Paper 13: Cropping systems in the subhumid zone of Nigeria

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Abstract

Given the projected rise in population and subsequent increase in cropping across the subhumid zone of Nigeria, innovations are needed that mutually benefit both crop and livestock sectors. An understanding of representative cropping systems is necessary in order to identify constraints and develop appropriate techniques for increasing the quantity, quality and availability of feed resources while assuring that subsistence needs are still met. To this end, baseline studies have been conducted with traditional crop farmers and Fulani agropastoralists to define current cropping patterns, management and yields, and the constraints to increased grain and forage production.

The prime aim of both farming and pastoral ethnic groups in cropping is to meet household consumption needs. For the Fulani, this is to reduce the need to sell animals for purchasing grain. Sorghum, maize and millet are the principal grain crops for both farmers and Fulani, although farmers also grow soyabeans, ginger and groundnuts for sale. Cropping patterns are typical of these throughout the zone; intercropping is prominent and a variety of cereals, pulses and tubers are grown. Soyabean and maize appear to be increasing in importance in the cropping pattern of farmers. Millet is apparently becoming less important.

The farmers in Abet still practice fallowing, although the availability of chemical fertilizer and the added labour involved in opening up fallow lands have resulted in more permanent cultivation of fields. Competition for labour between cropping and livestock husbandry seems to exist in the Fulani agropastoral system in Kurmin Biri.

Grain yields of farmers are comparable to those in other subhumid locations in Nigeria. The Fulani, who rely principally on cattle manure and experience competition for labour with cattle management, still attain comparable yields to the specialized farmers, who almost exclusively use chemical fertilizer.

Introduction

Crop production can be increased by improving yields or by expanding the area under cultivation. In Nigeria's subhumid zone, where population is rising rapidly and supplies of inputs are limited, the most common response is to cultivate more land. As the area under cultivation increases, prime grazing areas will diminish, with ruminant livestock becoming more and more dependent on fodder obtained from cropland. With the reduction in fallowing, or in some cases its complete disappearance, the role of livestock in maintaining soil fertility through manure could become an important factor in sustaining productivity in many parts of the zone. Likewise, the use of animals as a source of power and transport can greatly increase the returns to labour in cropping. This paper presents a general discussion of cropping systems across the zone and the results of in-depth studies carried out on the cultivation practices of indigenous crop farmers and Fulani agropastoralists in the ILCA case study areas of Abet and Kurmin Biri.

General description of cropping systems

Cropping systems across the zone are characterized by tremendous diversity. The predominant form of crop husbandry in the case study areas is the rainfed cultivation of annual cereal crops. Areas under cultivation are generally small (2 to 4 ha), the primary objective of farmers being to meet subsistence needs. Surplus crops, however, are sold and some cash crops may be grown.

Because cropping operations are almost exclusively done manually, labour is the major input. The amount of land cultivated annually per household is therefore a function of family and/or hired labour availability during periods of peak demand, namely during land preparation and weeding. Although this labour constraint is the critical factor in many parts of the subhumid zone where population densities are low, in areas of high population concentration land is the limiting factor. Norman (1978), working in three villages in the northern part of the Nigerian subhumid zone, found that farm size is inversely related to population density. Similar relationships in the subhumid zone of Benin and Togo have also been found (Steiner, 1982). In areas of high population density, the return per unit area, rather than the return per unit labour, becomes the critical production factor (Burnham, 1980).

As in much of sub-Saharan Africa, intercropping, or the simultaneous cultivation of two or more crops on the same piece of land, is common throughout the zone. Norman (1974) reviews the numerous physical and technical advantages of intercropping over sole cropping. The main advantages mentioned by farmers relate to maximizing returns from limited resources and stabilizing income over time (Abalu, 1976). The range of local climatic and soil conditions, resource availability, and markets or farmers' tastes and preferences allows a wide variety of cereal, pulse and tuber crops to be grown. The zone's long growing period of 180 to 270 days accommodates the predominant crops of the north, including sorghum, millet, groundnuts and cowpea, as well as yams, cocoyams, cassava, rice and maize in the more humid south. A variety of subsidiary crops and vegetables are also grown.

By combining crops of different growing periods, farmers develop highly diversified cropping patterns involving as many as 5 to 6 but more commonly 2 to 3 crops in a mixture (Okigbo and Greenland, 1976; Steiner, 1982). The most complex mixtures and highest yielding plots are small areas close to the household where soil fertility is maintained at high levels through concentrated additions of animal manure, night soil, household sweepings, ash, etc. The complexity of crop mixtures, as well as crop yield, generally decline in fields more distant from the household. In these fields, yields are generally proportionate to the additions of organic manure and chemical fertilizer and the levels at which crop rotations and fallowing are practiced.

The zone's relatively high rainfall subjects soils to leaching and erosion, with a consequent loss in productivity if cultivated continuously. Fallowing is commonly practiced as a means of maintaining land at a steady productive level without its undergoing severe or progressive degradation. When the fallow period is long enough in relation to the cropping period on the given soil type, natural vegetation restores soil organic matter, nutrient status and structure, and suppresses weeds, pests, and/or diseases that may have been a problem during cropping years.

Ruthenberg (1980) describes agricultural systems in the subhumid zone as being in transition between shifting and permanent cultivation: the frequency of cropping is increasing and fallowing is decreasing. In these systems, the cultivation factor R[1/] is 30 to 40, with loss of soil fertility being a particular problem. In areas of high population density where land is the limiting factor, the length of fallow periods is greatly reduced or the practice abandoned altogether. The opportunity cost of leaving land idle is high and farmers are encouraged to surrender their usufructuary rights to fallow land (Norman, 1978). In low population areas, the limited labour supply is concentrated on cultivating the most productive lands, leaving less productive land to regenerate. Shifting cultivation, typified by slash-and-burn, and involving the movements of whole communities from one site to another every few years, is today found only in isolated areas within the subhumid zone of Nigeria.

[1/ $R = \frac{\text{crop years} \times 100}{(\text{crop years} + \text{fallow years})}$]

Young and Wright (1980) have determined fallow period requirements for the major soil types of the savanna zone (i.e. 180 to 270 growing days) at different levels of inputs (Table 1). Even at high input levels, all soils would require some fallow period to maintain productivity. The uncertain availability and expense of the necessary inputs to maintain soils at high or even medium fertility levels limit the use of such inputs by most farmers. Soils in the zone therefore require fallowing. The optimum length of the fallow period can be reduced by the application of organic manure, if this is available in sufficient quantities.

Table 1. Cultivation factors (R values) of soils in the savanna zone of tropical Africa.[a/]

Soil type	Input levels[b/]		
	Low	Intermediate	High
Regosols, Arenosols, Acrisols	15	35	65
Ferralsols	15	35	70
Luvisols	30	50	75
Nitosols	30-55	80	90
Cambisols	50	60	85
Vertisols	55	75	90
Fluvisols, Gleysols	70	80	90

[a/] R = number of crop years x (100)/(crop plus fallow years). The savanna zone corresponds to the area where the growing period is 180 to 270 days.

[b/] Low = traditional methods of farming with no use of chemical fertilizers or transported organic manure.

Intermediate = use of improved agricultural techniques but limited technical knowledge and/or capital resources. Fertilizers at levels of 50-100 kg/ha of nutrients and/or practicable amounts of organic manure.

High = modern methods with advanced technology and high capital resources. Fertilizers at levels of maximum economic return, chemical weed control, adequate soil conservation methods.

Source: Adapted from Young and Wright (1980).

Cropping by farmers in Abet

The baseline information on cropping practices by indigenous farmers in Abet has been derived from 35 farming units representing a 15% sample in a 32 km area. The farming unit consists of one nuclear family and its land holding. Land used by these farm units can be divided into three general categories: small gardens adjacent to the compound, cultivated fields at various distances from the compound, and fallow lands that are generally furthest from the compound.

Cultivated areas

There is a large range in the number of cultivated fields per farmer and hence in the area devoted to crops among the 35 farmers, as shown in Table 2. On average, farmers cultivate between 1.5 and 3.5 ha, although some cultivate considerably more. When the area cultivated by the 35 farmers is extrapolated to the total farming population in the 32 km^2 area, it is estimated that 23% of the total land area is under cultivation. This corresponds closely to the 25% found by aerial survey (Milligan et al, 1979).

Table 2. Cultivated areas of crop farmers in Abet (1981).

	Farmers (No.)	Fields/farmer	Field total	Estimated area[a/]	
				Farmer (ha)	Total (ha)
	4	2	8	1.42	5.68
	6	3	18	2.13	12.78
	12	4	48	2.84	34.08
	6	5	30	3.55	21.30
	2	6	12	4.26	8.52
	2	8	16	5.68	11.36
	2	9	18	6.39	12.78
	1	10	10	7.10	7.10
Total	35		160		113.60

[a/] Estimated areas based on average field size derived from 41 fields or total cultivated areas of 16 farms where mean = 0.71, SD± = 0.49, range = 0.26 - 1.29.

A total of 23 crops combined in 64 cropping enterprises were identified in farmers' fields. Sorghum, millet, maize and soybeans are the most important crops (Table 3) and intercropping is the predominant practice although millet is almost exclusively sole cropped. Of the total enterprises, two crops in combination is the most common (38%), followed by three crops (26%), sole crops (25%), four crops (6%), and five crops (5%).

The long-season sorghum variety of the Guinea race (Sorghum bicolor) cultivated in Abet is the dominant type of sorghum in the savanna belt of West Africa (Harlan and de Wet, 1974), while a late variety of millet (Pennisetum typhoides) transplanted from nurseries is restricted to more humid areas (Nwasike et. al, 1982). Maize (Zea mays) consists mainly of improved varieties that are widely cultivated in Nigeria (IITA, 1981). The soybeans (Glycine max) grown are a long-season variety with an indeterminate growth habit, while groundnuts (Arachis hypogaea) are short-season, small-kerneled Spanish types. Significant soybean production is confined to only two areas in central Nigeria (Knipscheer and Ay, 1982), one of which includes Abet.

As with most crop farmers across the zone, the first priority of Abet farmers is food crops to meet household needs. However, surpluses are sold and some crops, notably soybean, groundnuts and ginger, are grown primarily for sale. Farmers' decisions on cropping patterns take into consideration the onset and probable duration of the wet season, input availability (especially fertilizers) and, to some extent, prices (Balcet, 1982). A generalized planting and harvesting pattern for sorghum, millet, maize, soybean and groundnuts in relation to rainfall distribution in Abet is given in Figure 1. Although the early rains can be very erratic, the wet season in Abet is long enough to allow some flexibility in planting the major crops as well as the cultivation of a wide range of subsidiary crops.

Figure 1. Crop planting and harvesting patterns in relation to rainfall distribution and soil moisture in Abet.

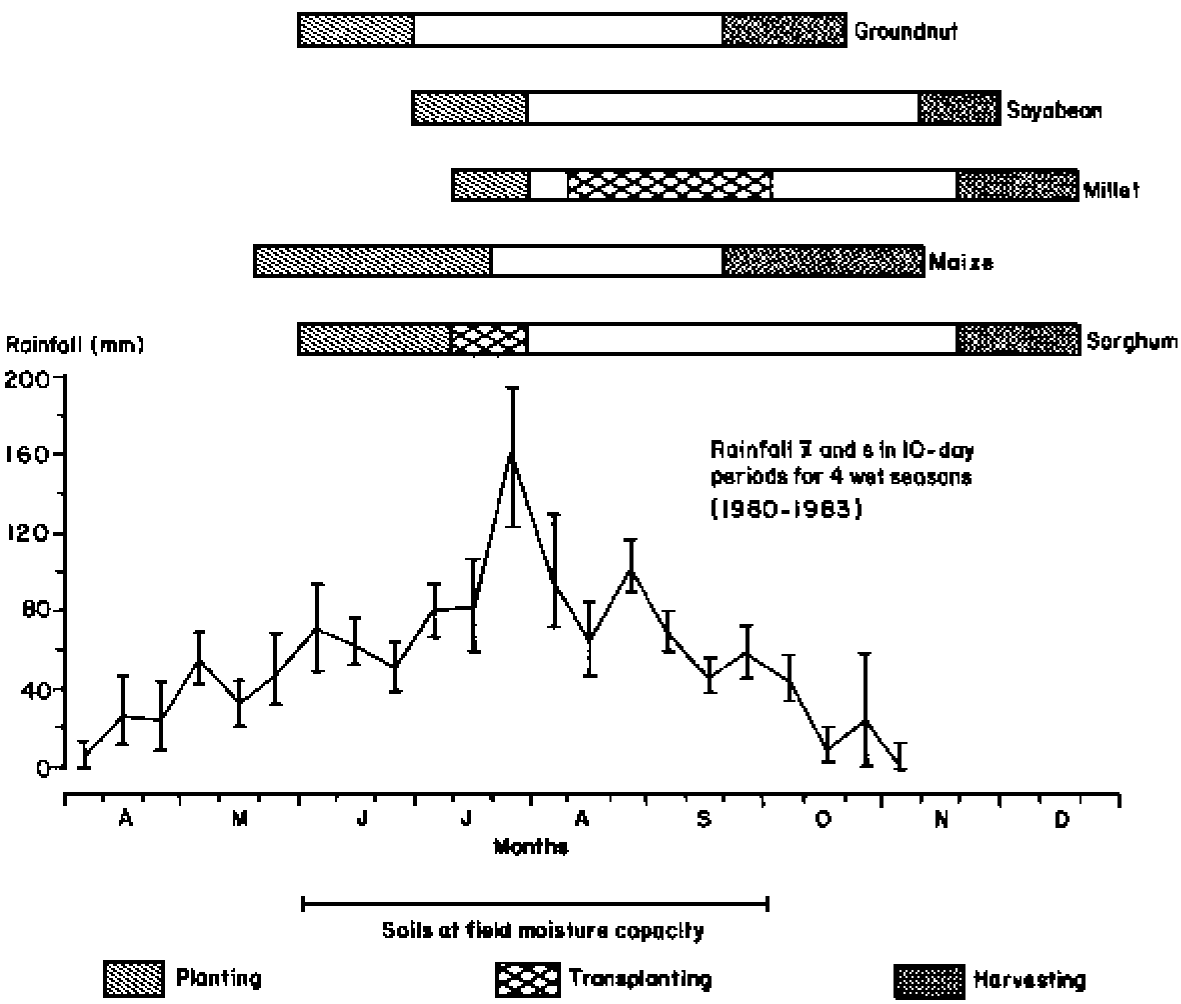

Table 3. Cropping patterns for crop farmers in Abet (1981).

Crop enterprise	Plots (No.)	Plot sizes		Cultivated area (ha)	% of total cultivated area
		(No.)	Mean (ha)		
Millet	86	18	0.53	45.58	40
Sorghum/maize	32	4	0.55	17.60	15
Sorghum/soybean	38	9	0.30	11.40	10
Sorghum	30	11	0.34	10.20	9
Sorghum/maize/soybean	23	6	0.29	6.67	6
Others[a/]	121			22.15	20
Total	330	48		113.60	100

[a/] Others: 59 other cropping enterprises involving the above-mentioned and the following 19 crops: groundnuts, African rice (Oryza glaberrima), ginger (Zingiber officinale), lima bean

(Phaseolus lunatus), yams (Dioscorea spp.), okra (Hibiscus esculentus), cocoyam (Colocasia esculentus), sweet potato (Ipomoea batatas), finger millet (Eleusine coracana), fonio (Digitaria exilis), cowpeas (Vigna unguiculata), cassava (Manihot esculenta), pepper (Capsicum annuum), garden egg (Solanum incanum), spinach (Amaranthus spp.), sesame or beneseed (Sesamum indicum), roselle (Hibiscus sabdariffa), bitterleaf (Vernonia spp.), and kenaf (Hibiscus cannabinus).

During the early wet season, priority is given to sorghum and maize over cash crops and food crops of lesser importance. When a farmer sees that self-sufficiency in these crops has a high probability of success, then he will consider income generation. Maize is the first crop to be planted. Sorghum is interplanted 2 to 3 weeks later, during which time groundnut fields are also prepared and planted. Soybeans are interplanted into sorghum/maize and sorghum fields in mid-July, concurrently with weeding operations and the establishment of millet nurseries. The harvest starts with maize and groundnuts in mid-September. Sorghum, millet and soybeans are harvested, approximately a month after the rains have ended, from mid-November to mid-December. Maize serves an important purpose in filling the 'hungry gap' between the sorghum and millet harvests. A retrospective survey on the change in cropping patterns in Abet shows that both maize and soybean are gaining in importance while millet may be declining (Table 4).

Table 4. Frequency of crops in crop mixtures farmers in Abet (N = 54 plots).

	Crop plantings[a/]			
Crop	**1978**	**1979**	**1980**	**1981**
Sorghum	15	24	19	23
Maize	1	3	8	10
Millet	41	26	34	19
Soybean	7	7	8	12

[a/] Number of times crop was planted alone and/or in a mixture.

Due to the various climate, input availability and price factors that can influence crop selection, cropping patterns are highly flexible. If early rains are unusually erratic and/or late, resources may have to be shifted to millet. When early rains are normal and mineral fertilizers readily available, more maize is planted. Changes in market prices particularly affect the amount of resources devoted to the cash crops, soybean, groundnuts and ginger.

Fallowing

Fallowing still figures in the Abet cropping cycle although, due to the availability of fertilizers and the added labour involved in recultivating fallow land, more and more land is being permanently cultivated. Of the 35 farmers, 5 cultivated all their land without fallowing. The remaining farmers have an average of 1 to 3 fields in fallow. Observations indicate that more recently fallowed fields are of comparable size to currently cultivated fields (0.71 ha), while fields fallowed for a longer period tend to be larger and further from the compound. These observations confirm those made during the aerial survey of Abet, which also estimated that 33% of the total land area was in fallow (Milligan et al, 1979).

Fallow periods vary from 1 to over 20 years, and occur for six reasons (Table 5). Sixty percent of the 89 fallow fields had fallow periods of 5 years or less. Fifty-eight per cent of those were due to lack of labour to recultivate the land. Soil fertility regeneration, suppressing the buildup of pests, and farmers' poor health together accounted for only 20% of fallow land. Three of the 35 farmers had allowed Fulani to settle on their fallow fields.

Table 5. Reasons for fallow and length of fallow periods in Abet.

Reasons for fallow	Fallow period (years)						
	1	**2**	**3**	**4**	**5**	**>6**	**Total**
Labour shortage	3	4	2	7	4	32	52
Sufficient fields	6	3		3	1	3	16
Low soil fertility	2		4	3	2	1	12
Poor health		2		2			4
Fulani settlement			1	1	1		3
Pests	2						2
Totals	13	9	7	16	8	36	89

History of the cropping patterns for 54 plots belonging to 29 farmers revealed that 41 or 76% of the plots had been cultivated for as long as the farmer could remember, suggesting that a high proportion of cropland in Abet is permanently cultivated. When practiced, fallow periods are generally less than 5 years, and may well be getting even shorter. Land with fallow periods greater than 5 years, therefore, can be considered as permanent fallow. Labour, not land, limits crop production in Abet. Schooling and employment opportunities outside the area have reduced available farm labour. As a result, there is a high incidence of permanent cultivation and permanent fallow.

Inputs

Labour is the major input in the Abet cropping system, singe all work is done manually. The amount of land a farmer cultivates each year is thus a function of family and/or hired labour availability.

Total and operational labour inputs for six plots each of sorghum, sorghum/maize, and millet were recorded during the 1982 wet season. Recordings were made at various times of the day and lasted for approximately 1 hour per observation, so that rest periods could be taken into account. Although there was great diversity in working abilities within and between age groups, the mean time spent by each household member per operation was used to calculate total labour expended per crop operation.

Sorghum/maize intercropping required a total of 766 hours/ha or 29% and 69% more labour than sorghum and millet sole cropping respectively. The total labour input for sorghum sole cropping (594 hours/ha) was 31% greater than for millet (453 hours/ha). Labour differences between intercropping and sole cropping sorghum were principally associated with the added labour of harvesting maize (202 hours/ha).

In Abet, contour ridging is the normal practice. Ridging at approximately 85-cm intervals to a height of 30 cm was exclusively done by males, and planting/transplanting principally done by females. The two operations are performed concurrently, such that the time of ridging/planting/transplanting was that of peak labour demand for each crop enterprise. Although ridging requires a major labour input, only half of the land area covered is actually cultivated. Benefits associated with ridging include the concentration of organic and inorganic fertilizers, water conservation during dry periods, and prevention of rapid rainfall runoff or waterlogging during wet periods. Ridging and transplanting millet accounted for over half the total time spent on millet sole cropping. Although ridging in mid-August demands less time (142 hours/ha) than ridging in the early dry season (181 hours/ha), the transplanting operation requires 72 hours/ha or 22% of the total labour devoted to millet. However, the principal advantage of transplanting over a 6- to 8-week period is the spread of labour demands between cropping enterprises (e.g. weeding sorghum and maize fields, harvesting early maize and groundnuts).

Weeding is normally performed in three operations: thinning of an oversown area and/or hand-roguing of weeds; hoeing or the partial breakdown of ridges to remove weeds on the ridge and bury them in the furrows; and ridging-up, when ridges are reconstructed with the soil and organic matter removed during hoeing. Thinning may be excluded if an area is not sown heavily and/or weeds are not severe. Sorghum is almost always oversown to ensure good establishment, with later thinning to obtain transplants and/or to intercrop soybeans. Thinning sorghum is almost always necessary, adding a labour input that is not associated with maize or millet. The prevalent practice of interplanting soybeans in sorghum and sorghum/maize fields to fill in gaps along the ridge coincides with either thinning or hoeing operations and requires no additional labour in future weeding operations. Any additional labour involved is associated only with the time required to plant and harvest soybeans. Harvesting soybeans, however, competes with labour for sorghum and millet because all three crops are harvested during the same period.

Fertilizer is a diversely managed input by farmers in terms of types and quantities used as well as the methods and timeliness of application. All the surveyed farmers use fertilizer, which is currently subsidized by the government. Although farmers are well aware of the benefits of fertilizers, little distinction is made between types and the amounts to apply to the various crops. Fertilizer management depends on when and in what amounts the different kinds of fertilizer become available to the farmer. If available before the onset of the wet season, some fertilizer is incorporated into the ridges. Otherwise, the most prevalent practice is to apply small amounts at the base of plants, usually at the same time as weeding.

Grain yields

Sorghum, maize and millet yields under traditional farmer management recorded at various locations in central Nigeria from 1980 to 1982 averaged 840 kg/ha for each crop (Nigerian Federal Ministry of Agriculture, 1983). In areas of similar rainfall to Abet, sorghum and millet sole crops yielded 1040 kg/ha and 650 kg/ha respectively, while sorghum and maize as single intercrops yielded 920 kg/ha and 860 kg/ha respectively. Yields of sorghum, maize and millet recorded from farmers' fields in Abet from 1981 to 1983 (Table 6) appeared comparable to yields in other locations in Nigeria. (APMEPU, 1980).

Table 6. Grain yields of major cropping enterprises over a 3-year period in Abet.

Cropping enterprise	Average grain yields (kg/ha)			Mean
	1981 (n=42)[a/]	1982 (n=22)	1983 (n=32)	
Sorghum	1000	n.r.	n.r.	1000
Sorghum/maize	970/n.r.	970/1500	770/640	900/1070
Sorghum/soybean	890/150	900/380	900/340	900/290
Millet	740	770	390	640

[a/] Number of 100 m^2 for all cropping enterprises from which yields/ha were calculated.
n.r. = not recorded.

The marked reduction in 1983 sorghum/maize intercrop and millet yields can be attributed to uneven rainfall distribution, which resulted in late planting. The 1983 wet season in Abet was unusual in that early rains were erratic: there was a wet period in late July, and the rains ended abruptly 4 weeks before normal cessation. Although total 1983 wet-season rainfall in Abet was normal (1310 mm), its uneven distribution adversely affected yields. Sorghum and maize intercrop yields were reduced by 21% and 52%, respectively, and millet sole crop yields by 49% compared with 2 previous normal wet seasons. Sorghum yields, when intercropped with soybeans, were the same during the 3 years because soybeans are interplanted in fields where sorghum has been planted early.

Cropping by Fulani in Abet And Kurmin Biri

Given the relationship between cattle and cropping within the Fulani agropastoral system, there may be a potential for increasing feed resources from the Fulani cropping system. A study was undertaken with Fulani cooperating with ILCA to investigate the extent and methods of crop production in the agropastoral system (Powell and Taylor-Powell, 1984).

The majority of the 25 sampled Fulani had been farming for most of their lives, if only on a limited basis. All said, however, that their cropping had expanded over the years to offset the rising price of grain. Cropping played an important role in the production system, preventing cattle from having to be sold to buy grain. The aim was to contribute to or satisfy household consumption needs rather than to produce for market. Surplus supplies are sold, however, and a few Fulani were experimenting with soybean as a cash crop. The similarity in practices between Fulani and local crop farmers as well as the Fulani's own comments indicate that the Fulani have learned their farming techniques from the neighbouring crop farmers.

Cultivated area

The area cultivated by the 25 Fulani households ranged from 0.23 to 2.19 ha, with an average of 0.87 ha/household. This was about one third of the crop area cultivated by Kaje farmers in the area. Delgado (1979) found that in central Upper Volta Fulani were cultivating an average of 2.46 ha per household, about two thirds of the crop area of neighbouring farmers.

Farm size, household size and herd size for Abet and Kurmin Biri are given in Table 7. Positive correlations were found between farm size and household size in both Abet ($r = 0.552$; $P<0.05$) and Kurmin Biri ($r = 0.695$; $P<0.01$), indicating that farm size increased with respect to household consumption needs. The expected relationship between farm size and household labour supply was found in Kurmin Biri, where a positive correlation existed between farm size and number of active males in the household ($r = 0.683$; $P<0.01$). However, this did not hold for the sample in Abet, perhaps due to the availability of some labour for hire and/or greater opportunities for off-farm employment. Although the sample was small, the negative but non-significant correlation between farm size and herd size found in Kurmin Biri ($r = -0.423$) may indicate labour competition when cropping and cattle husbandry are combined.

Table 7. Fulani farm, household and herd sizes, in Abet (1982) and Kurmin Biri (1983).

Location	No. of households	Household size		Farm size (ha/household)	Herd size[a/] (cattle/household)[b/]
		Persons	Active males (8 years and older)		
Abet	13	Mean 9	3	0.67	49
		(SD± 5)	(2)	(0.33)	(43)
		(range 2 - 19)	(1 - 6)	(0.23 - 1.19)	(10 - 182)
Kurmin Biri	12	Mean 12	4	1.10	53
		(SD± 6)	(2)	(0.53)	(24)
		(range 3 - 22)	(1 - 7)	(0.40 - 2.19)	(4 - 86)

[a/] Fulani herds also include sheep at a ratio of about 1 sheep to 4 cattle.

[b/] Calculated for nine herds because six households combined herds into three management units; three herds in Abet are also jointly managed, but cattle associated with each household are known.

While farm size increased with household size for both sites, average cultivated area per household in Kurmin Biri was nearly twice that of Abet. Household size was somewhat larger in Kurmin Biri than Abet, but the difference in average farm sizes is largely explained by the greater availability of land in Kurmin Biri. In Kurmin Biri, Fulani ostensibly have secure land rights within the governments grazing reserve. The reserve has not yet been officially gazetted and farmers are demanding compensation for their land (see paper 11). As a result, there is same tension between farmers and Fulani. Nevertheless, the low cultivation density in the reserve means that there are large areas of potential arable land. Once the initial high labour investment is made to clear land, however, the Fulani in Kurmin Biri expect to have secure and permanent rights to the land, whereas in Abet the clearing of land is not associated with secure land rights and Fulani have to negotiate with farmers for land to cultivate.

Crop enterprises

Sorghum and maize, either sole cropped or in combination, accounted for about 70% of the area cultivated by the 25 Fulani. Millet ranked third at 13% of the total area. The concentration of these cereal crops, staples in their diet, is in keeping with the Fulani's aim to meet household consumption needs. Rice and yams are also important in the Fulani diet but are considered special foods; they were purchased mainly because of the limited availability of low-lying land suited to rice cultivation and the labour required in preparing yam ridges. Although there are low-lying sites in Abet for rice cultivation, these are valuable areas and tend to be reclaimed annually by farmers.

Iburu (Digitaria iburua), the other cereal crop grown by the Abet Fulani, was sown by broadcasting seed in scattered small plots where cattle had been kept overnight. It involved no cultivation or subsequent management. Iburu was not grown by the Fulani in Kurmin Biri because it was a low priority crop and, since land was available, resources such as manure were better used for sorghum, maize and millet. Sweet potato was the predominant tuber, followed by yams and cocoyams. Again, the lower incidence of cocoyam in Kurmin Biri compared to Abet was due to the relative scarcity of suitable low-lying sites.

Sole cropping and two crops in combination accounted for 98% of the total area under cultivation in Abet and 97% in Kurmin Biri. Millet (a late variety transplanted from nurseries) and rice were always sole cropped. In Kurmin Biri the Fulani devoted 46% of the area to sole cropping and 51% to two crop mixtures versus 57% and 41% respectively in Abet. The greater reliance on sole cropping in the Fulani system and the absence of the diverse mixtures commonly sown by crop farmers in the region is attributed to the higher yields for less labour obtained in sole cropping - an expressed Fulani aim - and a greater dependence on the three staple grains. Delgado (1979) likewise found Fulani practicing a less labour-intensive mode of cultivation than farming groups, principally because of conflicts in labour requirements between cropping and herding. In northern Nigeria, it was found that mixed cropping required a 62% higher annual labour input/ha than sole cropping, although the difference reduced to 29% during the peak labour period (Norman et al, 1982).

Striga (Striga hermontheca), a parasitic weed associated with low fertility conditions, was a major problem in sorghum and maize fields in Abet but not in Kurmin Biri, where land has been more recently cultivated. Rotating sorghum and/or maize with millet to suppress striga, as done by crop farmers, was practised widely by the Fulani. Head smut (Sphaecelotheca reiliana) on sorghum and downy mildew (Sclerospora graminicola) on millet were also more prevalent in Abet than Kurmin Biri. Many of the Fulani used seed dressing, but the prevalence of these diseases suggests incorrect usage.

Cropping inputs

In general, the Fulani have become skilled cultivators. Only 3 of the 25 expressed disdain for cultivation and had hired out all farm work apart from planting and harvesting, the latter being a time of hired labour shortage. Twelve of the 25 Fulani hired no labour because it was either not available or it was unnecessary given their small farm sizes and sufficient household labour, or they had no money to spend on it. Only a few Fulani, however, farmed both morning and evening or throughout the day; most confined farm work to the morning hours. The Fulani employed any or a combination of four systems of labour use in cropping:

1. Self: All work is done by the individual farmer, with perhaps help from children and/or wife (wives).

2. Adashe: An arrangement among a group of relatives or friends who cooperate in cultivating each individual's farm in turn; such arrangements usually cover only the strenuous cultivation tasks such as ridging and weeding.

3. Gaya: Group work for a specific task with food and drink given in return; the group is not necessarily made up of Fulani alone.

4. Contract: Labour is hired, generally by the job; this may include tractor hire.

Three labour peaks were identified by the Fulani: May to early June, when land is being prepared for sorghum and maize planting; end July to September, when sorghum and maize are being weeded and millet is being cultivated; November and December (harvest time), when herding has to be the most closely supervised. Because grazing areas are reduced during the cropping season, careful herding is necessary to prevent crop damage. Most of the interviewed Fulani had sons or hired herder boys skilled enough to manage the herds alone for the rest of the year, but during harvest most household heads plus all possible labour must help with herding - often three to four men and boys with each herd - in order to keep the cattle out of unharvested fields.

None of the interviewed Fulani had ever used draught animal power. Animal traction had been introduced in Abet and was being used as late as 1980 by one crop farmer, but only four other farmers had ever used it. The principal deterrents to continued use were cited as the labour required to graze the animals and the inadequate extension support in providing training and replacement stock. Fulani did not express any interest in using cattle for farming. Their reasons included the perceptions that soils are heavy and studded with bush, equipment is expensive, cattle would suffer. Tractor hire was preferred, despite its limited availability.

The Fulani rely almost exclusively on cattle manure to fertilize their fields. Methods of manure application on cropland and their associated advantages and disadvantages are explained in detail in Paper 14. Almost all the Fulani surveyed (21 of 25) used some chemical fertilizer, although applications were generally confined to small areas and little was known about application rates or timing. Most of the Fulani stated a preference for chemical fertilizer because it gave higher grain yields than cattle manure. A disadvantage was that fertilizer had to be applied annually, whereas manure had a residual effect lasting 2 to 3 years. Also, the uncertain availability and timing of fertilizer distribution in the cropping cycle meant that most of the Fulani continued to rely mainly on cattle manure. Sorghum and maize received the majority of the available fertilizer, confirming their place as the most important crops.

Grain yields

Grain yields from Fulani fields in Abet and Kurmin Biri for 1983 are given in Table 8.

Table 8. Grain yields from Fulani fields in Abet and Kurmin Biri, 1983.

Location	Cropping enterprise	No. of plots[a/]	Mean grain yield[b/] (kg/ha)		
			Sorghum	Maize	Millet
Abet	Sorghum/maize	6	800 (170)	490 (170)	-
	Millet	4[c/]	-	-	370 (40)
Kurmin Biri	Sorghum/maize	8	630 (120)	510 (230)	-
	Millet	6[c/]	-	-	530 (160)
	Sorghum	5	740 (90)	-	-

[a/] Number of 100 m^2 areas.

[b/] Standard deviations are given in parenthesis.

[c/] Excludes two plots grazed by cattle in each location.

Combined sorghum and maize yields of 1290 kg/ha and millet yields of 370 kg/ha obtained by the Fulani in Abet were only slighty lower than those obtained by farmers in Abet for the 1983 harvest. In Kurmin Biri, lower rainfall was blamed for the reduced sorghum and maize yields of 1140 kg/ha. However, millet yields of 530 kg/ha were 40% greater than those obtained by the Fulani or by indigenous farmers in Abet. The higher millet yields obtained in Kurmin Biri were attributed to the timely transplanting of millet in response to the 1983 rainfall pattern. These data indicate that the Fulani who relied principally on cattle manure and experienced competition for labour with cattle management were attaining comparable yields to those of neighbouring crop farmers who almost exclusively used chemical fertilizer and were specialized farmers. Two millet fields in each site were accidentally grazed by their owners' herds just before harvest, reflecting one disadvantage of trying to crop and raise livestock in close proximity.

The average energy contribution of sorghum, maize and millet to annual household requirements was estimated to be higher in Kurmin Biri than in Abet, although there was considerable variability in both locations (Table 9). The larger cultivated areas and consequent greater overall grain output in Kurmin Biri account for the difference. Five household heads in both locations said that their yields of sorghum, maize and millet were sufficient, and that they would not need to buy these grains. Another seven Fulani said that they had met household requirements either in sorghum and maize or in millet production. Of the five households that were reportedly self-sufficient in the three grains, one produced enough annually for sale. The percentage contribution of the cereals to energy needs in the four other households that said they would not need to buy any of the three grains was 25, 41, 44 and 75´%, perhaps reflecting a range in preferences for other foods. It has been estimated that milk provides approximately 10% of the annual energy requirements of settled Fulani households in the area (Waters-Bayer, 1984). Although some energy is supplied by meat and by the produce from the small cultivated areas that the Fulani devote to other crops, the bulk of the deficit must be met through purchase.

Table 9. Sorghum, millet and maize grain contributions to household annual energy requirements in Abet and Kurmin Biri, 1983.

Location	No. of house- holds	Contribution to annual energy requirements[a/] (%)		
		Mean	SD± (%)	Range
Abet	13	33	24	9 - 90
Kurmin Biri	12	42	21	18 - 93

[a/] Assumes 20% grain loss in storage, 18.8 MJ energy/kg of grain dry weight, and an annual energy requirement of 3504 MJ/adult equivalent.

The Fulani cannot be viewed solely as cattle keepers. Cropping is becoming increasingly important in their production system to avoid the need to buy grain. For the settled Fulani in southern Kaduna State, however, self-sufficiency in grain production may weaken their relationships with the indigenous farming groups. These relationships are undergoing change as the Fulani become less dependent on farmers for grain purchases while the farmers rely increasingly on chemical fertilizers (although the decrease in subsidy may modify farmer reliance on chemical fertilizer - previously subsidized to 75%, fertilizer is being subsidized at only 25% in 1984).

The land tenure pattern in this region makes it difficult to envisage any significant expansion of Fulani cultivation. Where Fulani can secure land, as on the government grazing reserve or through guaranteed occupancy rights, competition for labour between herding and cropping may become the major limitation if hired labour is unavailable during seasonal shortages. When land, hired labour and fertilizer are available, however, Fulani appear willing to expend livestock earnings to increase crop production. Around Zaria, Norman et al (1982) found Fulani cattle owners cultivating larger farms than non-cattle owning farmers (3.7 ha versus 2.2 ha), apparently because their livestock revenues made it possible for them to purchase usufructuary rights and to hire more labour.

If meeting subsistence grain needs is the goal, Fulani are not likely to jeopardize food production in order to increase forage production, particularly if there are alternative dry-season feed resources in the region, albeit of low quality. Because of the relatively small areas under cultivation by Fulani agropastoralists in the study area, any increase in forage production is likely to be minimal. Herd size relative to cultivated area becomes an important consideration in trying to improve cattle nutrition through integrating crop and forage production. But just as herders are taking up farming, so are farmers investing in cattle (cf Toulmin, 1983; McCown et al, 1979; Diarra, 1975). It appears that innovations to increase feed resources from cultivated land would best be directed towards agropastoralists or mixed farmers who cultivate sufficient land to allow forage production to have a sizeable impact on animal nutrition.

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