LAND DEGRADATION & DEVELOPMENT

Land Degrad. Develop. **13**: 221–231 (2002)

Published online 23 April 2002 in Wiley InterScience (www.interscience.wiley.com). **DOI**: 10.1002/ldr.499

FALLOW CULTIVATION SYSTEM AND FARMERS' RESOURCE MANAGEMENT IN NIGER, WEST AFRICA

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Received 14 November 2001; Accepted 14 February 2002

ABSTRACT

A survey was carried out in 136 farm-households from seven villages in 1995 and 1996 to analyse the traditional fallow cultivation system in Niger. Farmers were asked to give information about land use on their fields, focusing on cropping and fallow periods as well as on cultivation changes compared to the past. In addition, they were interviewed about their management strategies to maintain or improve soil fertility.

Millet-based systems clearly dominate at all sites, either in pure form or intercropped with cowpea, groundnut, sorghum or roselle. At present, almost half of all farmers cultivate their fields on average up to 5 years until it is left fallow. About one-third use their fields permanently. Most farmers use short fallow periods of 1 to 5 years. Moreover, there was a decrease in the cropping area left fallow, and the fallow period also decreased steadily in the past years. In the mid-1970s the average fallow period was about 8 years, decreasing to 2·5 years in 1996. The actual fallow periods are too short to allow sufficient positive effects on soil fertility and farmers are aware of this problem. Consequently, farmers employ different fertilization techniques which aim at maintaining or restoring the soil nutrient pool of the fields while providing physical protection against wind and water erosion. Most farmers use animal manure to improve soil fertility and apply mulch from different sources, millet stalks and branches, for soil regeneration. Few farmers employ other strategies such as mineral fertilizer or planting pits.

The farmers try to optimize the use of internal and external resources resulting in a mixture of different fertilization and soil protection methods. Internal resources play by far the most important role. Due to the generally limited resource availability farmers concentrate their management efforts on certain areas within each field or on selected fields only. This means a decreased crop production for the individual household and a higher risk of soil degradation because of soil mining or increased erosion risk on the field area where soil fertility management cannot be practised.

KEY WORDS: degradation; millet; semiarid; soil conservation; soil fertility; Sahel

INTRODUCTION

Agriculture is the most important economic sector in semiarid Niger, with 85 per cent of the population working in it (Tassiou, 1998). It is characterized by small-scale and low-input farming under rainfed conditions and livestock husbandry. Production level in the southern part of Niger, the Sahelian Zone, is low because of inherently poor soil fertility and highly variable inter- and intraannual, but low precipitation. In the other parts of the country where precipitation is too low for cropping, mobile livestock activities predominate.

In the past, the fallow cultivation system prevailed in southern Niger. Farmers cultivated fields for 2–5 years, followed by a long period of fallow of more than 15 years. When a field was left fallow, they started to cultivate other fields on the village territory. Since the population increased enormously during the last twenty years (1968: 3·9 Mio, 1998: 10·1 Mio) (FAO, 2002), this system underwent great changes. An increase of agricultural production during that time for the growing population has only been accomplished by doubling the land area under cultivation from 2·3 Mio ha^{-1} to 5·0 Mio ha^{-1} while yield per hectare of the most important crop millet decreased from 488 $kg\,ha^{-1}$ (average 1961–69) to 377 $kg\,ha^{-1}$ (average 1991–99) (FAO, 2002). Even with the

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greater production volume the food supply for the increasing population has so far not been maintained. Also, the expansion of cropland led to increasing wind and water erosion. Erosion of fertile topsoil on the fields continuously led to a decrease in soil fertility. Moreover, natural vegetation cover decreased significantly (Breman and Kessler, 1995). In some areas, former tree savannas were transformed to shrub or grass savanna. In general, farmers recognized the disappearance of many tree species (Wezel and Haigis, 2000). Given the problems the farmers are faced with at present, the objectives of this research were to analyse the extent to which the fallow cultivation system changed and how farmers try to meet the increasing problem of soil fertility decline.

MATERIAL AND METHODS

A survey was carried out in 136 farm-households from seven villages located in southern and central Niger in 1995 and 1996 (Figure 1 and Table I). The villages Chical, Boulkass, Sounga-Dossado and Kirtachi-Seybou, were selected in the framework of the Special Research Programme (SRP) 308 'Adapted farming in West Africa'. An interdisciplinary team of the SRP searched for appropriate sites to install on-farm field trials in order to test different agricultural innovations developed by various SRP projects. One pre-condition for the site selection was, that the sites were to be located along a climate gradient from the drier to the more humid areas of Niger (see Graef *et al.*, 2000). Serkin Hatchi and Dan Indo were chosen in addition to the four southwestern villages by a socio-economic project of the SRP focusing on innovation adoption. Intensive literature study indicated higher adoption rates for agricultural innovations in the Maradi region (see Heidhues *et al.*, 1999). Finally the village Liboré was selected by an affiliate research project to the SRP. This project investigated the effect of land tenure changes on resource use and economic behaviour of smallholders in Niger. In this context, distance to the capital Niamey was

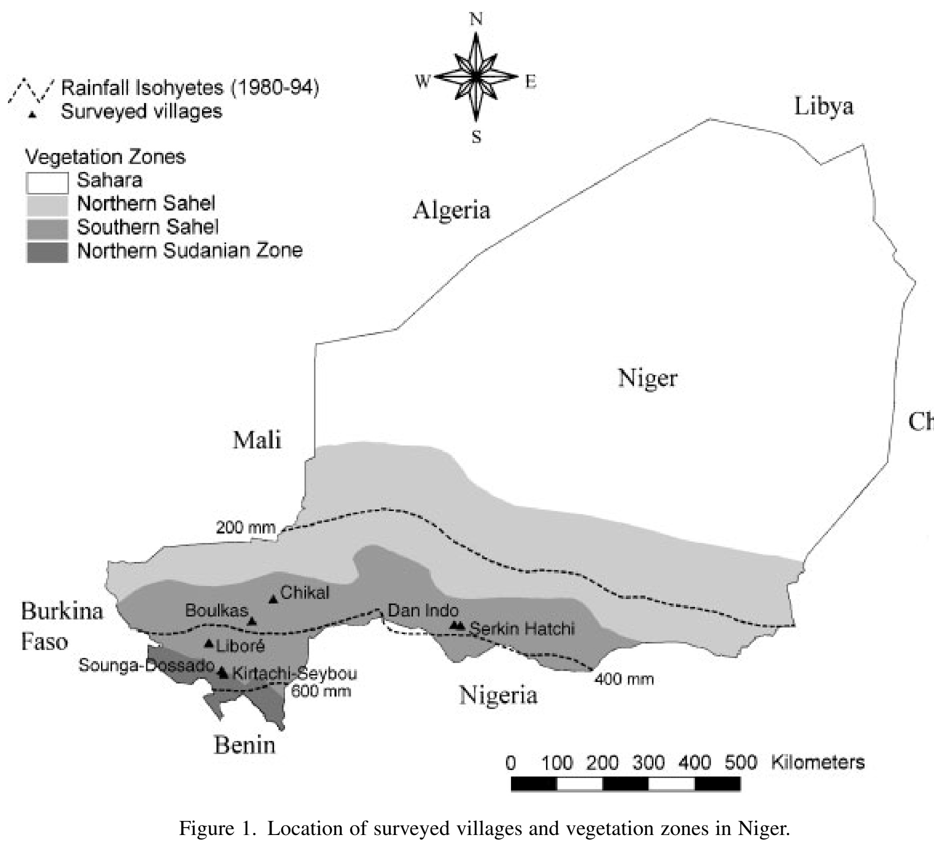

Figure 1. Location of surveyed villages and vegetation zones in Niger.

Table I. Characteristics of selected villages in southern Niger

Village name	Location	Mean annual precipitation (1980–94) in mm	Number of sample households	Ethnic group
Kirtachi-Seybou	12°47′N; 2°28′E	581	21	Djerma
Sounga-Dossado	12°52′N; 2°26′E	581	19	Djerma
Liboré	13°25′N; 2°13′E	515	20	Djerma
Serkin Hatchi	13°36′N; 7°16′E	441	27	Haussa
Boulkass	13°49′N; 3°05′E	409	18	Djerma
Dan Indo	13°44′N; 6°58′E	369	12	Haussa
Chical	14°15′N; 3°26′E	334	21	Haussa

an important criteria for site selection (see Neef, 1998). All villages were chosen out of a larger number of sites after they had been visited during intensive field surveys.

Climate in southern and central Niger is semiarid with an annual precipitation of about 300 to 600 mm. Prevailing soils are nutrient poor, sandy Arenosols and loamy-clayey soils with thin sand cover (mostly Leptosols). Phosphorus is the most limiting soil nutrient for agricultural production. The main cultivated crop is pearl millet (*Pennisetum glaucum* (L.) R. Br.) often intercropped with cowpea (*Vigna unguiculata* (L.) Walp.). Contract herding with cattle, sheep and goats is common, but a small number of animals is kept permanently on the farm compounds to ensure a supply of milk and meat.

Farm-households were selected randomly, and the farm chiefs were invited to a village assembly to present to them the socio-economic research project and its planned activities. This project was scheduled to take three years to implement a variety of surveys covering all aspects of a farming systems research. After the project presentation each farm chief was asked to draw a sheet of paper out of a box. This box contained as many sheets as there were farm chiefs in the village according to the information provided by the village chief. But only some of the sheets had been marked with numbers corresponding to the intended sample size. Each farmer who drew a marked sheet was asked if he agreed to participate in the research project. This sampling procedure was chosen due to the lack of local statistics or even a reliable list of all farm chiefs. Out of the 136 selected farm-households 129 were headed by male farm chiefs, while seven farms were managed by female farmers.

For the interviews, semistructured questionnaires were used. The interviews were held in the respective local languages (Djerma and Haussa) with the help of experienced interpreters and took place at the farmers' compounds. The questionnaire covered several topics related to natural vegetation and field management. They were asked to give information about fertility issues related to their fields, on the applied cultivation and fallow periods differentiated between four periods (i.e. 20, 15, 10 and 5 years ago), as well as their preferences and uses of species of the natural vegetation and changes of vegetation over time. Further they were interviewed about their management strategies to maintain or restore soil fertility of their fields. Statistical analysis included in this data from the survey focusing on the cultivation and fallow issue as well as the management strategies. Because the target of the specific survey, whose results are presented here, was to collect data about the general management strategies, it did not cover past and present land use of each individual field cultivated by the sample farmers. Therefore the presented means on fallow periods and the relative area under cropping and fallowing are not calculated as averages for the fields cultivated by each sample farm. Furthermore these data describe the average values given by the farmers concerning their basic field management. In addition, data on millet yield and size of farmers' fields was gathered. Each field was measured with the help of a global positioning system (GPS). Data on millet yield presented in Figure 2 represent the yield level in the respective village. They were calculated as arithmetic mean of all millet fields cultivated by the whole of sample farmers in each village.

RESULTS

The cropping systems differ in the type of crops cultivated, the crop mixtures applied and the relative distribution of crops in the seven villages analysed (Figure 2). Millet-based systems clearly dominate at all sites, either in pure

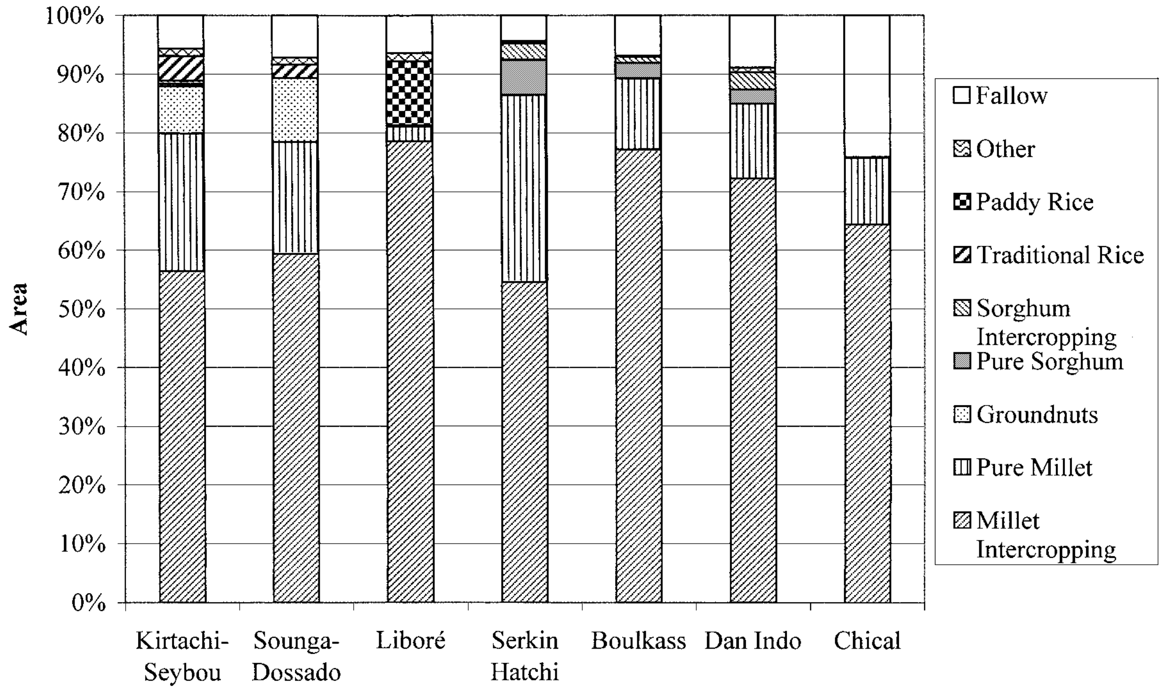

Figure 2. Cropping systems and their area share in villages of southern Niger in 1996.

form or intercropped with cowpea, groundnut (*Arachis hypogaea* L.), sorghum (*Sorghum bicolor* (L.) Moench) or roselle (*Hibiscus sabdariffa* L.). The distribution of the crops reflects the different ecological conditions, particularly precipitation and soils. At the drier sites of Boulkass, Dan Indo and Serkin Hatchi, millet was cultivated on 85–89 per cent of the cropping area. Additionally, drought-tolerant crops like groundnuts are cultivated. In villages close to the river Niger (Sounga-Dossado, Kirtachi-Seybou, Liboré), the shares of millet-based systems were slightly lower with 79–81 per cent of the total cropping area. Exclusively in these villages, either paddy or traditional rice, and to a very limited extent maize, are cultivated. Chical, the village with lowest precipitation and thus highest production risk has a high percentage of 24 per cent of fallow land for the analysed households compared to the other villages where fallow is less than 10 per cent of the cropping area. Other crops such as okra (*Abelmoschus esculentus* (L.) Moench), tigernuts (*Cyperus esculentus* L.) and bambara groundnuts (*Vigna subterranea (L.) Verdc.*) are cultivated only on very small areas.

At present, almost half of the farmers questioned in the seven villages cultivate their fields on average up to 5 years until they are left fallow (Figure 3). About one-third use their fields permanently. A few farmers crop them between 6 and 20 years. Most farmers (64 per cent) use short fallow periods of 1–5 years, some cultivate their fields permanently (Figure 4). Only very few farmer used an average fallow period of more than 5 years. It should be stated that the cultivation and fallow periods are average values given by each farmer which do not necessarily reflect the exact years of cultivation of their different fields and the fallow period. For instance some farmers mentioned that they had previously held an average fallow period of 2–10 years, although at present they did not have any fallow. Thus, the average actual fallow period of 2·5 years given by the farmers in 1996 is probably too high.

Compared to the present situation the cultivation to fallow ratio was quite different in the past. According to the farmers' statements, most of them still had fewer fields cultivated than fallow 15 or 20 years ago, i.e. in the mid-1970s and early 1980s (Table II). While farmers in Chical and Boulkass already cultivated most fields 20 years ago, the other villages followed this trend 15 or 10 years ago. The situation changed in the mid-1980s. Most farmers mentioned that they had more fields under cultivation than fallow land from that time on and this trend continued

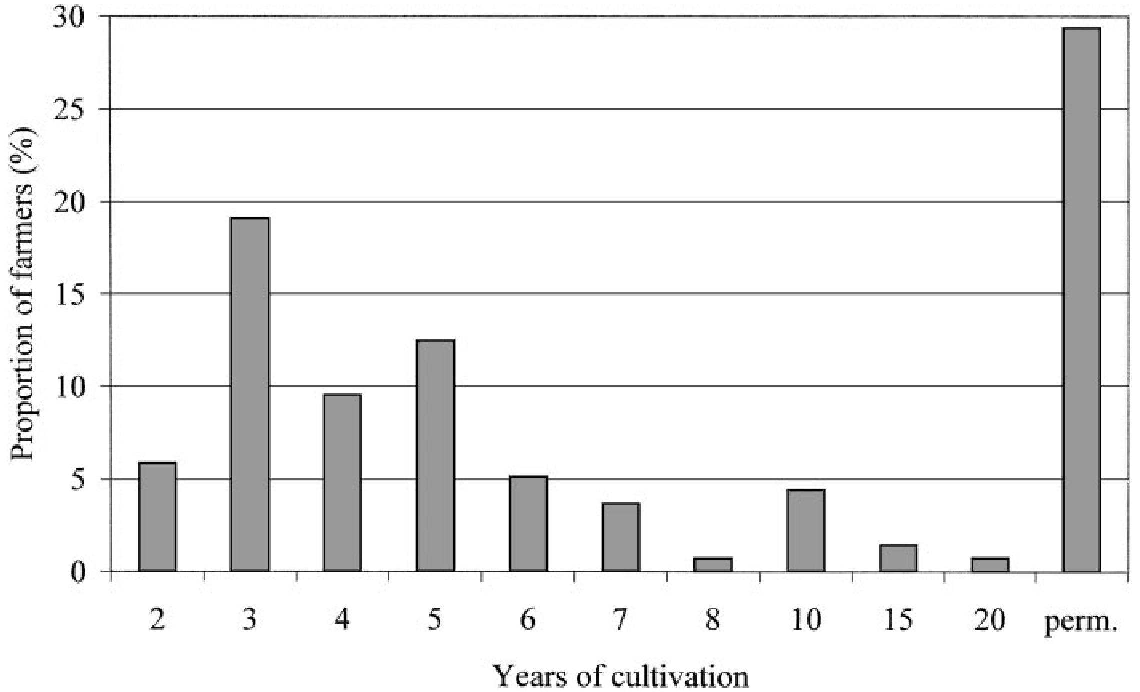

Figure 3. Number of years farmers cultivate their fields in Niger (total = 136 farmers, perm. = permanently cultivated).

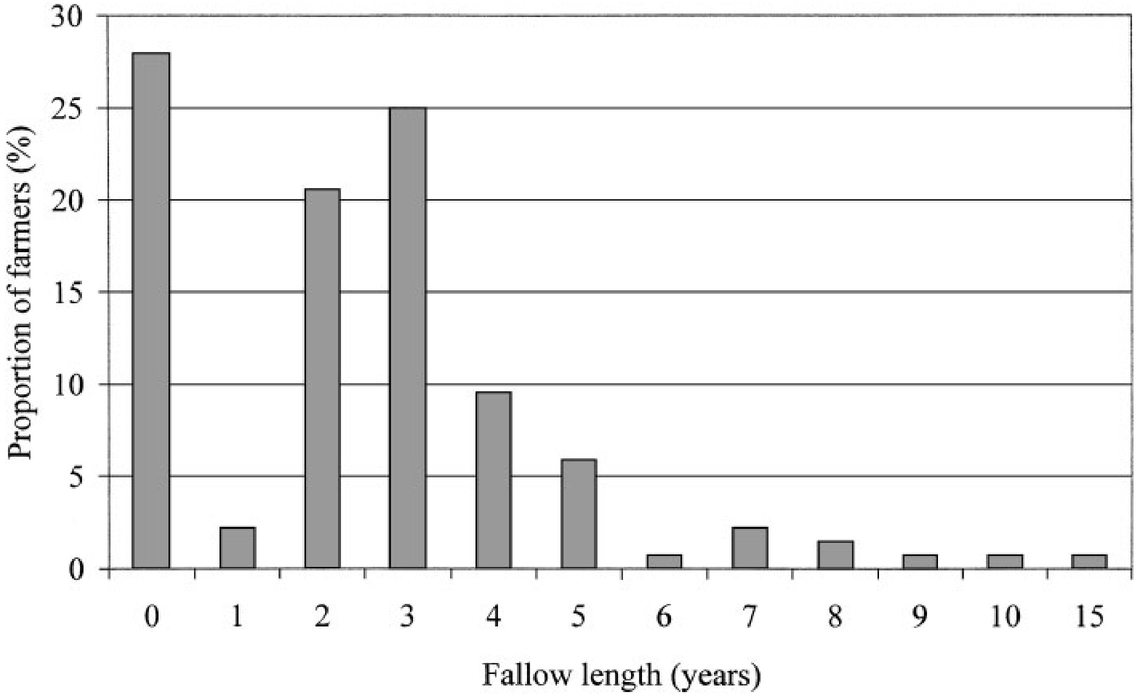

Figure 4. Length of fallow period used by farmers in Niger (total = 136 farmers).

Table II. Farmers' statements to the relation of cultivated to fallow fields at farm level 20, 15, 10 and 5 years ago in Niger, West Africa

Village	More fields cultivated than fallow (%)			
	20 years	15 years	10 years	5 years
Kirtachi-Seybou ($n=21$)	19	33	95	100
Sounga-Dossado ($n=19$)	11	11	84	100
Liboré ($n=20$)	15	80	100	100
Serkin Hatchi ($n=27$)	19	33	82	96
Boulkass ($n=18$)	78	94	89	100
Dan Indo ($n=12$)	0	50	58	92
Chical ($n=21$)	76	71	86	86
Total ($n=138$)	32	52	86	96

up to the present where almost 100 per cent of the farmers cultivate more fields than are left fallow. This trend indicates the increased land shortage in the villages. Farmers are more and more forced to convert their former fallow land into cultivated fields in order to secure self-sufficiency for the farm-household. Nowadays they must also use fields belonging to them for a long time, but formerly left fallow because of the distance from the compound and lack of need. Additionally some farmers are even forced to clear new fields and take them under cultivation at locations where unused land resources exist. Although not all farmers are forced to do so, this extension of cultivated land overlaps the shifting in the relative changes of cropped to fallow land. Therefore the survey covered only information for past years (see Table II) to avoid any misinterpretation of farmers' responses. Present data on fields under cultivation or fallow are added to complete the outlined trend from other sources. Splitting, as a kind of rotation, between fallow and cultivation on the same field is not applied as long as fertile parts of the field exist. Furthermore, farmers tend to cultivate as great an area as possible partly because of the high rainfall variability (Graef and Haigis, 2001). They concentrate cultivation on the more productive parts within the fields leaving infertile parts fallow (Altmann, unpublished thesis, 1997). Therefore it requires intensive remote sensing to assess precisely the area under cultivation and fallow, which was beyond the scope of this survey.

As well as the decrease in the cropped area left fallow, the fallow period has also decreased steadily (Figure 5). In the mid-1970s the average fallow period was about 8 years, decreasing to 2 years at the beginning of the 1990s. In 1996, fallow periods were 2·5 years according to the farmers. But, 7 per cent of the farmers could not provide detailed information related to years under cultivation or under fallow because they could not remember or because they did not count the years. Also some farmers mentioned that they had provided information about cultivation and fallow length they normally used, but at present were forced to cultivate permanently because of food shortages and scarce land for cultivation. The recent development of the use of a special kind of in-field fallow makes it almost impossible to give an exact number of fallow years for such fields.

Although not directly considered by the survey, land tenure seems not to play any significant role in determining the application and duration of fallow. The present situation is characterized by nearly complete disappearance of fallow both on owned and rented fields. On rented fields the reason mainly lies in the fear of the tenant farmer that the field might be lost to the owner in the case of non-cultivation. The motives for permanent cultivation on owned fields with secure land rights are basically the necessity to secure self-sufficiency, since the farmers are forced to compensate for the decreasing millet yields with an increase in cultivated land.

In the face of the decreasing importance of fallow in order to restore soil fertility, farmers employ different fertilization techniques. Mainly these are traditional techniques, but there are also newly introduced ones. The fertilization techniques aim at maintaining or restoring soil nutrient pool and providing physical protection for the fields against wind and water erosion. Most farmers use animal manure to improve soil fertility of their fields (Table III). Another highly appreciated strategy is the application of mulch, mostly millet crop residues, but also branches from the pruning of natural vegetation during field preparation. Only a few farmers use other strategies such as mineral fertilizer or planting pits.

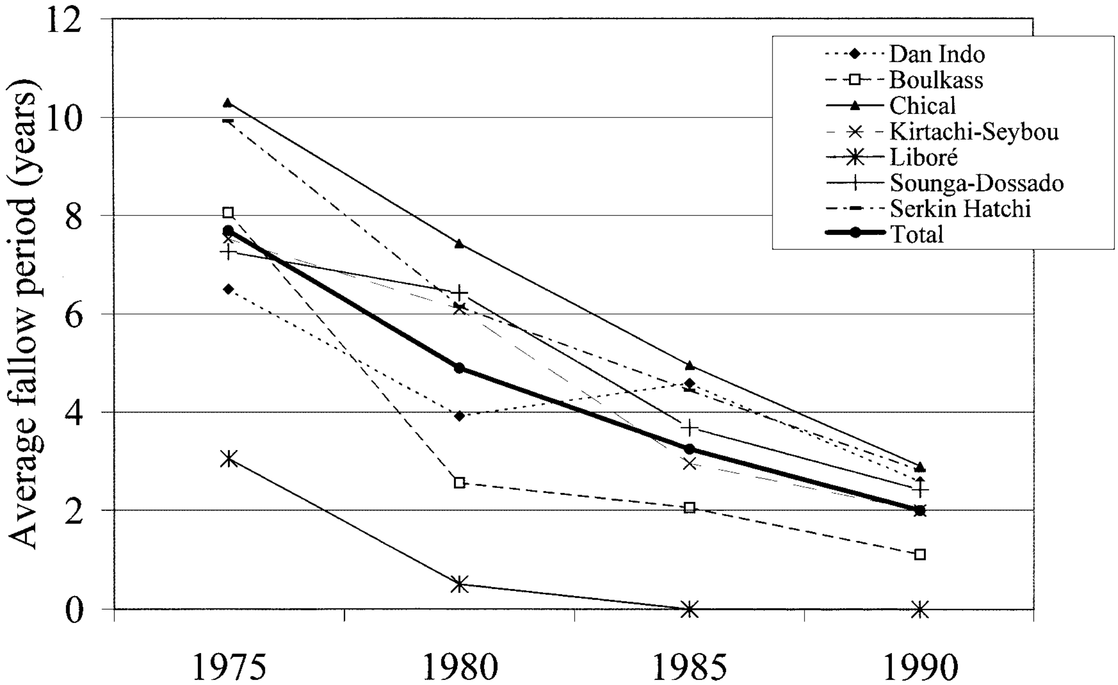

Figure 5. Decline of the fallow periods during the last 20 years in the sample villages.

In the case of animal manure, this was used in all villages by more than 80 per cent of the farmers except for those in Chical (Table IV). The main source of manure are animals kept at the farm compound. This manure was either broadcast on the whole field area or placed only on selected spots. While both techniques occur, placed application was generally preferred to optimize the effect of the limited amount of manure. Moreover, the farmers applied manure mostly on fields located within a 1 kilometre radius of the compound, where fallow periods are shorter than on remote fields. Both lack of manure and of transport were given as the main reasons for this.

Because of their own limited manure resources, farmers purchase additional manure through grazing contracts from either sedentary or transhumant herders. To guarantee fertilization of the whole field animals are corralled overnight, but regularly change their location during the duration of the grazing contract. Only in Sounga-Dossado

Table III. Strategies of farmers in Niger to improve or maintain soil fertility (total = 136 farmers)

Strategy	Number	Percentage
Animal manure	100	74
Livestock grazing (grazing contracts)	57	42
Millet crop residues (broadcast or placed)	77	57
Mulching with branches from natural vegetation	44	32
Fallow	57	42
Mineral fertilizer	17	13
Planting pits (zaï)	10	7
Tree planting	5	4
Compost	5	4
Windbreaks at field borders	1	1
Elimination of soil crusts	1	1
Other mulch (old roofs and fences)	2	1
Rotation of small areas planted with groundnut within the field	1	1

Table IV. Manure application methods of farm chiefs in seven villages of Niger (1996)

	Manure application (%)				
Village	No	Broadcast	Placed	Grazing contract	Zaï
Kirtachi-Seybou ($n = 21$)	19	5	48	57	—
Sounga-Dossado ($n = 21$)	19	10	76	48	—
Liboré ($n = 20$)	10	20	90	10	—
Serkin Hatchi ($n = 27$)	7	19	86	15	70
Boulkass ($n = 16$)	13	—	81	13	63
Dan Indo ($n = 13$)	—	23	100	—	69
Chical ($n = 21$)	62	5	38	10	—
Total ($n = 137$)	20	12	75	23	27

and Kirtachi-Seybou were these contracts widely used (Table IV). Depending on the farmers' financial situation and the amount of manure required, the duration of these contracts varied between 3 and 90 days (34 days on average). Often farmers use the grazing contract to fertilize fields that were further away from the compound.

The method of zaï (also called tassa) (Table IV) is often used to fertilize and rehabilitate lateritic or degraded soils. It is a traditional method from Burkina Faso and Mali which was introduced by development projects in Niger at the beginning of the 1990s (Hassan, 1996; Sterk and Haigis, 1998). For this, small holes are dug with a hoe to capture run-on water and relatively fertile aeolian sediment during the dry season. Before the first rains, the farmers add a small amount of manure to each pit to cultivate different crops (Ouedraogo and Kaboré, 1996; Wedum *et al.*, 1996). This technique was also introduced in Boulkass, Dan Indo and Serkin Hatchi by different development projects.

Mulching plays another important role as a fertilization method, primarily based on the use of internally available resources on the farm. Most important are millet stalks. Depending on the amount of millet stalks

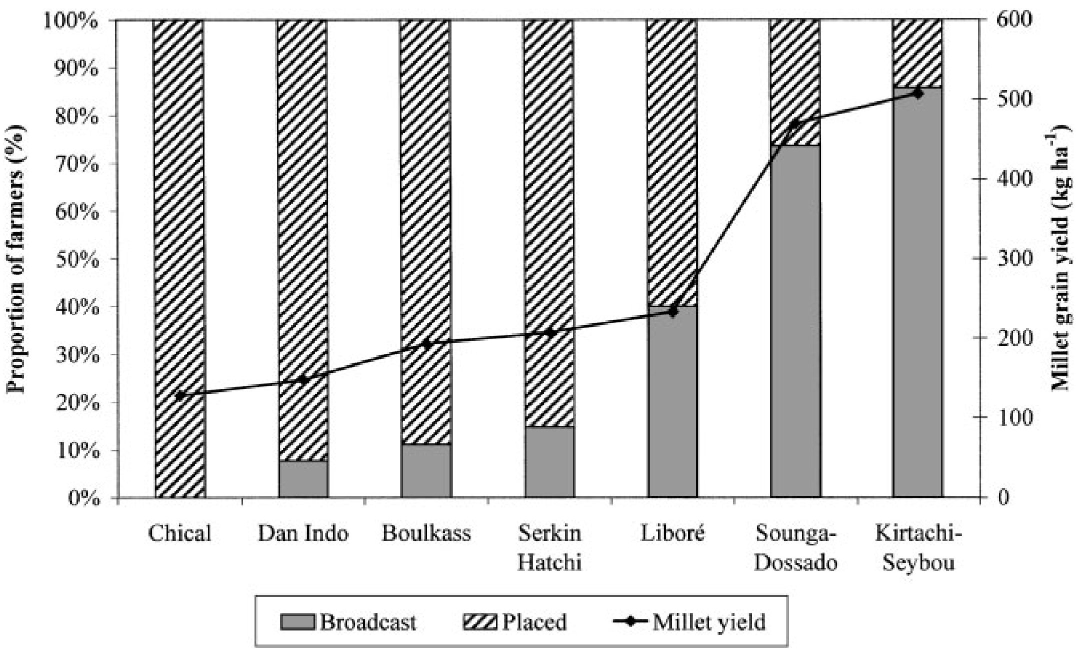

Figure 6. Broadcast and placed millet stalk application and millet yield in seven villages of Niger (1996).

produced, farmers either apply them broadcast (large amount of millet stalks available) or placed on smaller spots (small amount of stalks available) (Figure 6). In Kirachi-Seybou and Sounga-Dossado the higher millet yields allow most farmers to leave the crop residues broadcast on the fields. In contrast, low yields because of low precipitation in Chical force farmers to select spots in the fields where they prefer to apply the millet stalks as a mulch, often on degraded or infertile spots. However, farmers at sites with lower yield levels are aware of the insufficiency of the amount of millet stalks. They compensate for this with branches from natural vegetation or in rare cases with material from old roofs and fences (Table III).

DISCUSSION

The practice of extending the cultivation area, even onto marginal land with low agricultural potential, resulting in the decline of fallow land is also found in other parts of semiarid West Africa (Broekhuyse and Allen, 1988; Vierich and Stoop, 1990; Floret *et al.*, 1993). This is also true for shortening the fallow periods; physical and chemical soil degradation is often the consequence. In Niger, yields per hectare have decreased in recent years (World Resource Institute, 1998). A good indicator for this development is the fallow cultivation coefficient (area of fallow land divided by the area of cultivated fields). SEDES (1987) found a decline from 7·1 to 2·9 from 1960 to 1985 in Niger. From land-use analyses in SW Niger carried out by D'Herbès and Valentin (1997) as well as Loireau and d'Herbès (1994) in 1992, fallow cultivation coefficients of 1·8 and 2·2 could be calculated. Calculations for this study from the transect investigations of Graef (1999) confirm the downward trend. The present coefficient of 1·2 (1·0 in densely populated areas) reveals the dramatic decrease of the fallow cultivation coefficient from 1960 (about 7·1) to 1995–96.

The decline of the fallow period is crucial for soil fertility management, because organic matter content normally increases during the fallow period (Roose, 1993). On the prevailing sandy soils in the study villages in particular, organic matter has the function of nutrient fixation. Thus, 98 per cent of nitrogen can be stabilized in the soil (Ssali *et al.*, 1986 cited in Floret *et al.*, 1993). But, in young fallows no or only small increases were measured (Penning de Vries, 1980; Feller *et al.*, 1993). In the case of organic matter and nitrogen content of fallow land in SW Niger, an increase with age has been demonstrated, but it took at least 15 years of fallow to allow significant soil organic matter and nitrogen content to build up (Wezel, 1998). This means for the farmers in Niger, that most actual fallow periods are too short to allow sufficient positive effects on soil fertility. Farmers are quite aware of this problem because less than half of the farmers use fallow periods to improve soil fertility, most of the other farmers are forced to cultivate all of their fields in every year. Anyhow, short fallow periods can also have an important effect on soil fertility, but only if natural shrub regrowth is occurring on the fallow land. Around the shrubs, nutrients from unprotected soil areas are deposited with soil transported during convective storms and cause small islands of fertility on fallow land and fields (Wezel *et al.*, 2000; see also Chappel *et al.*, 1998). This effect is even greater during cultivation periods. Farmers are familiar with this effect because they often plant millet in these areas more densely, but in general they do cut most of the shrubs because they prefer 'clean' fields. Around uncut shrubs, water and nutrient competition with crops occurs, but nevertheless yields are higher compared to field areas without shrubs, due to increased soil fertility (Wezel, 2000a; Wezel, 2000b). Instead of using fallow periods, most farmers try to meet the increasing nutrient deficiency by applying manure, mineral fertilizer or compost. But, normally the socio-economic situation of the households allows these fertilization strategies only on part of farmers' fields. The other possibility used by the farmers to increase the nutrient status of the soils is the application of different mulch materials. They provide not only an import of nutrients to the fields (branches from natural vegetation), but also at least the maintenance of nutrients on the fields (crop residues) and protect fields from wind erosion (Sterk and Spaan, 1997). If fields are unprotected, wind erosion causes an enormous loss of the nutrient-rich topsoil material (Sterk *et al.*, 1996), with the consequence of reduced millet production (Sterk and Spaan, 1997; Wezel and Böcker, 1999). Farmers would like to apply more millet stalks on their fields, but sufficient material is rarely available because they have a multi-purpose use. Rural households use them as mulch and fodder as well as for construction or as fire material. Also, the local ecological conditions influence considerably the amount of millet stalks available (see Figure 6). Mulch from natural vegetation is also limited because it is needed as fodder, fuel wood or for construction.

In the search for new options to fertilize their fields, farmers at Liboré more recently started to spread urban garbage on their fields. Because no garbage separation is practised in Niger, it contains the complete range of household wastes including a considerable amount of organic matter. This waste is collected in small and open containers. Liboré is located 15 km south of the capital Niamey. The garbage collectors pass the village on their way to one of the urban waste disposal sites. In 1996, farmers asked the dustman to deposit the containers at selected locations on their fields for a small fee of 2000 FCFA (exchange rate: 1 euro = 660 FCFA). The reasons for this spontaneous innovation were the lack of manure and the complete removal of millet stalks by outsiders, since millet stalks are regarded as a free good after the field owner has taken the amount he needs. Everybody can collect it during the dry season. The proximity of Liboré to Niamey with a high demand for fodder results in a fast and complete removal of any millet stalks on the fields around the city. Consequently farmers looked for alternative fertilizer sources. According to farmers' observations, garbage application resulted in better yields than manure. Thus farmers indicated that they intend to continue this method and extend it to all cultivated areas not receiving manure. It was interesting that farmers mentioned that they have no problems with the dirty field appearance due to plastic bags and other inorganic litter nor to see it as any problem for their field work. There is no analysis is available about the noxious or toxic components that enter the field through the garbage deposition.

CONCLUSIONS

Given the rising pressure on land, Niger's farmers pursue two often contradictory objectives in managing their fields: they try to expand cultivation to as much available area as possible and that is available to them, and at the same time they try to minimize soil degradation. In their efforts to achieve these objectives simultaneously they extend their agricultural activities spatially and temporarily to such an extent that traditional fallow systems have nearly disappeared. One can only wonder how long this can continue.

Various factors and constraints determine site-specific cropping systems at farm level. These systems try to optimize the use of internal and external resources resulting in a mixture of different fertilization and soil protection methods. Internal resources play the most important role in field management strategies aiming at maintaining soil fertility. External resources were used to a minor extent. Nevertheless, their generally limited availability forces farmers to concentrate on certain areas within each field or on selected fields only. On the one hand this means a decreased crop production for the individual household, on the other hand a higher risk of soil degradation because of soil mining or increased erosion risk on the parts of the fields where soil fertility management cannot be practised.

Farmers were shown to have a broad knowledge on their environment as exemplified by the different techniques used for soil fertility management. In order to introduce new management strategies for combating soil and land degradation, the farmers' extensive knowledge must be integrated into the development of the innovations for a successful adaptation.

ACKNOWLEDGEMENTS

Many thanks to F. Graef for providing the soil transect data and for helping to calculate the fallow cultivation coefficient.

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