Der Tropenlandwirt, Beiträge zur tropischen Landwirtschaft und Veterinärmedizin,
99. Jahrgang, Oktober 98, S. 125 - 132.

Comparisons of Understorey Vegetation in Planted Fallows of Seven Multipurpose Tree Species (MPTS) in South-Western Nigeria

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Key words: Understorey vegetation, Multipurpose trees, allelopathy

Abstract

Planted fallows of seven multipurpose tree species were analysed in order to reveal their impact on understorey vegetation in South-Western Nigeria. Although having light environment under their canopy comparable with most of the other tree species, *Nuclea latifolia* and *Pterocarpus santalinoides* had the lowest density and biomass of understorey vegetation. Only *Milletia thoningi* had lower understorey biomass than these two tree species although it had higher understorey density. Soil fertility was not a limiting factor for the undergrowth since those three species which had the highest undergrowth density and biomass had either comparable or lower fertility status. This implies that, the suppressive effect of *Nuclea latifolia* and *Pterocarpus santalinoides* on the understorey growth might have been due to allelopathic effects caused by secondary metabolites leached from the tree canopy during precipitation or from the floor litter during decomposition. Because of the limitations imposed by the lack of randomisation of the tree stands in the site, conventional analysis of variance was not appropriate. Instead, the calculated means for each variable was used to compare the results.

1 Introduction

The environmental degradation of tropical forests underlines the urgency of tree planting. Wood products from fast growing exotic compensate for the reduced supply from the disappearing natural forests. In the humid and sub-humid tropics, shifting cultivation to sustain soil fertility and avoid weeds is no longer sustainable due to population pressure. In South-Western Nigeria for example, farmers can no longer afford to fallow

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for more than four years. As a result, the integration of fast growing multipurpose trees into the farming systems of the tropics has been widely recommended (KANG et al. 1990). The most important beneficial effects of these trees on soils can include improvement of soil structure, increase in nutrient availability and reduction of weed problems (MONTAGNINI and SANCHO 1995; AKOBUNDU et al. 1992).

However, concerns about the impact of exotic tree species on the environment could limit their integration into agroforestry systems. In areas of water and nutrient stress, some of these tree species can compete with crops and herbaceous undergrowth for these resources. Trees also release metabolites into the soil which may adversely affect the germination and growth of herbaceous species through allelopathic interactions (SURESH et al., 1987). Eucalyptus species for example are alleged to suppress the forbs and graminoids underneath the trees (LISANEWORK and MICHELSEN, 1993). This suppression could be due to nutrient and water depletion (MALIK and SHARMA, 1990). It could also be due to phytotoxic compounds released from leaf litter which could have an inhibitory impact on the understorey in planted fallow vegetation (CHOU and KUO 1986). Biochemically, many plants produce toxic chemicals which inhibit the growth of other plants, a process called allelopathy. "Such allelopathic chemicals have been demonstrated in plant communities to be a factor of ecological significance by influencing plant succession, dominance, species diversity, structure of plant communities and productivity" (KUO et al, 1989). The suppression of understorey vegetation can have negative impact on the top soil through increased erosion particularly in hilly ecologies.

The aim of this study was to investigate the effects of seven fallow tree species on the undergrowth vegetation in South-Western Nigeria. Consequently species abundance and biomass were studied.

2 Materials and Methods

The study site was an arboretum at the research station of the International Institute of Tropical Agriculture, IITA, Ibadan, Nigeria (7° 30' N, 3° 54' E). IITA lies in the forest savanna transition zone with bimodal rainfall having peaks in July and September. The mean annual rainfall is 1250 mm while the mean temperature is 31.8° C.

The tree species investigated were established in pure stands in 1990. There were four rows with 4 m between rows and 2 m distance between trees within rows. The tree stands investigated were *Gliricidia sepium* (*G/s*) (Jacq) Walp, *Grewia pubescens* (*G/p*) (P. Beauv.), *Pterocarpus santalinoides* (*P/s*) (P'He'r.ex), *Enterolobium cyclocarpum* (*E/c*) (Jacq) Griseb., *Nuclea latifolia* (*N/l*) (Sm.)., *Milletia thoningii* (*M/t*) (Schum. & Thonn.) Bak., and *Terminalia superba* (*T/s*) (Engl.& Diels).

3 Sampling of understorey vegetation

In each tree stand, 5 quadrats of 1 m^2 were randomly placed. Within each quadrat, herbaceous species were identified, counted and then uprooted. They were sorted by species and dried at 80° C for dry matter determination. Because of the relatively small biomass of the species, the three quadrats were bulked by species before drying.

4 Light Transmission, Floor litter, and Soil sampling and analysis

Light transmission in the tree plantations was measured at 15 hours for a week long. A quantum photometer (Model LI-185B) was placed between the tree stands at five places for the measurement of the incoming radiation. Light transmission was calculated as a percentage of total light incidence outside the tree stands. Results for the week were averaged to give single values for each tree species. The floor litter under the trees was collected in 5 randomly placed 1 m^2 quadrats in July 1996. The samples were dried to constant weight at 60 °C in an oven before weighing.

Soils were sampled under the tree species in the arboretum stands and analysed for pH, organic carbon, phosphorus, nitrogen, calcium, potassium, sodium, and magnessium (IITA, 1982).

5 Statistical analysis

Since in the arboretum the four tree stands per species were not randomised, the replicate samples taken within each site provided a single mean per site for each variable measured. Because of the lack of proper site replication, conventional analysis of variance was not appropriate (Hurlbert, 1984). Instead, the calculated means for each variable was used to compare the results from the 7 species. The standard errors of the means are shown in the Tables.

6 Results

Understorey vegetation in tree stands

The density and biomass of the understorey vegetation are given in Table 1. The highest number of understorey species was found under *Gliricidia sepium* (17 species). *Enterolobium cyclocarpum* had the lowest number of understorey species (8 species). *Grewia pubescens* and *Terminalia superba* each had 15 understorey species. *Nuclea latifolia* and *Pterocarpus santalinoides* had 12 species each while *Milletia thoningii* had 10 species. Species density under *Nuclea latifolia* and *Pterocarpus santalinoides* were lower than under the other tree stands. The density of species under *Gliricidiasepium* was the highest (80 plants/m^2).

Table 1: Dry weight of forest floor litter, light transmission, biomass and density of understorey vegetation in tree stands of 7 fast growing fallow tree species

Treatment	Biomass of understorey vegetation (g/m^2)	Density of understorey vegetation ($plants/m^2$)	Percent radiation ME/sec x m^2)	Floor litter (g/m^2)
Terminalia superba	62.46	65 (17)	47 (12)	92 (24)
Milletia thoningii	1.40	50 (11)	2 (0)	55 (6)
Gliricidia sepium	62.13	80 (6)	12 (2)	38 (4)
Enterolobium cyclocarpum	26.26	57 (13)	7 (2)	64 (4)
Grewia pubescens	50.09	66 (27)	5 (0.7)	42 (4)
Pterocarpus santalinoides	16.34	23 (10)	7 (3)	86 (8)
Nuclea latifolia	24.40	18 (7)	3 (0.3)	106 (15)

Numbers in parenthesis refer to standard error, n = 5

Table 2: Understorey species composition in planted fallows of 7 multi-purpose trees

Fallow Tree Species							
Weed species	*N/l*	*M/t*	*T/s*	*G/s*	*P/s*	*G/p*	*E/c*
Axonopus compressus	-	17	-	7	1	7	1
Talinum triangulare	6	31	1	7	4	4	9
Commelina benghalensis	1	2	1	1	-	1	1
Sedges	-	3	4	2	1	-	-
Chromolaena odorata	-	-	-	-	-	3	-
Oxalis spp	-	1	2	3	1	-	-
Leucaena leucocephala	2	1	-	-	-	39	-
Cynodon dactylon	1	1	-	1	1	2	-
Sida acuta	-	-	-	-	-	2	-
Seteria barbata	3	1	8	13	3	1	12
Oplismenus bumanii	-	-	-	12		1	5
Chloris pilosa	-	-	-	-		1	-
Synedrella nodiflora	1	-	26	20	7	-	27
Spermacoce ocymoides	-	-	6	4		-	-
Dioscorea spp	-	-	-	6		-	-
Centrosema pubescens	1	-	-	-		-	-
Sida Veronicefolia		1	6	-	2	3	2
Phyllanthus amarus	2	-	-	1	-	-	-
Desmodium scorpirus	-	-	3	3	1	-	-
Peperonia pellucida	-	-	-	1	-	-	-
Pterocarpus santalinoides	-	-	-	-	1	-	-
Boerhavia diffusa		-	1	-		-	-
Bracharia lata		-	2	-		-	-
Others	0.99	0.33	0.99	0.66	0.66	1.65	0.33

Oven dry weights of all species under *Milletia thoningii, Nuclea latifolia, Pterocarpus santalinoides* and *Enterolobium cyclocarpum* were lower than under *Terminalia superba, Grewia pubescens* and *Gliricidia sepium*. The most pronounced reduction in understorey biomass was under *Milletia thoningii.*

The botanical composition of the understorey vegetation is presented in Table 2. The botanical composition varied between tree species. The most abundant species under *Terminalia superba, Gliricidia sepium,* and *Enterolobium cyclocarpum* were *Setaria barbata* and *Synedrella nodiflora. Axonopus compressus, Talinum triangulare, Oplismenus bumanii* were also present under *Gliricidia sepium* stands. *Axonopus compressus* and *Talinum triangulare* were the only species present under *Milletia thoningii* in high densities. Sixty-nine percent of the understorey species in *Grewia pubescens* stands was *Leucaena leucocephala*. Under *Nuclea latifolia* stands, *Talinum triangulare* was the dominant species.

7 Discussion

The density of the understorey species under *Nuclea latifolia* and *Pterocarpus santalinoides* was lower than under the other tree species. The biomass of the understorey was also less than under the other tree species with the exception of *Milletia Thoningii* under which the biomass was the least. The soil fertility status showed that organic carbon, available P and K and mineral nitrogen, were higher under *Nuclea latifolia* and *Pterocarpus santalinoides* than under other species (Table 3). In comparison, only *Milletia thoningii* had lower values of the soil nutrients. Therefore differences in the understorey vegetation under the tree species cannot be attributed to nutrient limitations. Bhatt *et al* (1997) showed that reduction in the biomass of the understorey species under *Juglans regia* and *Fiscus neerifolia* was not due to nutrient limitations.

Light transmission was below 20% for all except *Terminalia superba* stand which had 47 % light transmission. Inspite of the low light transmission, species density under *Gliricidia sepium* was high (80 plants/m^2), on the other hand it was very low under *Pterocarpus santalinoides* and *Nuclea latifolia*. There was no pattern relating light transmission to density and productivity of the understorey species. Although *Milletia thoningii* and *Nuclea latifolia* had the same light transmission, the density of the understorey vegetation under *Milletia thoningii* was 64% higher than that under *Nuclea latifolia*. Conversely, the biomass of understorey vegetation under *Nuclea latifolia* was 94% more than under *Milletia thoningii*. Light transmission under *Pterocarpus santalinoides* was similar to that under *Enterolobium cyclocarpum*. However, *Pterocarpus santalinoides* had lower understorey species density and biomass. This indicated that differences in the species density and productivity under the tree species was not due to light transmission. The botanical composition of the understorey was also not affected by light transmission. *Synedrella nodiflora* was for example the most abundant species under *Terminalia superba, Gliricidia sepium* and *Enterolobium* cylcocarpum. *Enterolobium cylcocarpum,* however, had the lowest understorey illumination. The most abundant floor species under *Grewia pubescens* were *Leucaena leucocephala* seedlings. This can be explained by the presence of *Leucaena leucocephala* trees near *Grewia pubescens* tree stands. *Talinum traingulare* was the dominant floor species under *Milletia thoningii*. This might partly explain the extremely low biomass of the understorey vegetation under *Milletia thoningii,* since *Talinum traingulare,* a succulent species had very low dry matter.

Table 3: Chemical characteristics of soils in planted fallows of some tree species

Species	NO3+ NH4-N	%C	%N	P	K	Ca	Mg	Na	Ph
	μg/g soil			(mg/kg)	Cmol (+)/kg				
Nuclea latifolia	7.97	1.64	0.18	3.60	0.10	3.80	0.90	0.30	6.30
Milletia thoningii	3.23	0.63	0.08	2.60	0.10	0.90	0.30	0.10	5.90
Grewia pubescens	6.23	0.90	0.10	1.30	0.10	1.60	0.50	0.20	5.90
Terminalia superba	5.05	1.04	0.11	7.60	0.30	2.80	0.50	0.20	6.10
Glricidia sepium	5.09	1.34	0.15	3.70	0.20	2.50	0.40	0.20	6.10
Pterocarpus santalinoides	9.89	1.62	0.17	5.90	0.40	4.50	1.10	0.30	6.00
Enterolobium cycocarpum	5.76	1.14	0.13	1.60	0.10	1.00	0.50	0.10	5.90

It is clear from this investigation that paucity of vegetation under tree canopies was not due to competition for growth resources (light and nutrients) but was probably owing to allelopathic effects caused by secondary metabolites leached from the tree canopy during precipitation or from the floor litter. A similar conclusion was drawn by Bhatt *et al.* (1997) while investigating a number of agroforestry trees for understorey exclusion in Garhwal Himalayas. The impact of trees on understorey vegetation can also be due to combined effects of tree canopy leading to reduced illumination at the forest floor and allelopathic agents in trees leaves whose release suppresses the ground vegetation (LISANEWORK and MICHELSON 1993). This effect was observed by Michelson *et al* (1996) under *Eucalyptus lusitanica* plantations in Ethiopia. This combined effect might have occurred in the case of *Pterocarpus santalinoides* and *Nuclea latifolia*, which, though having similarly low floor illumination as the other tree species, had lower floor species density and biomass. Kamara *et al.* (1998) found leaf extracts of some agroforestry tree species including *Nuclea latifolia* and *Pterocarpus santalinoides* to supress germination and early growth of cowpea. They also observed growth reduction of cowpea when mulch from these species were incorporated into the soil.

The phytotoxic influences of agroforestry tree crops might be due to the presence of tanins, phenolics and other secondary metabolites found in various plant parts (LOHAN et al 1983). Chuo and Kuo 1986 attributed the relatively lower density of weeds beneath a *Leucaena* plantation to secondary plant metabolites leached from *Leucaena* leaves and litter producing an allelopathic effect. Although light intensity measured under the canopy of *Delonix regia* was sufficient for the growth of the understory species, Chou and Leu (1992) found a unique pattern of weed exclusion under the canopy of the tree. This was attributed to the accumulation of litter, leachates, and metabolites formed from biodegradation

8 Conclusion

The suppression of the undergrowth under *Pterocarpus santanlinoides* and *Nuclea latifolia* seemed to be allelopathic in nature although combination with low illumination effects cannot be ruled out. Therefore a more sophisticated research to investigate the role played by leached metabolites from trees and the decomposing floor litter in undergrowth regulation is needed. One major limitation of the work reported here was the lack of randomisation of the tree stands in the site.

Vergleich von Unterwuchsvegetation unter gepflanzten Brachen von sieben Baumarten in Süd-West Nigeria

Zusammenfassung

In einer Studie wurden gepflanzte Brachen von sieben Baumarten untersucht, um ihren Einfluß auf den Unterwuchs zu bewerten. *Nuclea latifolia* und *Pterocarpus santalinoides* zeigten eine geringere Dichte und Biomasse in dem Unterwuchs ungeachtet des Lichteinfalles und der Bodenfruchtbarkeit. Nur *Milletia thoningi* ergab eine niedrigere Unterwuchsbiomasse obwohl es eine höhere Unterwuchsdichte zeigte. Dies führte zu der Schlußfolgerung, daß der Unterdrückungseffekt von *Nuclea latifolia* und *Pterocarpus santalinoides* auf den Unterwuchs möglicherweise auf allelopathische Effekte durch sekundäre Metabolite zurückzuführen war, die von dem Blätterdach durch den Niederschlag oder von dem sich zersetzendem Blattmaterial am Boden ausgewaschen wurden. Wegen der Limitation der fehlenden Randomisierung der Baumstände war die konventionelle Varianzanalyse nicht möglich. Die berechneten Mittelwerte wurden deswegen gebraucht um die Ergebnisse zu vergleichen.

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