and inducing rainfall. During periods of food scarcity, which invariably coincided with the farming season, some of these plant species became significant food sources for the people. The most commonly mentioned tree/shrub species as present on respondents' farms were Mangifera indica, F. albida, Vitellaria paradoxa, Parkia biglobosa, F. sycomorus gnaphalocarpa, Blighia sapida, Anacardium occidentale, Diospyros mespiliformis, A. africana and M. oleifera, listed in this decreasing order. However, in terms of plant population, V. paradoxa probably had the highest density.

Table 3. Trees/shrubs maintained or cultivated on crop farms

No.	Tree/Shrub	Reason
1	F. albida	Animal feed; income generation; soil fertility improvement; mitigate soil erosion; windbreak; fuelwood shade
2	F. sycomorus gnaphalocarpa	Animal feed; soil fertility improvement; fuelwood; shade
3	Cussonia arborea	Animal feed; increases rainfall
4	Cordia myxa	Animal feed; human food
5	Combretum molle	Animal feed; soil fertility improvement
6	Mangifera indica	Animal feed; human food; income generation; shade
7	Blighia sapida	Animal feed; human food; shade
8	Hibiscus sabdariffa	Animal feed; human food
9	Vitex doniana	Animal feed; human food
10	Afzelia africana	Animal feed; soil fertility improvement; fuelwood
11	Pterocarpus erinaceus	Animal feed; soil fertility improvement; fuelwood; shade
12	Celtis intergrifolia	Animal feed; human food

13	Anacardium occidentale	Animal feed; human food; income generation
14	Vitellaria paradoxa	Animal feed; human food; income generation; shade
15	Parkia biglobosa	Animal feed; human food; income generation; fuelwood
16	Moringa oleifera	Animal feed; medicine; human food; soil fertility improvement
17	Crataevia adansonii	Animal feed; shade
18	Tectona grandis	Income generation; wood; shade
19	Cajanus cajan	Animal feed; fuelwood; human food
20	Acacia nilotica	
21	Diospyros mespiliformis	Animal feed; human food; fuelwood
22	Lannea acida	Animal feed; human food
23	Orange	Human food
24	Azadirachta indica	Fuel wood; shade
25	Adansonia digitata	Animal feed; human food
26	Detarium microcarpum	Animal feed; human food
27	Psidium guajava	Human food
28	Saba senegalensis	Human food

There was a tendency for species that constituted food items or were potential sources of cash to be mentioned more frequently by the respondents as present on their farms. Of the 10 most common tree and shrub species found on their farms, seven served as both food and animal feed for the respondents. Moringa oleifera, P. biglobosa and B. sapida appeared to have been identified by the women more than the men.

Conclusion

- The common and preferred fodder tree and shrub species by the respondents were F. albida, F. sycomorus gnaphalocarpa, A. africana, P. erinaceus, C. molle and A. senegalensis.
- Three of them, namely F. albida, F. sycomorus gnaphalocarpa and A. africana were among the commonest trees and shrubs present on farms. In the process of developing technologies that would increase fodder availability, due cognizance must be taken of farmers' interest in having multipurpose tree species.
- There may be the need to develop community nurseries to nurse seedlings of important fodder tree species for enrichment planting.

Acknowledgements

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