INFLUENCE OF GRAZING REGIME BY CATTLE ON THE SOIL SEED STOCK AND GERMINATION PATTERN IN THE ANNUAL RANGELANDS OF THE SAHEL

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1. INTRODUCTION

A herbaceous layer dominated by annual plants, especially grasses, and scattered shrubs (among which are *Acacia* and *Combretum* species) characterise the rangeland vegetation in the Sahel that extends to the south of the Sahara over 6000 km East-West and 400-600 km North-South. The climate is tropical semi-arid with 200 to 600 mm of rain falling in 2 to 4 months. Annuals establish with the first rainfalls and adjust their growth to the rain distribution that varies largely over space and between years. This explains the large shifts observed in the herbaceous production and species composition (Grouzis 1992). Pastoral and agro-pastoral systems exploit this fluctuating resource by grazing cattle, sheep, goats and camels opportunistically under communal management. This implies livestock mobility and results in high spatial and temporal variations in grazing pressure that may affect herbage productivity and, in the longer term, species composition (Hiernaux 2000). The objective of the trial conducted at Sadoré ICRISAT research station was to assess the effects of cattle grazing, either during the wet or the dry season, all year round or not at all, on species composition and soil seed stock in a young fallow field. The effects of the four grazing treatments were compared to residual effects of crop treatments applied to the millet crop five years earlier, consisting of mulching with millet stalks and phosphorus fertiliser applications.

2. MATERIALS AND METHODS

The ICRISAT Research Centre is located at Sadoré (13°15'N 2°18'E, rainfall 533±147mm.y^{-1}) in southwest Niger. A one hectare field was cropped with millet until 1996 under a factorial trial design with 96 10x10 m plots (Buerkert, Mahler & Marschner 1996) to measure the effect on yield of mulching and fertilizing. From 1997 to 1999 the fallow field was left ungrazed and monitored to assess the residual effect of cropping treatments. Since 2000, four cattle grazing regimes have been superimposed on the design: dry season (0.25 Tropical Livestock Unit.ha^{-1}), wet season (0.25 TLU.ha^{-1}), dry plus wet season grazing, and protection from grazing, each applied to a quarter of the field. For this experiment 4 plots of 100 m² were selected within each grazing treatment blocks, corresponding to four contrasted agronomic treatments (0 or 2000kg.ha^{-1} millet stalk mulch, 0/5 or 7 kg.ha^{-1} P). In each plot, soil seed banks were sampled in 8 quadrats (1m²) placed at systematic random. Soils were sub-sampled within quadrats over 20*20 cm (*ex-situ* germination) or 10*10 cm (seed counting) with 2 cm depth. Soil seed banks were assessed by counting seeds under binocular microscope after extraction by sieving and flotation in a glucose solution (d=1.2). *Ex-situ* germinations were monitored in pots watered every three days in a glasshouse maintained at 35°C, seedling were also monitored *in-situ* in two 20*20 cm sub-samples per quadrat. Variance analyses (GLM procedure with Tukey-Cramer test at 5%: LSD) were performed on the 13 most frequent species.

3. RESULTS

The number of seeds counted in the top soil averaged 6648.4 ± 3859.6 m^{-2} across treatments, about three time more than the density of germinations (2291.2 ± 602.9 m^{-2}) observed *ex-situ*, itself 2.5 time more dense (963.8 ± 345.5 m^{-2}) than observed *in-situ* seedlings (Hérault & Hiernaux 2003).

Grazing only affected some of the seed/seedling parameters: seed density decreased with wet season grazing while *in-situ* seedling density increased with dry season grazing. In both cases, the trend was mainly due to changes in non-legume magnoliopsides (Table 1). Wet season grazing also decreased the density of *ex-situ* germination legumes and increased that of grasses. These trends were explained by density changes of a few species. The decrease in soil seed density with wet season grazing, for example, was mostly due to *Phyllantus pentandrus*, *Hisbiscus sabdariffa* and *Hibiscus asper*. The *in-situ* seedling density of *Hibiscus* also decreased with wet season grazing while that of *Eragrostis*

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tremula increased. The increase in *ex-situ* germination of grasses was due to *Ctenium elegans* while the drop of *Cassia mimosoides* germination explained the decrease of legumes.

Table 1. Average density of seeds counted in the 2 cm topsoil, density of the *ex-situ* germinations and *in-situ* seedlings over 16 plots either grazed (1) or ungrazed (0) during the dry and the wet season

	Counted seeds (m^{-2})					***Ex-situ* germinations (m^{-2})**				
	Dry		**Wet**		**LSD**	**Dry**		**Wet**		**LSD**
	1	**0**	**1**	**0**		**1**	**0**	**1**	**0**	
Aristida sieberiana						39.1	3.5			18.3
Ctenium elegans								1121.5	673.4	309.7
Alysicarpus ovalifolius						48.1	19.5			25.6
Blepharis linarifolia						33.6	0	33.6	0	27.7
Cassia mimosoides								121.9	254.3	68.1
Hibiscus ssp.	89.1	254.7	112.5	231.2	84.6					
Merremia pinnata						162.5	87.5			64.8
Phyllantus pentandrus			1306.2	2453.2	747.8					
All Grasses								1368.8	914.8	353.0
All *Fabaceae*								161.3	316.4	85.4
Other magnolopsides			2662.5	4981.2	1078.1					
All species			5070.2	8226.5	1986.2					
Number of species			6.0	7.2	0.7					

	***In-situ* seedlings (m^{-2})**				
	Dry		**Wet**		**LSD**
	1	**0**	**1**	**0**	
Digitaria gayana	31.4	9.5			15.2
Eragrostis tremula			18.6	6.1	8.2
Alysicarpus ovalifolius	37.3	12.9			20.2
Cassia mimosoides	28.7	9.0			15.5
Hibiscus ssp.			27.0	54.7	17.5
Merremia pinnata	112.9	41.6			33.1
Phyllantus pentandrus	201.1	132.6			46.7
Tephrosia gracilipes	16.8	0.2			16.1
Walteria indica	38.9	15.8			19.1
All Grasses					
All *Fabaceae*					
Other magnolopsides	496.9	330.9			85.4
All species	1146.9	829.5			215.8
Number of species	10.1	9.2			0.8

Dry season grazing decreased the density of the soil seed stock of *Hibiscus* as did wet season grazing. On the contrary, dry season grazing increased the density of *ex-situ* germination of a grass, *Aristida sieberiana* and that of several magnoliopsides (Table 1). Dry season grazing also increased the density of *in-situ* seedlings of *Digitaria gayana* and of several magnoliopsides. Interaction between wet and dry season grazing was only significant for the *in-situ* seedling density of *Hibiscus*, with a severe reduction when grazed both seasons (Table 2).

Table 2. Contingency table of in-situ density of seedlings of Hibiscus ssp., depending on the grazing status during wet and dry seasons.

***In-situ* seedling density (m^{-2})**		**Dry season**			
		Ungrazed		**Grazed**	
		m	s.d.	m	s.d.
Wet season	**Ungrazed**	47.6	56.9	61.6	73.8
	Grazed	46.9	54.8	7.0	15.8

4. DISCUSSION

The average seed density of the top soil of this five-year old fallow field and the proportion of grasses are relatively low for the Sahel (Carrière 1989). The later could result from the grasshopper outbreak in 1998 that eradicated grass seedlings (Hiernaux, 1998). About half of the differences between seed and seedling densities could be related to non-viability or unbroken dormancy, the other half being related to sub-optimal conditions for germination, competition or consumption (insects, lizards) at very early stage of seedling development. Dry season grazing increased the density of germination *in-situ* and the number of species that germinated, but not the seed density in the soil, showing triggering effect of trampling on seed germination. On the contrary, wet season grazing decreased the density of seeds and the number of species as expected from grazing off-take (*Hibiscus*) and trampling (*Cassia mimosoides*) with the exception of the seedling density of grasses tolerant to grazing such as *Ctenium elegans* and *Eragrostis tremula* (Gérard *et al*. 2001). Generally however, the effects of grazing on both the seed bank and seedling establishment were modest compared to the residual effect of soil amendments. The residual effect of mulching with millet stalks systematically explained the first axis of the factorial analysis carried out on seed and seedling densities of all treatment plots (Unpublished data). Grazing, however, tend to reduce the heterogeneity in spatial distribution of species except *Phyllantus pentandrus* which was more evenly distributed under protection from grazing because of its extended seed dormancy.

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