The importance of animal traction and defoliation of pearl millet in a Sahelian agro-pastoral system in the Séno-Bankass, Mali.

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Abstract

In the pearl millet based agro-pastoral systems in the south-eastern part of Mali weeding is either done by hand or using animal traction. To feed the draught animals, used for weeding and transport, farmers are harvesting fodder. One of these comprise stripped millet leaves. To evaluate these millet production systems including draught animals, and defoliation, qualitative interviews were conducted in eight villages in the Séno-Bankass area (1991) and day-to-day activities were monitored in one village (1992). The existing defoliation practice was compared to results obtained from on-station defoliation trials. These showed that farmers' practice of leaving the upper leaves from stalks with grains in milk stage, and defoliating only plants on manured fields, results in an optimal balance between grain yield reduction and fodder quality of the harvested biomass. It is concluded that the use of animal traction for weeding increases efficiency on manured fields only. Furthermore, a reduction in millet grain yield through partial defoliation can be compensated in at least average rainfall years by the benefits of the obtained good quality fodder by either selling the fodder or feeding it to selected animals.

Résumé

Dans les systèmes agro-pastoraux du sud-est du Mali qui sont basés sur la culture de mil perlé, le sarclage est fait à la main ou par traction animale. Pour nourrir les animaux de trait, les paysans récoltent les fourrages. Un de ces fourrages se compose de feuilles de mil prélevées avant la maturité des grains. Pour évaluer les systèmes de production de mil y compris les animaux de trait et la défoliation, des enquêtes qualitatives ont été menées dans huit villages du Séno- Bankass (1991) et un suivi des activités agricoles dans un village (1992). La pratique de la défoliation était comparée aux résultats des essais de défoliation obtenus en station. Il en est ressorti que la pratique indigène, qui laisse les feuilles supérieures des tiges ayant des grains en stade laitier, et qui ne défolie que des plants sur des champs fumés, aboutit à une balance optimale entre la réduction du rendement en grains et la récolte d'un fourrage de qualité. Cette baisse du rendement, due à une défoliation partielle, peut être compensée dans des années à pluviométrie au moins moyenne, par les bénéfices de la vente du fourrage, ou son utilisation par des animaux sélectionnés. En plus, il était conclu que l'utilisation de la traction animale pour le sarclage augmente l'efficience sur les parcelles fumées seulement.

***Keywords*:**
pearl millet, *Pennisetum glaucum*, defoliation, animal feed, draught animals
***Mots clés*:**
Mil perlé, *Pennisetum glaucum*, défoliation, fourrage, animal de trait

Introduction

In the densely cropped south-eastern, Sahelian part of Mali (Séno-Bankass, Mopti region), pastures are lacking during the rainy season. Since draught animals are used throughout the cropping season for weeding and transport activities, farmers are systematically harvesting animal feed. At the end of September, when the millet grains are in the milk stage (approximately 90 days after sowing), and the quality of available road-side grasses starts to decrease, farmers are defoliating plants of pearl millet (*Pennisetum glaucum* (L.) R. Br.) leaving the two to three upper leaves at the stalk. The stripped millet leaves are fed green, especially to draught animals (donkeys, oxen), which are important during the grain harvest period. Harvesting millet leaves at a moment when their quality is still good is an interesting possibility to overcome feed shortage during the rainy season, but it may affect grain production. Furthermore, the practice may demand too much time of the farmer.

The present study evaluates this defoliation practice in agro-pastoral farming systems in the Séno-Bankass. Results are compared with on-station experiments, studying the effects of defoliation on grain yield, carried out at the Station de Recherche Zootechnique/Sahel (Niono, Ségou region) during the rainy seasons of 1991 and 1992 (Tielkes & Wessel, 1998).

Materials and methods

The Séno-Bankass receives rains between May and October with a long-term average annual precipitation (1959 to 1988) of 530 mm yr^{-1} (Van Duivenbooden & Gosseye, 1990). Rainfall recorded at the research village of Tori (3° 42.52'W 13° 35.36'N) was 500 mm in 36 days of 1991 and 710 mm in 46 days of 1992. The Séno-Bankass, with predominantly loamy-sandy soils, is a relatively highly populated area within the Mopti region (32 persons km^{-2}; Veeneklaas *et al*., 1990), and has become a major millet production zone of Mali during the past 40 years (Krings, 1991). The vegetation of fallow lands and road-sides is dominated by the grasses *Schoenefeldia gracilis*, *Cenchrus biflorus* and *Eragrostis tremula*.

Qualitative interviews on crop and livestock production practices were conducted with 50 sedentary households in 8 villages in a 20 km radius around Tori before the start of the 1991 rainy season. In 1992, the day-to-day activities related to crop production on the fields of 6 households in Tori were monitored throughout the growing season.

To obtain labour requirements, an observer assisted farmers in recording daily activities on their, family cultivated, village and bush fields. Individual cultivated fields, which are in most cases cultivated by women and cropped with bambara groundnut (*Vigna subterranea*), peanuts (*Arachis hypogaea*) and hibiscus (*Hibiscus subdariffa*) could not been followed. Village fields are located in the direct vicinity of the village and each year cropped, while the bush fields are 2-3 km away and sometimes left under fallow. The observer also recorded market prices for cereals, fodder, and animals on the weekly market of Tori from April till December 1992.

Millet yields were estimated by harvesting millet grain and stover in 75 plots of 25 m^2; 44 plots on manured fields and 31 plots on non-manured fields. Stover and stripped leaves of millet, and road-side grasses were analyzed for residual dry matter (DM), ash (CA) and nitrogen (N) content according to standard procedures (Naumann *et al*., 1983). Digestible organic matter (DOM) and metabolisable energy (ME) content were derived from *in vitro* gas production of samples incubated with cattle rumen fluid according to Menke *et al*. (1979).

Results and discussion

Cropping system

The main cropping system in Tori is based on a low density planted (3,200 pockets ha^{-1}, SD 970) local pearl millet variety. It is sown on hills and weeding is done by hand (hoe: MW), or it is sown on ridges in which case animal (donkey-oxen) traction (AT) is used. Both cultivation practices can be found on manured village fields which receive farm yard manure every other year at a rate of about 5.8 t ha^{-1}, and on non-manured bush fields (Table 1). Only in case households have no (2%) or only small (20%) village fields, manure is applied on the bush fields. The non-manured bush fields are generally left under fallow for three to four years after three years of millet and one year of fonio (*Digitaria exilis*) cultivation.

Table 1. Selected production characteristics of an average household in the Séno-Bankass (means of the 1991 and 1992 surveys).

Tableau 1. Caractéristiques sélectionnées de production d'un ménage moyen dans le Séno- Bankass (moyens des investigations de la campagne 1991 et 1992).

Average household (*1991*):				
Size (heads)			17	
Worker equivalents (WE)[1] during rainy season			7.8	
Livestock during rainy season (TLU) [2]			4.0	
Draught animals (n):	oxen		0.36	
	donkeys		1.24	
Plough possession (% of households)			56	
Plough utilisation (%)			30	
Cart possession (%)			72	
		Households (%, 1991) cultivating crops on:		
		village fields only	bush fields only	both fields
Cultivated area (ha, *1992*):				
Millet/ *Pennisetum glaucum* (7.28)		28	2	70
and Cowpea/ *Vigna unguiculata* associated		32	8	42
Sorghum/ *Sorghum bicolor* (0.23)		16	40	4
Fonio/ *Digitaria exilis* (0.42)		24	46	4
B. groundnut/ *Vigna subterranea* (0.27)		38	28	2
Groundnut/ *Arachis hypogaea* (0.12)		26	36	2
Fallow land (1.97)		0	46	0
Millet cultivation practice:				
Manual weeding (on hills)		20	2	52
Animal traction (on ridges)		4	0	12
Manual weeding plus animal traction		0	0	10
Manure application		78	2	20

[1] WE: male between 15 and 60 years equals 1 WE, female between 15 and 60 years equals 0.7 WE.

[2] TLU: tropical livestock unit, animal of 250 kg liveweight

Labour requirements

Pearl millet cultivation required 83% of the farmers' time dedicated to rainfed agriculture. Weeding labour requirements amounted to 58% and 45% of the total, for the manured MW and AT millet cultivation, respectively (Table 2). The average millet cropped area was highly correlated to the labour capacity available for the first weeding (r^2=0.82; n=15 fields) and averages 1.7 ha per worker equivalent (SD 0.3; WE: male between 15 and 60 years equals 1 WE, female between 15 and 60 years equals 0.7 WE), for both MW and AT weeded fields. Farmers using AT for weeding did not cultivate a larger area, but accomplished the first weeding more rapidly and started the second weeding approximately 11 days earlier than farmers weeding manually. This resulted in a significant increase of grain yield by 296 kg ha^{-1} on manured fields only (Table 2). On these fields with manure application, the use of AT for weeding increases the nutrient availability for crops through a reduction of the uptake of nutrients by the weeds, and a better fragmentation of the manure and its incorporation into the soil as compared to manual weeding. Without manure application, weeding was also accomplished earlier on the AT fields than on the MW fields, but it did not improve grain yield. This indicates that on non-manured fields, nutrient availability is more limiting for millet growth than weed competition.

Inputs for animal traction

Although 56% of the households investigated in 1991 possessed a plough, only 30% were using it for weeding (Table 1). Animal availability limits its use because for an effective AT weeding, farmers need at least one ox and one donkey. This was for only 22% of the households the case. The 1992 survey showed that those households had the plough drawn by the ox for 4.5 h day^{-1} and by the donkey for 1.5 h day^{-1}. Accordingly, only 8% used the donkey as the only animal for weeding activities. This low value is surprising since almost 90% of the households (1991) had at least one donkey. Despite the higher cost of carts (30,000 FCFA = 600 FF; 1992), compared to a plough

(19,000 FCFA), 72% of all households possessed a cart, indicating that the use of donkeys for transport was far more important then their use for weeding.

During the day, draught animals graze road-sides and receive cuttings. Every evening, donkeys are offered 2 to 5 kg green fodder and oxen receive 3 to 10 kg. This feeding practice requires about 2.2 h day^{-1} and implies that if a farmer has to harvest all the feed for his ox-donkey combination during a 90-days interval when the animals are used for weeding and transport activities, an extra 198 h is needed for the AT systems.

Using the data given above, some efficiency characteristics can be calculated (Table 3). These characteristics may explain why the use of AT in a millet system seems to be profitable only when households also possess a cart, thus have transport facilities, as has also been observed by Jansen (1993) for western Niger.

Table 2. Estimated labour requirements (h ha^{-1}) per worker equivalent in millet cultivation (Tori, means of 1992), and millet production data (kg DM ha^{-1}, Tori, means and standard deviations, 1991 and 1992) for four cultivation practices.

Tableau 2. Estimation du besoin (h ha^{-1}) en main-d'oeuvre des différents travaux de la culture de mil (Tori, moyennes de 1992) et le rendement de la culture du mil (Tori, moyennes et écart-type, 1991 et 1992) pour quatre techniques culturales.

	Manual		Animal traction	
	+ manure	- manure	+ manure	- manure
Labour requirements (h ha^{-1})				
Manure transport and application[1]	59	--	59	--
Field clearance[2]	--	15	--	15
Field preparation/burning of crop residues	11	8	11	8
Sowing/resowing	17	17	17	17
First weeding	142	120	85	75
Second weeding	95	80	77	67
Harvest: cutting of stalks	20	20	20	20
cutting and collection of panicles	33	27	40	29
transport and stocking of panicles	32	33	48	34
Total	*409*	*320*	*357*	*265*
yield characteristics (kg DM ha^{-1})				
Harvested plots (n)	18	26	26	5
Grain	546^{bc} *(223)*	432^{c} *(167)*	842^{a} *(293)*	406^{c} *(131)*
Stover	2550^{b} *(232)*	1915^{c} *(759)*	3699^{a} *(1277)*	2049^{c} *(502)*
Total biomass[3]	3330^{b} *(1110)*	2525^{c} *(870)*	4865^{a} *(1573)*	2610^{c} *(663)*

[1] application of 2.9 t of manure ha^{-1} a^{-1}, on the basis of an estimated application of 5.8 t ha^{-1} every 2nd year
[2] assuming 3 years of millet production, labour requirements for clearing are 45 h ha^{-1} after a fallow of approximately 4 years
[3] total biomass includes grain, panicle residues, and stover; within rows, values with different letters differ at $P<0.05$

Table 3. Efficiency characteristics for the use of animal traction (AT) with and without fodder collection as compared to manual weeding (MW).

Tableau 3. Les caractéristiques d'efficience pour l'utilisation de traction animale (AT) avec et sans collecte de fourrage, comparé avec le sarclage manuel (MW).

	AT compared to MW (%)	
	manured	non-manured
Grain yield	+34	-6
Weeding time requirements	-46	-41
	production efficiency (kg grain h^{-1})	
	manured	non-manured
MW	1.3	1.3
AT without fodder collection	2.3	1.5
AT with fodder collection	1.5	0.9

MW: manual weeding, AT: animal traction weeding

Evaluation of defoliation practise

Although current millet defoliation practice is limited to small areas on the village fields only, the potential fodder yield amounts to 200 and 300 kg DM ha^{-1} for the MW and AT cultivation systems, respectively. On-station experiments revealed that a partial defoliation of millet leaving the three upper leaves at the moment that 50% of the plants have grains in the milk-stage, reduces grain yield by about 7% (40 and 60 kg DM ha^{-1} for MW and AT weeded manured village fields, respectively). Fertilizer application can to some extend compensate grain yield reduction due to defoliation practices (Tielkes & Wessel, 1998). These findings explain the farmers' practice of a partial defoliation of the plants on the manured village fields. In addition, the feed quality of the pearl millet leaves exceeded that of the grasses (a mixture of *Schoenefeldia gracilis* and *Eragrostis tremula*) harvested at the same time, and that of pearl millet crop residues (Table 4).

Table 4. Nutrient content of road-side grasses, defoliated millet leaves and crop residues (manured fields, Tori, 1992).
Tableau 4. La valeur alimentaire des herbes de bordure, des feuilles de défoliation du mil et des résidues de récolte (champs avec fumure, Tori, 1992).

	Dry matter	Ash	Protein	DOM[1]	ME[1]
Fodder	(%)	(g kg^{-1} DM)			(MJ kg^{-1} DM)
Road-side grasses[2,3]	26	188	70	596	7.43
Stripped millet leaves[3]	23	154	81	601	7.62
Millet crop residues[4]					
leaves	49	128	61	463	5.82
stems	29	46	35	366	5.18
stem basis	33	194	27	341	3.31
threshed panicles	83	77	44	n.a.	n.a.

[1] DOM: digestible organic matter, ME: metabolizable energy
[2] road-side grasses: mixture of 40% *Schoenefeldia gracilis* and 60% *Eragrostis tremula*
[3] sampling date: end of September (n=3)
[4] sampling date: one week after grain harvest (n=12); proportion of leaves, stem and stem basis (DM) was 23, 56 and 21%, respectively; mean panicle residue was 32% of total panicle weight

Even though a defoliation before milk-stage of the grains would yield a better quality fodder, grain production would be severely reduced. On the other hand, a defoliation at the dough stage of the grains does not influence grain yield, but the forage obtained does not meet the quality criteria of feed for maintenance of metabolizable energy for ruminants (cf. Anonymous, 1984). With the existent defoliation practice, farmers seem thus to have found an optimal balance between reduction of grain yield and good fodder quality. However, the defoliation practice supplies only small amounts of animal feed during 3 to 4 weeks in the late rainy season which are used only as green feed for the draught animals. Since animals are an increasingly important component of the sedentary millet production systems in Sahelian countries (Scoones & Toulmin, 1995), good quality forage is more and more needed at the farm level throughout the year.

If farmers in the Séno-Bankass practised the defoliation of pearl millet systematically and tried to sell the fodder or build up a feed stock, they would have to anticipate because of the grain reduction, a monetary loss for MW and AT of 1600 and 2400 FCFA, respectively. The direct selling of the harvested leaves would give only a profit of 600 to 800 FCFA ha^{-1} for MW and AT, respectively, if millet leaves were sold at the same price as road-side grasses (10 FCFA kg^{-1} DM), making this practise economically non-attractive. It would, therefore, be far more interesting for the farmer to make hay from the leaves and to sell or use it during the dry season. Even with a 10% loss of material during hay making, and assuming a price of 20 FCFA kg^{-1} millet hay, a price between millet stalks (12-15 FCFA kg^{-1}) and cowpea hay (35-45 FCFA kg^{-1}), the MW and AT cultivation systems would give a profit of 2360 and 3360 FCFA ha^{-1}, respectively. Conserved as hay, the good quality forage obtained can also profitably be used for sheep fattening with associated higher economic returns (Tielkes & Gall, 1998).

It is, however, realised that the profitability of the defoliation practice depends largely on millet grain prices, which will increase during dry years in such a way that no direct monetary profits can be obtained. Nevertheless, the fact that the defoliation practice secures a certain quantity of millet biomass to be used by ones own animals instead of leaving it in the field for communal use, should not be under estimated, as more frequently, farmers want to keep their own crop residues (Fernández-Rivera *et al*., 1994). This growing individual use of (millet) biomass produced will have far-reaching effects on the field level in terms of increased export of organic matter (Lamers & Feil, 1993), and on the village level in terms of the relationship between nomadic and sedentary people (Van Den Brink *et al*., 1995).

Conclusions

In the Séno-Bankass, animal traction plays an important role and increases efficiency on the manured fields of the millet based cultivation systems. To assure the feeding of the draught animals towards the end of the rainy season, a partial defoliation of millet offers the possibility of harvesting a good quality forage. However, when executed systematically on a large scale, the farmer has to anticipate a reduction of about 7% in grain production. But, in economic terms, and in average rainfall years, the loss of grain yield due to defoliation can be compensated by selling the defoliated leaves or by hay making, and building up a stock of feed for the dry season which can be used for supplementation of selected animals (draught animals, fattening sheep, lactating cows). This shows that a sacrifice in one component of the system, here a reduction in grain production, can have beneficial effects for the integrated agro- pastoral system. This finding opens possibilities for a more widespread introduction of this defoliation practise in millet based Sahelian agro-pastoral systems.

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