

EFFECT OF THE TEMPERATURE AND RAINFALL ON SHEA TREE FRUIT PRODUCTION

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Shea (*Vitellaria paradoxa*) is an oleaginous fruit producing tree species of Sudanian savannas in Africa. The fresh pulp from fruits of the tree and the butter extracted from the kernels play an important economic role in rural areas of Sudan. The butter is used for cooking, lightning, soap making and is also used as skin moisturizer. The possibility of using Shea butter as a substitute to cocoa butter and its increasing use in cosmetic industry has raised the export prices of Shea butter. The fruit production varies widely among different years. The present study was carried out in parkland of Tengrela Department, North of Côte d'Ivoire, to determine the effect of temperature and rainfall on Shea tree fruit production. It showed that in some years Shea tree fruit yield increases with the average monthly rainfall, but is not influenced by the air temperature.

Key words: Shea tree, fruit production, temperature, rainfall, Côte d'Ivoire

INTRODUCTION

Vitellaria paradoxa C. F. Gaertn. (Sapotaceae), commonly called Shea tree is a characteristic species in Sudano-Sahelian savannas in Africa. The different organs of the tree are usefully employed in various fields of the everyday life. The wood of Shea tree is used for making tools while the roots, the bark and leaves have medicinal applications. The sweet pulp of its fruits represents a valuable source of energy during the early part of the rainy season. The butter extracted from the kernels is the most important product of Shea tree. It is frequently used for local domestic purposes such as cooking, lightning, in soap manufacture or as skin moisturizer, as well as in traditional medicinal (Hall *et al.*, 1996; Maranz *et al.*, 2004; Teklehaimanot, 2004). Shea butter is also sought in patisserie for its high dough pliability and in confectionery as a cocoa butter substitute. Additionally, due to its characteristics, Shea butter is used as a base for cosmetic and pharmaceutical preparations for the treatment of dry hair and skin (Boffa *et al.*, 1996, Hall *et al.*, 1996).

Very early, the unquestionable economic interest of Shea tree, had led the scientists to be interested in the plant. Studies were generally related to the biology of the tree and the technology of butter production (Halff, 1945; Chevalier, 1948, 1946, 1943; Delolme, 1947; Bourlet, 1950; Ruyssen, 1957; Demarest, 1958). But if the technological study led to concrete results with the development of simple equipment for the extraction of butter, the problems relating to the biology of the tree have not been treated in a satisfactory way. However, some previous works have been done on genetic improvement and multiplication of the tree (Sallé, *et al.*, 1991; Bagnoud *et*

al., 1995; Boffa *et al.*, 1996; Guira, 1997; Lovett and Haq, 2000; Bouvet *et al.*, 2004; Sanou *et al.*, 2005; Sanou *et al.*, 2006; Akrofi and Amoah, 2009; Paré *et al.*, 2009), Shea tree remains up to now a picking product. Because Shea tree populations are wild, fruit production fluctuates from year to year. A better knowledge of Shea tree stand productivity is essential for improved fruit production. According to Von-Maydell (1983) and Boffa *et al.* (1996), Shea tree fruit production is liable to improve through the definition of genetic and environmental productivity characters and appropriate silvicultural management practice. But, every few efforts have been made in this way (Bayalla *et al.*, 2005; Okullo *et al.*, 2004). We hypothesized that Shea tree fruit production is influenced by climatic factors. According to Boffa *et al.* (1996), potential productivity of Shea trees was influenced by genetic variability and by external factors still to be identified. The objective of the present study, therefore, was to determine the influence of rainfall and temperature on Shea tree fruit production on a five years period.

MATERIALS AND METHODS

Description of the study site

The study was carried out on the Shea trees parkland of Tengrela Department, in the North of Côte d'Ivoire. This area has been situated between the 10th and the 11th degree of Northern latitude and between the 6th and the 7th degree of Western longitude. The Shea trees parkland covers a surface of 24 hectares. According to Traoré and Da (1996), this park could come from the dissemination of Shea seeds by the sofas (warriors) of Samory TOURE during their

conquest of the North of Côte d'Ivoire, in 1898. It is located at 1 km in the North-East of Tengrela. The climate is tropical with a unimodal rainy season lasting from May to October, while the rest of the year (from November to April) constitutes the dry season. The monthly average temperature varies between 24°C and 33°C.

Shea is a tree widely encountered in dry savannas, forests and parklands of Sudan zone, but it does not extend into coastal areas (Boffa *et al.*, 1996). It occurs on an estimated 1 million km² between western Senegal and northwestern Uganda, where annual rainfall ranges from 500 to 1200 mm (Sallé *et al.*, 1991). The species is found on various soil types but avoids alluvial hollows or land subject to flooding. It reproduces mainly sexually and most often it is insect-pollinated. Fruiting of Shea tree may start at 10 years of age and attains full fruit production between 20 to 50 years (Okullo *et al.*, 2004). It flowers in the dry season (Von-Maydall, 1983). Ripening of fruits takes place during the rainy season.

Data collection and analysis

The study consisted in determining the effect of temperature and rainfall on Shea tree fruit production. The park was squared in plots according to their size

(figure 1). The plots n° 1 to 17 measure one hectare each one, the others (n° 18 to 36), less than one hectare. The location of the trees in the park was facilitated using oil painting. Indeed, each tree in the park was marked with oil painting bearing an identification number. Plots 1, 5 and 13 respectively comprising 38, 37 and 53 trees were randomly selected (figure 1) to undertake the study. Thus, on the whole, 128 Shea trees were sampled. All fruits produced by sampled trees were harvested manually from May to July, each year. The fruits of a Shea tree gradually ripen one at a time, asynchronously. The ripened ones fall under the foliage on the ground. The yield of each tree was given after daily collection of the fallen fruits. To have the annual production of each tree, we made the sum of the daily batches.

The daily temperature and rainfall of research area were recorded by the meteorological station of National Center of Agronomic Research, for 5 years: 1998, 1999, 2000, 2001 and 2002, from which average monthly temperature and rainfall were calculated.

The data collected on fruit production were subjected to analysis of the post-hoc test Newman Keuls, which is a multiple comparison test. The Pearson Correlation Coefficient was used to calculate the effect of the temperature and rainfall on Shea tree monthly fruit production.

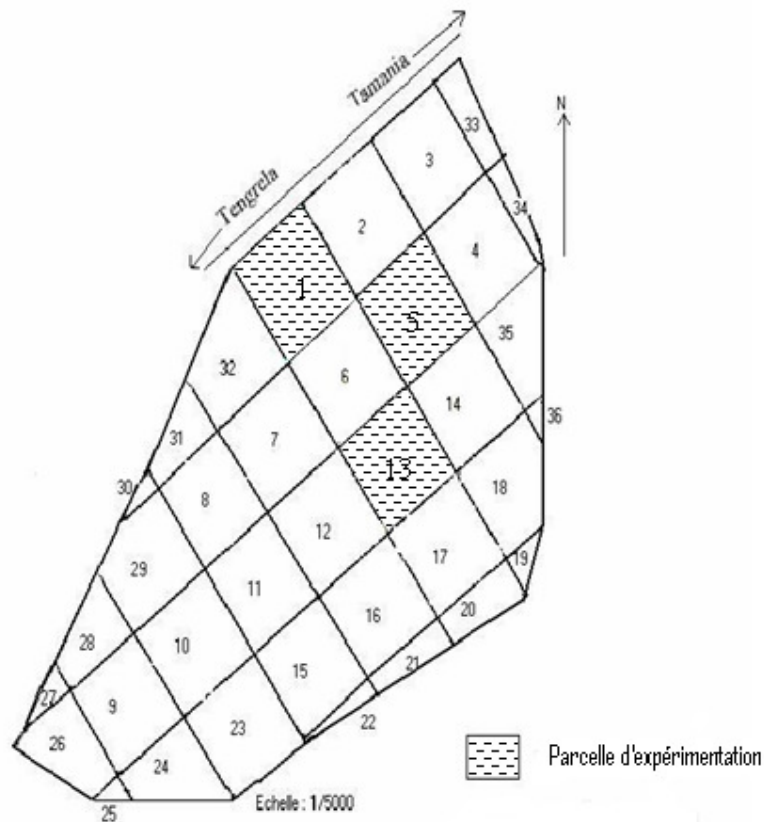


Figure 1: Grid of plots of the park of Shea trees, Tengrela, Côte d'Ivoire.

RESULTS

Production in fruits of Shea tree

Figure 2 presents the evolution of the fruit falling of the whole sampled Shea trees during the 5 years of the study. The evolution of fruit falling of the whole trees presents 3 phases. The first phase shows an increase in the rate of fruit falling with time, the second phase translates a peak of the rate of fruit falling and the third phase presents a decrease of the rate of fruit falling at the wire of time. It is noted that the period of Shea tree fruit harvest is located between the end of May and the beginning of July in the north of the Côte d'Ivoire. We observed a shift in the period of fruit production one year to the other at Shea tree. Indeed, in 1998 the essential of the fruit yield was recorded in May. But, for the others years (1999, 2000, 2001 and

2002), the optimum of the production was obtained in June, with a shift from one year to another. The production of Shea tree varied from 0 to 14713 fruits per tree (Table 1). The annual average of production recorded from 1998 to 2002, was ranged between 794 and 2098 fruits per tree. The coefficient of variation of these averages is high. That shows a strong variability of fruit production from one Shea tree to another. Data of this study suggested that the average annual production of Shea tree varied significantly throughout the 5-year period (Figure 3). Indeed, average annual production of fruits had maximum value in 1998 and then it dropped from 1999 to 2000 when it reached its minimal value. From 2000, it increased to have maximum value in 2002.

Table 1: Average, minimum, maximum and coefficient of variation (CV) of fruit production by Shea trees (n=128), from 1998 to 2002 in the Shea trees parkland, Côte d'Ivoire.

Years	Average	Minimum	Maximum	CV	Letters of the Newman Keuls test
1998	1657.91	38	7187	74.37	c
1999	1413.34	0	9713	111.4	bc
2000	794.42	71	2623	69.95	a
2001	1123.64	0	4667	81.34	ab
2002	2098.35	32	14713	102.76	d

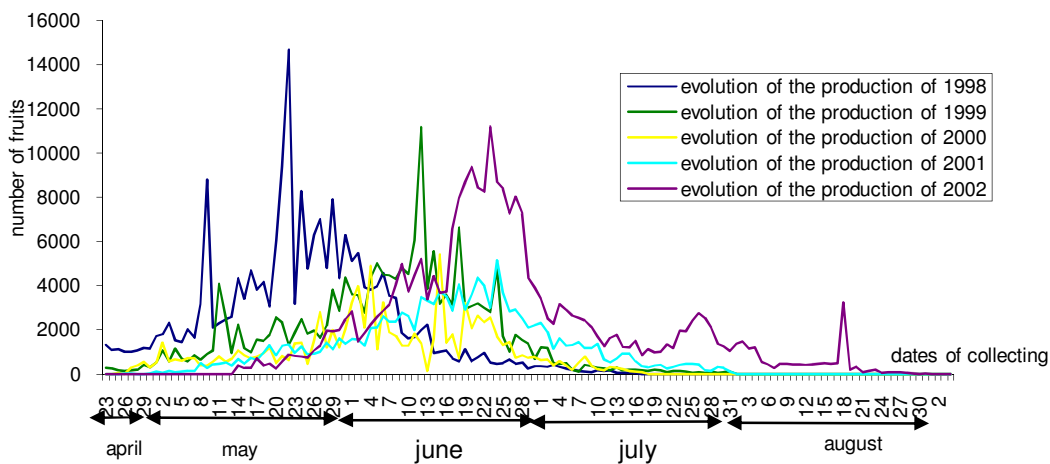


Figure 2: Evolution of fruit production of Shea trees (n = 128), from 1998 to 2002.

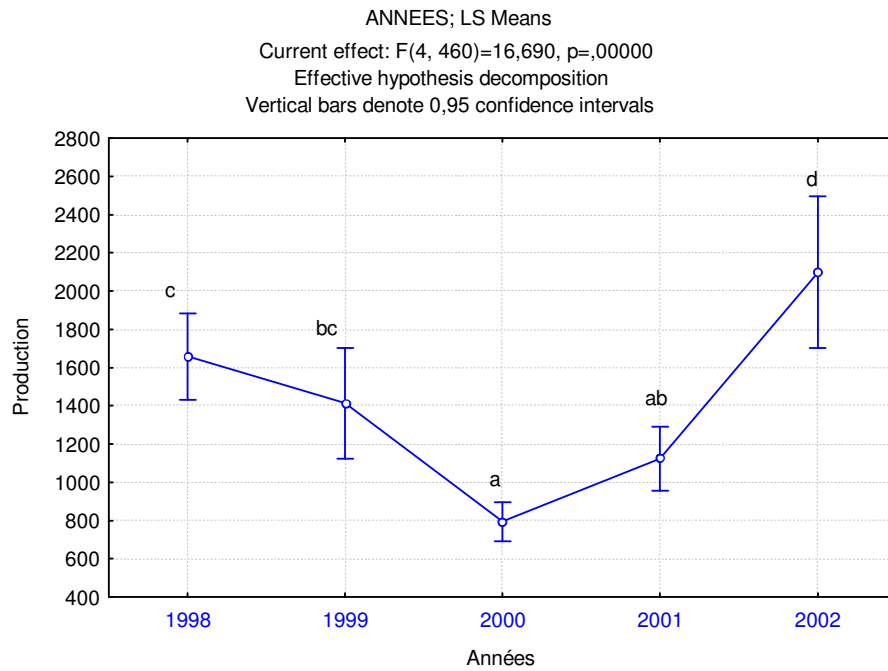


Figure 3: Interannual variability of fruit production of Shea tree (n = 128) in Shea trees parkland, Tengrela, Côte d'Ivoire.

Effect of the temperature and rainfall on Shea tree fruit production

Figure 4 gives the distribution of monthly temperatures of the research area during 5 years. Data of the study suggest that the average monthly temperature did not vary greatly and were usually ranged from 24.6 to 31.5 °C each year. In 1998 and 2002, temperature was appreciably higher than in

1999, 2000 and 2001. It is also noted that in fact the productions of 1998 and 2002 were highest. But Temperature did not have a significant role in fruit production at Shea tree. Indeed, a positive relationship was not found between the monthly average temperature and the number of fruit produced, in the 5 years data (table 2).

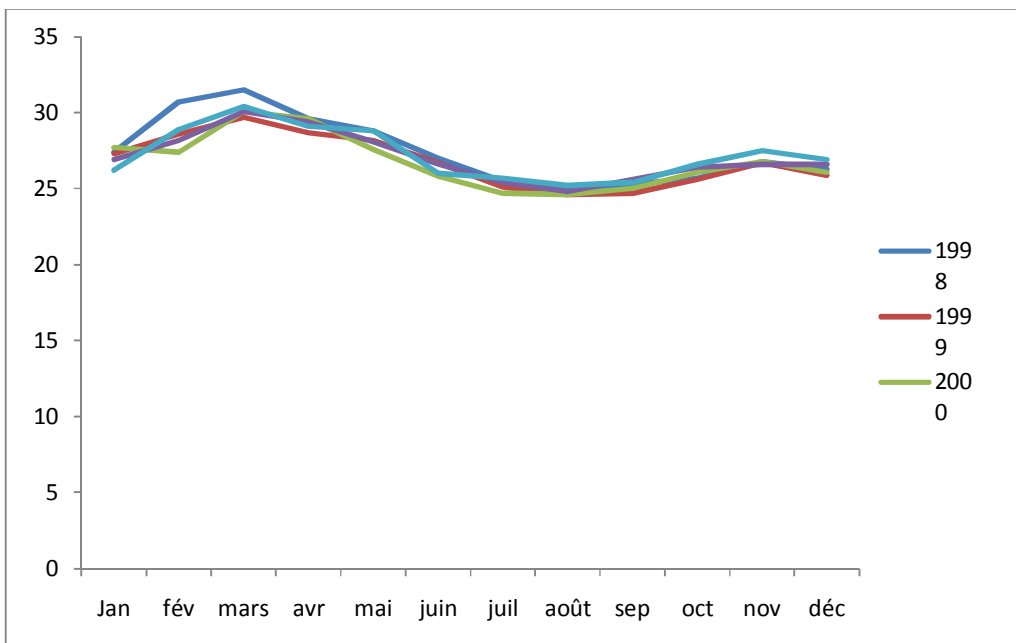


Figure 4: Monthly distribution of the temperatures in Shea trees parkland of Tengrela Department, 1998 to 2002

Table 2: Correlation among monthly Shea tree fruit production (n=128) and weather data (temperature and rainfall).

		Fruit production				
		1998	1999	2000	2001	2002
Temperature	r	0.48	0.34	0.25	0.43	0.5
	p	0.17	0.21	0.35	0.23	0.06
Rainfall	r	0.5	0.43	0.32	0.47	0.67
	p	0.06	0.15	0.29	0.12	0.01

Figure 5 shows the average monthly rainfall of the research area, during 5 years. The average monthly rainfall differs from one year to another. Indeed, the peak of the average monthly rainfall was obtained in fine July in 1998, 2001 and 2002, whereas it intervened in August in 1999 and 2000, with of course a shift more or less significant from one year to another. Rainfall

varied considerably with almost no rain in some months to over 519.9 mm in others. Positive relationship between average monthly rainfall and fruit production appeared only in 2002 (table 2). Number of fruit produced was more strongly related to the amount of rainfall than to the amount of temperature in 2002.

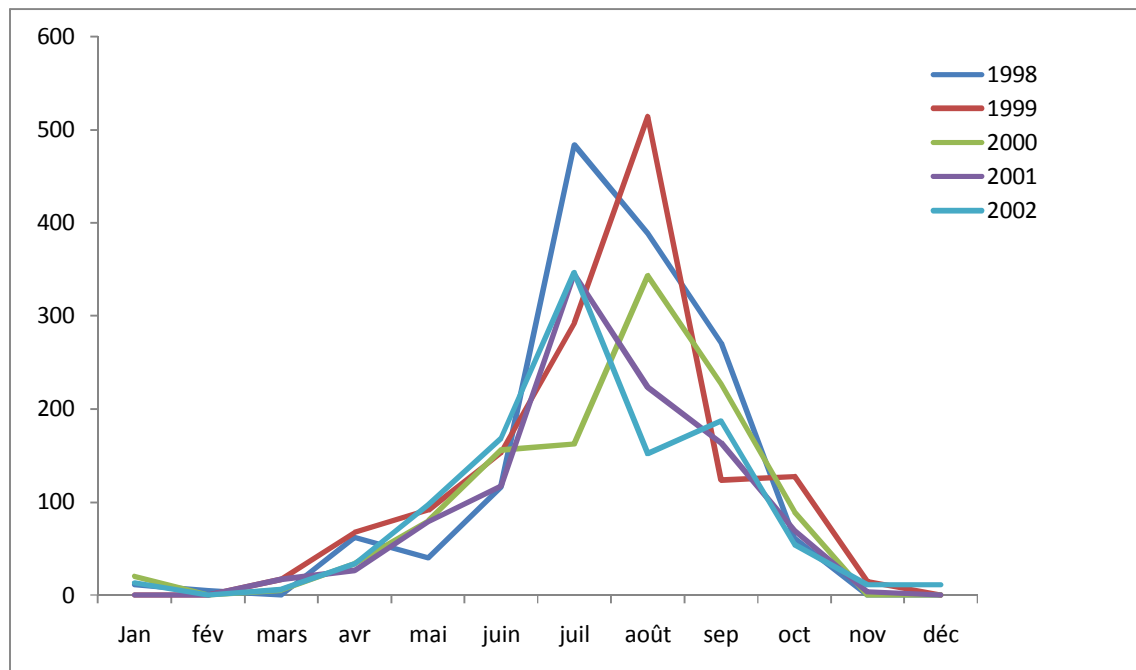


Figure 5: Monthly distribution of the rains in Shea trees parkland of Tengrela Department, 1998 to 2002

DISCUSSION

Production in fruits of Shea tree

Our results showed that the average annual production of Shea tree was ranged between 794 and 2098 fruits per tree. These results are in agreement with those of Ruysen (1957) which locate the average of the production in fruits of this wide species between 15 and 20 kg of fresh fruits per tree, that is to say from 0 to 15000 fruits per tree. The results suggested a strong variability of the fruit production from one tree to

another. These observations agree with earlier reports that Shea tree populations are wild and diverse in phenotype and genotype, and hence fruit production varies from a tree to the next (Fontaine *et al.*, 2004; Lovett and Haq, 2000). Data of this study showed that Shea tree fruit production fluctuates from a year to another. Several factors influence Shea tree fruit production and Millogo-Rasolodimby (1989), thinks that the entomophilous pollination plays a significant role in the variability of the fruit production of Shea tree according to years. Indeed, Shea tree reproduces

mainly sexually and most often it is by insect-pollination. But, for Laroussilhe (1979) the variability of the fruit production could come from endogenous factors of regulation. It can for example be a question one period of rest following a high production. Indeed, a strong production mobilizes all the nutritive reserves of the plant. The branches do not have time to accumulate sufficient hydrocarbon substances necessary to floral differentiation for the following year. It thus follows a lower production and so on.

Effect of the temperature and rainfall on Shea tree fruit production

In our study the temperature amount was not related to the number of fruits produced. Number of fruit produced was related to the amount of rainfall in 2002. These results corroborate Bonkougou (1987) and Half (1945) findings which indicate that there are not fine correlations between Shea tree fruit production and the climatic parameters. But our results are not in agreement with those of Desmarest (1958), which indicates that high temperatures during flowering would involve necessarily an increase in Shea tree fruit production. We agree with Adam and Ferrand (1954) whose affirm that the relations between Shea tree fruit production and the rainfall level are complex and often confused.

Number of fruit produced was more strongly related to the amount of rainfall than to the amount of temperature in 2002. Previous work (Cambroy, 1989), indicate that the expression of the potential of a plant, in a given site, is conditioned by 4 fundamental variables of the environment: the temperature, the availability of water, the conditions of the ground and biotic factors. These factors influence the occurrence of the spontaneous species and the economic level of the crop plants, that is to say their productivity. Cambroy (1989) specifies that the availability of water and rainfall level constitutes the dominating factor influencing the conditions and rhythm of the plant life. So the increase of number of fruits produced with the amount of rainfall.

CONCLUSION

Several features make the Shea tree a valuable resource for producer countries. It is an important economic commodity both locally and internationally. However, Shea is mostly a subsistence product resulting from gathering activities of local people. Shea tree populations are wild and annual fruit yields are variable. The attempts carried out so far to control the culture of this tree appeared unfruitful. In this study, we tested the effect of the temperature and rainfall on Shea tree fruit production. The study revealed significant relationships between the fruit production of this species and rainfall. It showed that production in fruits of Shea tree increases with rainfall but not with air temperature.

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