Effect of grazing intensities by steers on Caatinga ligneous stratum in the Semi-arid Northeast, Brazil[1]

Severino G. de Albuquerque[2];

[1] Published with the approval of Centro de Pesquisa Agropecuária do Trópico Semi-Árido (Embrapa Semi-Árido) Publishing Committee.

[2] Caatinga research scientist, Embrapa Semi-Árido. Caixa Postal 23 - 56302-970 - Petrolina, PE - Brasil (sgdea@cpatsa.embrapa.br).

ABSTRACT - A Caatinga vegetation was submitted to various grazing intensities (GI) by steers (1982-84) to verify their effect on ligneous stratum degradation. The study involved four GI: Heavy (1 steer/6.7 ha); Moderate (1 steer/10.0 ha); Light (1 steer/13.3 ha); Exclosure (no grazing). Areas under grazing varied from 40 to 80 ha, whereas exclosure had 20 ha. The research had two replications, occupying a total area of 400 ha. Data of woody species new plants density were determined annually in 1 m^2 plots, and data of shrubs and trees density were determined by Point-Centered Quarter Method in 1982 and in 1984. New plant density (Mean = 3.38 plants/m^2) was neither affected by GI, nor by years, although it was highest in 1984, the rainiest year. Shrubs density much decreased from 1982 to 1984 (21,109 vs. 13,229 plants.ha^{-1}), due probably to the 1982 big drought. Tree density little decreased in 1984 (447 vs. 401 plants.ha^{-1}), there being linear relation ($P<0.01$) between 1982 and 1984 densities. There was linear relation between tree density and density of tree species in shrub stages in 1982, but not in 1984, because the drought affected shrubs but not trees. There was, for some tree and shrub species, linear relation between adult plant and new plant densities. This fact occurred more in 1982.

Key-words: Tropical woodlands, shrubs and trees, new plants.

Efecto de intensidades de pastoreo por bovinos en el estrato leñoso de una Caatinga del Nordeste semiárido brasileño.

RESUMEN - Una vegetación nativa de Caatinga fue sobmetida a intensidades de pastoreo (IP) por buyes (1982-84), para verificar su efecto sobre la vegetación leñosa. La investigación envolvió quatro IP: Pesada (1 novillo/6,7 ha); Média (1 novillo/10,0 ha); Leve (1 novillo/13,3 ha); Exclusión (sin pastoreo). Los areas bajo pastoreo variaran de 40 asta 80 ha, enquanto que el area bajo exclusión era de 20 ha. El estudio tuvo dos repeticiones, ocupando el area total de 400 ha. Los datos de la densidad de plantas nuevas (altura < 0,5 m) de espécies leñosas fueron colectados anualmente, en quadratos de 1 m^2, mientras que datos densidad de arbustos y de árboles fueron determinados por el Método de los Quadrantes en 1982 y 1984. La densidad de plantas nuevas (Média = 3,38 plantas/m^2) ni fue influenciada por IP, ni por el efecto de años, aunque ha sido más alta en 1984, el año más lluvioso. La densidad de arbustos disminuió mucho de 1982 a 1984 (21.109 contra 13.229 plantas/ha), debido probablemente a la grande sequia que ocurrió en 1982, y no a la IP. La densidad de árboles poco disminuió en 1984 (447 contra 401 plantas/ha), habiendo relación linear ($P<0,01$) entre las densidades de 1982 y 1984. Huvo relación linear entre la densidad de árboles y de arbustos de espécies arbóreas en 1982, pero no en 1984, ya que la grande sequia de 1982 affectó arbustos y no árboles. Huvo, para algunas especies arbustiva y arbóreas, relación linear entre la densidad de plantas adultas y de plantas nuevas.

Palavras-claves: Matas tropicales, arbustos y árboles, plantas nuevas.

Efeito de intensidades de uso por bovinos sobre o estrato lenhoso de uma Caatinga do Semi-árido do Nordeste brasileiro.

RESUMO - Uma pastagem nativa de Caatinga foi submetida a intensidades de uso (IU) por bovinos (1982-84), para se verificar o efeito sobre a degradação do estrato lenhoso. A pesquisa envolveu quatro IU: Pesada (1 bovino/6,7 ha); Média (1 bovino/10,0 ha); Leve (1 bovino/13,3 ha); Exclusão (sem uso). As áreas sob pastejo variaram de 40 a 80 ha, enquanto que a Exclusão ocupou 20 ha. A pesquisa teve duas repetições, ocupando uma área total de 400 ha. Dados de densidade de plantas novas de espécies lenhosas (altura < 0,5 m) foram coletados anualmente, em parcelas de 1 m^2, enquanto que dados de densidade de arbustos e árvores foram coletados pelo Método dos Quadrantes em 1982 e 1984. A densidade de plantas novas (Média = 3,38 plantas/m^2) não foi afetada por IU, e nem pelo efeito dos anos, embora ela tenha sido mais alta em1984, o ano mais chuvoso. Houve grande decréscimo na densidade de arbustos em 1984 (21.109 vs. 13.229 plantas/ha), causado provavelmente pela grande seca de 1982, e não pela IU. Houve pequeno decréscimo na densidade de árvores em 1984 (447 vs. 401 plantas/ha), havendo relação linear ($P<0,01$) entre as densidades de 1982 e 1984. Houve relação linear entre a densidade de árvores e a densidade de arbustos de espécies arbóreas em 1982, não havendo em 1984, pois a grande seca de 1982 afetou arbustos mas não árvores. Houve para algumas espécies arbustivas e arbóreas, relação linear entre a densidade de plantas adultas e a densidade de plantas novas.

Palavras-chaves: Matas tropicais, arbustos e árvores, plantas novas.

Introduction

Caatinga, a thorny deciduous dry woodland that covers most of the Brazilian Northeast, is dominated by woody plants, and may be the native pasture with the highest density of shrubs and trees in the world. In research works on native pastures conducted in Africa (Kelly & Walker 1976), in USA (Rippel et al. 1983), and in Australia (Walker et al. 1986), in which shrubs and trees densities were determined, no data higher than densities in Caatinga were found. Also in the proceedings of a symposium that took place in Africa, which was devoted exclusively to the ligneous stratum as source of forage (Le Houérou 1980), there was no paper which had registered a density higher than that found in Caatinga. Most of the Caatinga types are shrub-dominated, although as quoted by Sampaio (1995), some authors have claimed that most of the Caatinga area was originally covered with trees. Most of the ligneous species are deciduous, but the dried leaves are an important source of forage in the dry season (Kirmse et al. 1987). The paucity of grasses is one of its characteristics (Cole 1960), in comparison to other biomes such as Cerrado and Pantanal, but there is evidence that Caatinga invaded some formerly more open areas covered by grasses (Smith 1974), a situation analogous to those in USA and in Australia, in which overgrazing resulted in establishment of woody plants (Herbel 1985; Harrington & Hodgkinson 1986).

In spite of being less sensitive to overgrazing than pastures dominated by herbaceous stratum, Caatinga has also been degraded (Vasconcelos Sobrinho 1949; Andrade-Lima 1981), but there are no evidences that degradation was caused by overuse by livestock. It was caused probably by shifting cultivation and wood harvest because Caatinga-covered region is densely populated.

Cattle and goats are the main livestock species predominating in the São Francisco Sertão Zone, and in most properties, both species are reared together. Annual stocking rate is the most important factor in maintaining the stability of a native pasture, although in woody species dominated pastures, a high stocking rate might not have a damaging effect on woody plants, as observed by Kelly & Walker (1976). In Caatinga pastures, 15 ha/head of cattle is usually recommended (Banco do Nordeste do Brasil 1971).

As there is lack of information on which stocking rates by cattle could cause degradation on both herbaceous and ligneous strata of Caatinga, a research was conducted in the period 1981-84, with this objective.

Materials and Methods

Area description - The research was conducted at the Caatinga Experimental Station (9° 21' S Lat; 370 m altitude) of EMBRAPA-Agricultural Research Center for the Semi-Arid Tropics (Embrapa Semi-Árido), in Petrolina Municipality, Pernambuco. The area has flat topography and yellow podzolic soils with the following characteristics: pH = 5.8; $Ca^{2+} + Mg^{2+}$ = 3.3 m.e.; Al^{3+} = 0.07 m.e.; P = 3.5 ppm. Annual potential evaporation is 2,630 mm (Amorim Neto 1985), with a mean annual rainfall of 559 mm (Tab. 1), 80% of it falling in the period December-April, the period of highest evapotranspiration. The vegetation is an arboreous-shrubby Caatinga with the tree stratum dominated by *Mimosa tenuiflora* (Wildd.) Poir. Tree stratum covers only 88.1% of the area, and the participation of *M. tenuiflora* is 50.4% (Albuquerque & Bandeira, 1995). Shrub stratum is dominated by five species: *Lippia microphylla* Cham., *Croton rhamnifolius* (Kunth em.) Muell. Arg., *Calliandra depauperata* Benth., *Cordia leucocephala* Moric., and *Bauhia cheilantha* (Bong.) Steud. and they contribute to 96.5% of this stratum. In the lower stratum, there is the dominance of the terrestrial bromeliaceae *Neoglaziovia variegata* (Arr. Cam.) Mez, although with a phytomass highly variable, and of the herbaceous species *Herrissantia crispa* (L.) Briz. and *Selaginella convoluta* Spring.

The Caatinga Experimental Station, 2,780 ha, although expropriated by the federal government in 1968 for irrigation projects, was never used for this objective, being fenced only in 1976 by Embrapa. In this period, the area was kept under communal grazing by small goat and cattle raisers, under undefined stocking rates. After fencing, the area was kept free of grazing until the start of the research.

Research - It was conducted from August/1978 to August/1984, but most of the data were already published by Albuquerque (1999). The data reported here were collected from May/1982 to May/1984. Four grazing intensities (GI) were tested: heavy (H) - 1 steer/6.7 ha; moderate (M) - 1 steer/10.0 ha; light (L) - 1 steer/13.3 ha; Exclosure (Excl.), without use. All GI had two replications (R), totaling eight paddocks. As six steers were used per replication, experimental units under grazing varied from 40 to 80 ha, totaling 400 ha, with both 20 ha replications of the Exclosure. There was no fence dividing Exclosure replications.

To evaluate the influence of grazing intensities on new plants density of woody species, macroplots of 100 m^2 (20 x 5 m) were marked systematically on the paddocks, in the following numbers: six, 12, 18 and 24 macro plots on each replication of Exclosure, GI-heavy, GI-moderate and GI-light, respectively. This number of macro plots was adopted from 1982 on. In each macro plot, density of seedlings (height < 0.5 m) was determined once annually in May, by placing, at random, five 1-m^2 (2 x 0.5 m) quadrats.

Aiming at detecting some influence of GI on the arboreous-shrub stratum, another approach was adopted, that is, in the eight experimental units, the density of shrubs (height > 0.5 m) and trees was determined in 1982 and 1984, by the Point-Centered Quarter Method (Cottam & Curtis, 1956). In the areas of 40 (GI-heavy), 60 (GI-moderate) and 80 ha (GI-light), 100, 150 and 200 points, respectively, were evaluated. In the Exclosure, 56 and 42 points were evaluated in Repetitions I and II, respectively. The points were distributed in lines and the distance between points varied from 21 to 26 m, to avoid the same shrub or tree being measured twice. Compass was used to walk in the bush in straight line. In each quarter, two distance measures were taken, one for shrub and the other one for tree. Distinction between shrub and tree followed criteria of Walker (1976).

Data were analyzed taking into account for analysis of variance, the effects of grazing intensity and years on woody species new plants density, and of grazing intensity on arboreous-shrub stratum. Linear relation analysis were also conducted between trees, shrubs and new plant density in 1982 and 1984, and between the tree *Tabebuia spongiosa* Riz density and the density of its new plants, in the eight experimental areas.

RESULTS AND DISCUSSION

New plants density was neither affected by GI nor by years (Tab. 2). The relative mean density in the period 1983-84 was higher in GI-light (1 steer//13.3 ha), and this leads to the conclusion that the effect might have been of area factor instead of GI, because mean relative density in GI-heavy (1 steer/6.7 ha) was higher than GI-moderate and Exclosure, and in a 400 ha experimental area, variation among plots might be very high, and in present research, variation between repetitions of the same treatment was high. The last research year was the rainiest in the period, and this contributed to make GI without effect. On the other hand, Friedel (1986), in the Australian semi-arid, detected influence from sheep and rabbits on woody seedlings, but no effect from cattle. Caatinga is a dense vegetation and this aspect makes it less susceptible to overgrazing, because there not being isolated plants, the animals would have the tendency to browse all adult woody plants equally. In Australian ranges, woody plants being isolated, would be more susceptible to overgrazing by sheep, as detected by Hacker (1984).

As from analysis of variance, there was no influence of grazing (P>0.05) on density of shrubs and trees from 1982 to 1984, each of the six areas under use was divided in two parts, making up two subdivisions. Regarding the great difference of 37.4% between 1982 and 1984 shrub densities (21,108 vs. 13,228 plants/ha) (Tab. 3), already discussed in Albuquerque (1999), it was not caused by overgrazing but probably by the big drought of the 1981-82 period. The disappearance was higher in paddocks with higher densities. In two paddocks, that is, in GI-heavy (RI) and in Exclosure, as densities were low, there were increases from 1982 to 1984, and both areas are in opposite position regarding GI. There was also influence of species in the rate of disappearance, being higher in “tender” species, that is, in those species that can be easily broken. In three “tender” species - *C. leucocephala*, *L. microphylla* and *Lantana camara* - the mean difference was 57.6%, whereas in four “hard” species - *C. depauperata*, *B. cheilantha*, *C. rhamnifolius* and *C. sonderianus* - mean difference was only 13.2%. According to Bille (1978), in the 1972 big drought occurring at Sahel (Africa), there was the death of *ca*. 50 % of shrubs, even with a density much lower in comparison to density in present study. But in Africa, there were other livestock species (camels, sheep and goats) causing overgrazing, and when there is more than one species grazing in the same place, the chances of degradation in a drought increase. In present study, although the period 1980-81 is not included in data collection, its low precipitation might have caused stress in the ligneous stratum, that was extended to 1981-82.

Regarding data on shrub species density determined by Point-Centered Quarter Method and new plant density (height < 0.5 m) determined in 1 m^2 quadrat (Tab. 3), in most of the species it appears there is no relation between them, and one of the reasons is that plants not reaching fruiting age are included as adult plants. In addition, the methods were different. But, even using different methods, they covered almost uniformly each study area. So, in some cases there was significant linear relation (P<0.05) between adult and new plant densities (Tab. 4). As it can be seen in Table 4, excepting *J. mollissima*, the two other species in which there was linear relation, are “hard” species, that is, little affected by a drought. From Table 3 data, it might be noted that new plant density of any specific species do not follow any standard in relation to mother plant. For example, although total new plant density did not vary from 1982 to 1984, new plant density by species much varied, some species varying more than three times from 1982 to 1984, such as *C. ramnifolius* and *L. microphylla*, two important shrub Caatinga species. It was already detected (Albuquerque et al., 2001) that new plant density is highly and negatively influenced by *N. variegata* density.

There was in 1983, a great germination of seeds of the tree *T. spongiosa*, as occurred in a goat research, conducted during the same period (data not published yet). *T. spongiosa* new plants densities in

1982, 1983 and 1984 were 0.195, 23.76 and 1.501 plants/m^2, respectively, whereas total new plant density of all woody plants were 3.193, 3.107 and 3.831 plants/m^2, respectively. Taking into account *T. spongiosa* tree density in the eight experimental areas determined by Quarter Method, and new plant density determined in 1 m^2 quadrat, it was detected a significant ($P<0.05$) linear relation between them (Fig. 1). The causes of this high germination are unknown, but various factors might be involved. Angevine & Chabot (1979), reviewing this matter, emphasized the deficiency of good studies on ligneous species germination in general, and on tropical species in special. Grice and Westoby (1987), studying the germination of two shrubs in 11 places and during five seasons in Australia, noted that as in *Cassia* spp. as in *Acacia victoriae*, there was significant influence of seasons and places on new plants density. Taking into account the 11 places, in *Cassia* spp., there was season in which lowest and highest values were 0.06 and. 21.7 plants/m^2, whereas in *A. victoriae*, lowest and highest values were 3.3 and 25.7 plants/m^2, respectively. Setterfield & Williams (1996) verified that post-dispersion conditions for germination and establishment are probably more important than seed supply. In the present case of *T. spongiosa*, probably both factors, that is, seed supply and post-dispersion conditions had some influence on the high germination, because linear relation attests that tree density contributed to seed supply. Barbosa (2002), studying germination and growth strategies for eight Caatinga tree species with fast germination, including two *Tabebuia* spp. (*T. impetiginosa* and *T. aurea*), did not bring up any factor that could explain the occurrence of this high germination in *T. spongiosa*.

Regarding tree species density data, as occurred with shrub species, it appears there is no relation between adult plant/1982 and new plant/1983 densities, with exception of some species (Tab. 5). As occurred with shrubs, the density of new plants and shrubs of tree species do not follow any standard in relation to mother-plant, that is, the tree with highest amount of shrubs and new plants should have been *M. tenuiflora*, and this did not occur. There was for some species in the eight study areas, linear relation between tree and shrub densities in 1982, and tree and new plant density in 1982 and 1983 (Tab. 6). In 1984 there was less cases, and this would be an indication of the drought that messes up the relationship between adult and young plants. There was linear relation between total tree density/1982 and tree density in shrub stage/1982 (Fig. 2). This relation is illustrated by the fact that, in 1984 there was no relation due to the high shrub mortality of 30.6%, probably caused by drought. In some species such as *C. phyllacanthus*, density in shrub stage is lower than in tree stage. In total tree density, there was a difference of 10.3% between 1982 and 1984 (446.8 vs. 401.0 plants/ha), and this is considered a normal tree mortality, aggravated a little by the drought, the linear relation in the period being kept (Fig. 3). In the analysis of Fig. 2 and Fig. 3, 14 experimental areas were considered, due to the division of the six areas under use in two subdivisions.

From this research, the following conclusions might be drawn:

1. High grazing intensities by cattle did not affect woody species new plant density;
2. The linear relation between total tree density and total density of tree species in shrub stage, present in 1982, disappeared in 1984, probably due to the drought;
3. It was expected a linear relation between adult plants and new plants densities, but this occurred only with some species, mainly in 1982.

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Table 1. Pluviometric precipitation from October/1980 to September/1984, and historical mean (October/1963-September/2002). Bebedouro Experimental Station (*ca*. 6 km from experimental area). Petrolina, PE - Brazil.

Month	Precipitation (mm)				
	1980-81	1981-82	1982-83	1983-84	Historical mean
Oct.-Nov.	56.0	14.6	0.0	62.8	62.3
Dec.	34.0	90.7	82.2	7.2	78.0
Jan.	20.3	10.4	90.0	20.5	77.0
Feb.	4.8	20.6	166.4	3.9	81.0
Mar.	340.3	79.1	205.2	314.2	131.0
Apr.	20.5	97.4	0.8	122.9	79.4
May	0.5	1.4	0.0	44.6	18.7
Jun.-Sep.	8.4	50.2	37.6	29.2	29.0
Total	484.8	364.4	552.8	605.3	556.4

Table 2. Density of new plants (height < 0.5 m) of woody species, in the period 1982-84, in a Caatinga under four grazing intensities (GI) by cattle [heavy (H) = 1 steer/6.7 ha; moderate (M) = 1 steer/10 ha; light (L) = 1 steer/13.3 ha; Excl. = exclosure; R = repetition], and mean alteration in density in the period 1983-84, in relation to 1982, taken as 100.

	New plant density (plants/m^2)[1]								
Ano	H-RI	H-RII	M-RI	M-RII	L-RI	L-RII	Excl.-RI	Excl.-RII	**Mean**
1982	2.133	5.100	2.300	4.289	3.275	1.550	4.467	2.433	3.193
1983	3.467	4.083	3.378	3.500	3.000	1.192	2.833	3.400	3.107
1984	4.683	3.365	2.167	3.367	5.083	3.983	4.533	3.467	3.831
Mean	**3.428**	**4.183**	**2.615**	**3.719**	**3.792**	**2.242**	**3.944**	**3.100**	**3.378**
1982	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
1983	162.5	80.1	146.9	81.6	91.6	76.9	63.42	139.7	**104.3 a**[2]
1984	219.5	66.0	94.2	78.5	155.2	257.0	101.5	142.5	**140.9 a**
Mean/R	**191.0**	**73.0**	**120.5**	**80.1**	**123.4**	**166.9**	**82.5**	**141.1**	**122.6**
Mean/GI	**132.0 A**		**100.3 A**		**145.2 A**		**111.8 A**		

[1] New plants of the tree *Tabebuia spongiosa* Riz. are not included; [2] Means with same lower case letters in the column, and with same capital letters in the line are not statistically different (Duncan; P<0.05);

Table 3. Mean shrub density (height > 0.5 m), determined by Point-Centered Quarter Method, and mean new plants density (height<0.5 m) determined in 1 m^2 quadrat, in eight experimental areas under use by steers. Petrolina, PE - Brazil.

	Density (plants/ha[1])				
	1982		1983	1984	
Species	Shrubs[1]	New plants	New plants	Shrubs[1,2]	New plants
Cordia leucocephala	4,739	5,880.5	6,503.5	2,231**	4,773.3
Calliandra depauperata	2,909	2,179.0	1,388.4	2,254ns	1,400.8
Croton rhamnifolius	2,675	8,574.9	2,675.1	2,417ns	2,765.4
Bauhinia cheilantha	1,545	3,543.2	4,694.4	1,241*	2,916.2
Lippia microphylla	1,463	512.4	472.7	770**	1,797.1
Lantana camara L.	1,268	539.7	972.7	349**	1,369.0
Croton sonderianus Müell. Arg.	953	737.6	785.2	942ns	714.8
Other shrub species	3,506	3,369.5	3,750.0	1,603*	9,421.1
Tree species as shrubs	2,006[3]	[4]	[4]	1,391ns[3]	[4]
Cactus considered as shrubs	44.4	96.2	47.6	30.0ns	23.8
Total	21,108.4	25,433.0	21,289.6	13,228.0**	25,181.5

[1] Data of theses columns already published in Albuquerque (1999); [2] **, *, and ns refers to regression coefficient (r) between shrub density in 1982 and difference between shrub densities in 1982 and 1984, in the seven experimental areas. [3] Data also present in Tab. 5; [4] Data present only in Tab. 5.

Table 4. Correlation coefficients among shrub and new plant (NP) densities of main shrub species, in the eight experimental areas that compose Tab. 3 (Except *J. mollissima* absent in that table).

Species	Correlation coefficients (P<0.05)			
	Shrubs/82 vs. Shrubs/84	Shrubs/82 vs. NP/82	Shrubs/82 vs. NP/83	Shrubs/84 vs. NP/84
C. depauperata	0.96	0.79	0.76	0.82
C. sonderianus	0.94		0.91	0.71
L. microphylla	0.77			
Jatropha mollissima (Pohl.) Baill.		0.78		

Table 5. Mean tree and shrub (height > 0.5 m) densities, determined by Point-Centered Quarter Method, and mean new plants density (height<0.5 m) determined in 1 m^2 quadrat, in eight experimental areas under use by steers. Petrolina, PE - Brazil.

	Density (plants/ha[1])						
	1982			1983	1984		
Tree species	Trees[1]	Shrubs	New plants	New plants	Trees[1,2]	Shrubs	New plants
Mimosa tenuflora	174.2	258.4	87.8	1,150.8	148.8**	214.0	686.5
Caesalpinia microphylla Mart.	55.6	540.0	2,031.3	1,880.5	49.1**	428.3	1,559.0
Tabebuia spongiosa	54.2	293.4	[3]	[3]	55.9*	284.6	[3]
Mimosa arenosa (Willd.) Poir	41.7	519.7	2,877.5	3,277.8	34.1**	232.7	2,480.6
Cnidoscolus phyllacanthus (Pohl.) Müell. Arg.	30.5	18.57	43.6	237.6	22.3**	12.0	139.4
Manihot pseudoglaziovii Pax & K. Hoffm.	24.6	131.8	690.0	468.7	25.7*	64.1	1,737.6
Commiphora lepthophloeos (Mart.) J.B. Gillet	19.1	25.2	130.0	452.4	16.8*	5.8	5,115.1
Cnidoscolus vitifolius Müell. Arg.	14.5	3.72	51.6	206.3	15.7**	20.3	194.0
Acacia piauhiensis Benth.	10.0	38.7	119.0	0.0	11.7**	44.5	205.9
Piptadenia obliqua (L.) Pers.	3.3	27.1	55.5	1,968.5	3.4**	22.1	309.5
Spondias tuberosa Arr. Cam.	1.8	0.0	0.0	0.0	2.8ns	0.0	0.0
Other tree species	17.3	149.5	143.3	166.7	14.7ns	62.2	483.6
Total	446.8	2,006.1	6,229.6	9,809.3	401.0*	1,390.7	12,911.2

[1] Data of these columns already published in Albuquerque (1999); [2] **, *, and ns refers to regression coefficient (r) between tree densities in 1982 and 1984, in the eight experimental areas. [3] Due to high germination occurring in 1983, data are in text.

Table 6. Correlation coefficients among trees, shrubs and new plant (NP) densities of main tree species, that compose data of Table 5.

	Correlation coefficient (P<0.05)				
	Trees/82 vs. Shrubs/82	Trees/82 vs. NP/82	Trees/82 vs. NP/83	Trees/84 vs. Shrubs/84	Trees/84 vs. NP/84
A. piauhiensis	0.97	0.96			0.77
M. arenosa	0.97		0.93	0.88	
P. obliqua	0.81	0.80		0.94	
M. tenuflora	0.80	0.72			
C. phyllacanthus	0.74				
T. spongiosa			0.86		
C. vitifolius					0.87

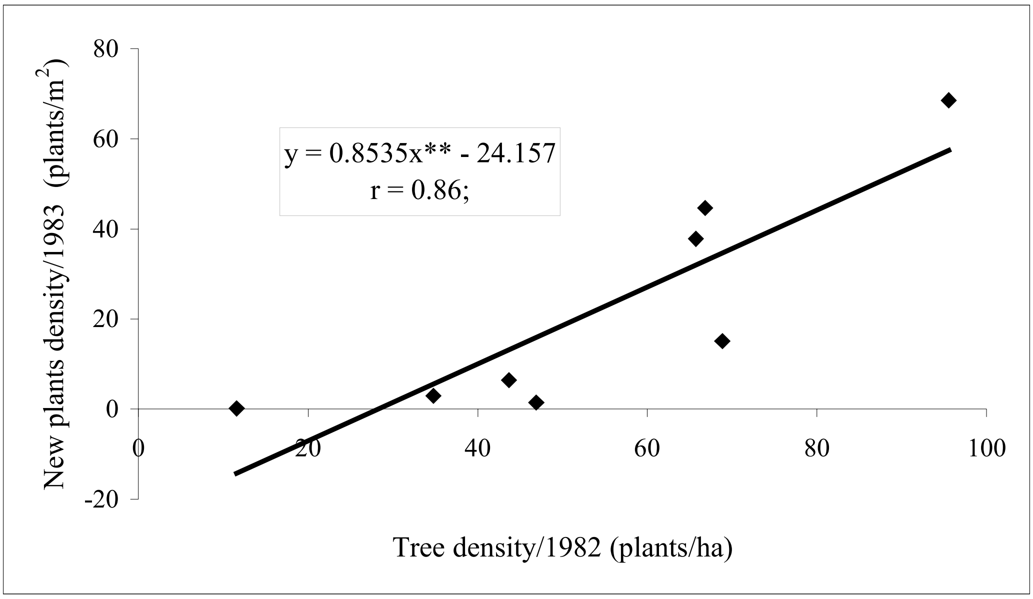

Fig. 1. Relationship between tree density/1982 and new plant density/1983 (height < 0.5 m) of *Tabebuia spongiosa* Riz., in the eight experimental areas.