Thaumatococcus daniellii (Benn.) Benth. – a Natural Sweetener from the Rain Forest Zone in West Africa with Potential for Income Generation in Small Scale Farming

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Abstract

The sweet prayers plant (*Thaumatococcus daniellii*) is widely found in tropical rain forests of West Africa. Local uses are versatile, ranging from cultivation as fetish plant in Gabon to collecting leaves from its natural habitat for wrapping and boiling food in Ghana and Nigeria. The most exiting use of *T. daniellii*, however, is its use as sweetener or taste modifier. The aril of the fruit contains thaumatins, a mixture of extremely sweet proteins. In many countries, it is used by the food and confectionary industry for substituting synthetic sweeteners. Presently, fruits are extracted from the natural habitat and sold to buying companies. The way how the fruits are collected, is often not sustainable. Integrating *T. daniellii* in cropping systems seems to be a promising way to lessen these shortcomings, contributing to both income generation and diversification of crop production by small scale farmers. Knowledge on its cultivation is not available. This study aimed at collecting basic information on *T. daniellii* and its potential for future cultivation. Therefore, interviews with key informants and a field trial were carried out in the Western Region of Ghana in 2002. The evaluation of the questionnaires improved the understanding of production conditions and contributed to identify possible production and adaptation constraints. The field experiment produced information on light requirements of *T. daniellii* for field establishment and growth during early growth stages.

Introduction

The sweet prayers plant or katemfe (*Thaumatococcus daniellii* (Benn.) Benth.) grows throughout the hot, humid tropical rain forest and coastal zone of West Africa (Franke, 1985; Mansfeld, 1986). Its natural habitat is the undergrowth of forest trees. *T. daniellii* is particularly found in southern parts of Ghana, Cote d'Ivoire and Nigeria. It is also known to

exist in the Princes Islands, Angola, the Central African Republic, Uganda and Indonesia.

Katemfe is a rhizomatous, perennial and monocotyledonous herb, propagating itself by rhizomes (Onwueme *et al.*, 1979). About 2 or 2.5 m long petioles arise from the rhizomes depending on the age and the environment of the plant (Fig. 1a). At the end of these long petioles are large broad and oval papery, tough, versatile leaves that are about 45 cm long and 30 cm broad. The leaves are ovate-elliptic rounded, truncate at the base, and shortly acuminate at the apex.

The inflorescence of *T. daniellii* usually arises from the lowest node and may be simple or forked with spikes about 8 to 10 cm in length and bracts, usually umbricate, about 3 to 4 cm in length (Tomlinson, 1961). The flowers that may be as long as the bracts form in short spikes close to the ground at the base of a swollen petiole (Fig. 1b). Sepals are broadly linear and about 1 cm in length. Corolla tubes are short and lobes are oblong and about 2.5 to 3 cm long. As many as 10 to 12 purplish-pink flowers may form on each inflorescence, but usually only 2, 3 or 4, rarely more than 4, of these form matured fruits (Fig. 1c). The plant flowers most of the year but is most prolific from July until late October, followed by fruit formation, maturing and ripening from January until mid-April (Onwueme et al., 1979).

a) b) c)

Fig. 1. *T. daniellii*: a) growing in a cocoa field in Ghana; re-growth one month after field clearing; b) open flower; c) fruit attachment to the roots.

The fruit grows on short stalks close to the ground and may be covered with plant debris as it clusters on the soil surface within the reach of insects and rodents. It is pyramidal or trigonal in shape, maturing from a dark-green through brown to crimson or bright-red colour when fully ripe and may weigh between 6 and 30 g depending on whether it has one, two or three seeds. Within the fruit are the black hard seeds that are covered by a thin layer of sticky, transparent gel. The seeds look more like stones when dried, obviously showing its hardness and impervious nature. It also has a soft, fleshy and juicy cap called an aril, which contains the sweet substances (Onwueme et al., 1979).

Local uses are multipurpose, ranging from cultivation as fetish plant in Gabon (Mansfeld, 1986) to collecting leaves for wrapping and boiling food in Ghana (Facciola, 1998) (Fig. 2). Large quantities of the fruit are consumed by the local people to sweeten over fermented palm wine and sour foods. From the aril of *T. daniellii*, an intensely sweet, non-toxic and heat stable protein – thaumatin - is extracted, used as sweetener or taste modifier in beverages, desserts, chewing gums and pet foods (Fig. 3).

Fig. 2. In Ghana, *T. daniellii* leaves are collected from its natural environment and sold on local markets for wrapping and boiling food.

Fig. 3. Thaumatin crystals are about 2,000-3,000 times sweeter than sucrose and neither allergic nor mutagenic or teratogenic.

Its present exploitation, however, is neither sustainable nor matching industrial demand. Introducing *T. daniellii* in cropping systems of peasant farmers is considered to contribute to income generation, diversification of crop production, adding value to non-tree forest products. This study aimed at collecting information on cultivating *T. daniellii*.

Materials and Methods

The study presented here was done in two parts. These were:

- interviews with key informants and
- a field trial.

The interviews and the field trials were carried out between April 29 and July 31, 2002 in the tropical rain forest zone of the south-western part of Ghana.

Interviews

The interviews were conducted with key informants by using questionnaires in rural communities. In total, 60 households were interviewed: 15, 25 and 20 near Asankragua, Samreboi and Enchi, respectively. Rural communities were selected according to their infrastructure.

Each questionnaire consisted of 46 questions, subdivided into the sections crop production, forest as a resource, sustainable crop production and local knowledge on *T. daniellii*.

Field trial

The field trial was established on a rubber plantation close to Oda-Kotoamso, a village located at about 10 km north of Asankragua in the Western Region of Ghana. Annual rainfall in this area is between 1400 and 2000 mm with two distinct rainy seasons from April to July and from September to November. The highest rainfall is recorded in June and

July. From December to March, there is a short dry season. Mean annual temperature is 26°C. The topography around Oda-Katoamso is slightly undulated and the altitude ranges between 91 and 396 m above mean sea level. The soil at the test site is characterised by a pH of 5, an organic C content of 1.3%, a total N content of 0.8%, an available P content of 45.3 mg/ha and an exchangeable K content of 0.12 c(+)mol/ha.

The trial was laid out in a split plot design with four replicates. The main factor was light: (i) low shade with an initial light transmission rate (LTR) of 0.80 or L1, (ii), medium shade with an initial LTR of 0.45 or L2 and (iii) heavy shade with an initial LTR of 0.15 or L3. The sub-factor was fertiliser application: (i) no NPK and (ii) 30 kg/ha of NPK.

The size of a single sub-plot was 6 m^2. Rhizomes were planted at a spacing of 50 x 50 cm and at depths of about 7 cm.

The statistical analysis was done as a two way analysis of variance (ANOVA) with the software Sigmastat 2.0. Data for a few parameters that failed the normality test were first transformed by rank before the two way ANOVA test was run.

Results

Farm size and structure

The interviews revealed that the majority of the households in the interview area had a size of ten individuals or less. Most of the farmers are small holders and generally had limited formal education. 80, 96 and 70% of the households in the rural districts of Asankragua, Samreboi and Enchi, respectively, had a farm size of less than 7.5 acres. In Samreboi and Enchi, 64 and 55% of the households, respectively, already have all land under cultivation, while in Asankragua 53% of the farms had up to 2.5 acres of forest reserve.

Crop production

Slash-and-burn agriculture is the predominant farming system and is practised by all the households that were interviewed. About 80% of households in Asankragua and Enchi had a cropping period longer than 5 years due to the production of cocoa, whereas 32% in the Samreboi area had cropping periods of five years or longer. Fallow periods ranged between three and five years or more in Asankragua. In the other two observation areas, the fallow period never exceeded five years. In Enchi, 15% of households have fallow periods between 3 and 5 years. In Samreboi, 64% of the farmers had only 1–2 years of fallow.

All households interviewed in the three observation areas were aware of forest degradation and attributed it to the slash-and-burn practice and demographic growth. In order to reduce the rate of forest degradation, intensification of crop production was suggested by 87%, 80% and 84% of the households in the three areas Asankragua, Samreboi and Enchi, respectively.

All interviewed households grew staple crops such as maize (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), plantain (*Musa* sp. L.) and cocoyam (*Colocasia esculenta* Schott) and cocoa (*Theobroma cacao* L.) as cash crop. Other cash crops are oil palm (*Elaeis guineensis* Jacq.) and kola nut (*Cola nitida* Schott et Endl.), but they are cropped at a much lesser extent. Thereafter, vegetables such as tomatoes (*Lycopersicon esculentus* Mill.) and garden eggs (*Solanum melongena* L.) play an important role in income generation, but at a much lesser extent in the Enchi area. Non tree forest products (NTFPs) collected from the forest of the observation area include *T. daniellii* leaves and fruits, edible mushrooms, snails (*Achatina achatina* L.) and game.

Local knowledge on T. daniellii

The questionnaire showed that only 20, 16 and 25% of the households in the Asankragua, Samreboi and Enchi areas, respectively, used the fruits as sweetener or sweets, although the majority of the households stated that they are intensely sweet.

Eighty per cent of the households in the Asankragua and Enchi areas collected *T. daniellii* leaves for sale, whilst 92% do so in Samreboi. Although in the Asankragua area nobody collects the *T. daniellii* fruits, 48% and 90% of households collected them in the Samreboi and Enchi areas, respectively (Table 1).

Table 1. Trade of *T. daniellii* in the observation area, Western Region of Ghana, 2002

	Asankragua	Samreboi	Enchi
Leaves sold (%)	80	92	80
Fruits sold (%)	0	48	100
Price/kg (Euro)	-	0.25	0.20

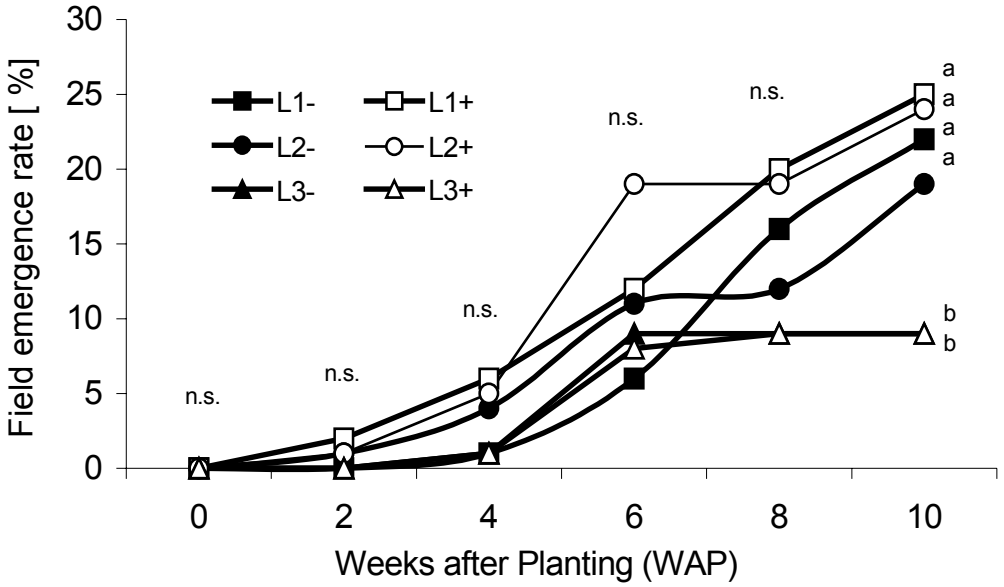
Women are mainly the fruit collectors. Long distance walk through thick forests makes fruit collection difficult. Selling of *T. daniellii* leaves is wide spread in the observation area. Fruit sale, however, largely depends on market opportunities as shown by data collected from farmers in Enchi and Samreboi.

Juvenile growth of T. daniellii as affected by light and fertilisation

In general, positive effects of fertiliser application were not observed within the first ten weeks of plant growth, except for an increased plant height at 2 and 6 weeks after planting (WAP) when *T. daniellii* was fertilised. This trend was not persistent and data were, therefore, not

shown in this study. Heavy shade, however, was detrimental to juvenile growth of *T. daniellii*, continuously showing significant differences towards the end of the observation period.

Field emergence of *T. daniellii* up to 10 weeks after planting (WAP) was low, reaching 25%, 20%, and 10% under low (L1), medium (L2), and heavy (L3) shade, respectively (Fig. 4). Differences between low or medium shade and heavy shade were significant ($P \leq 0.05$).

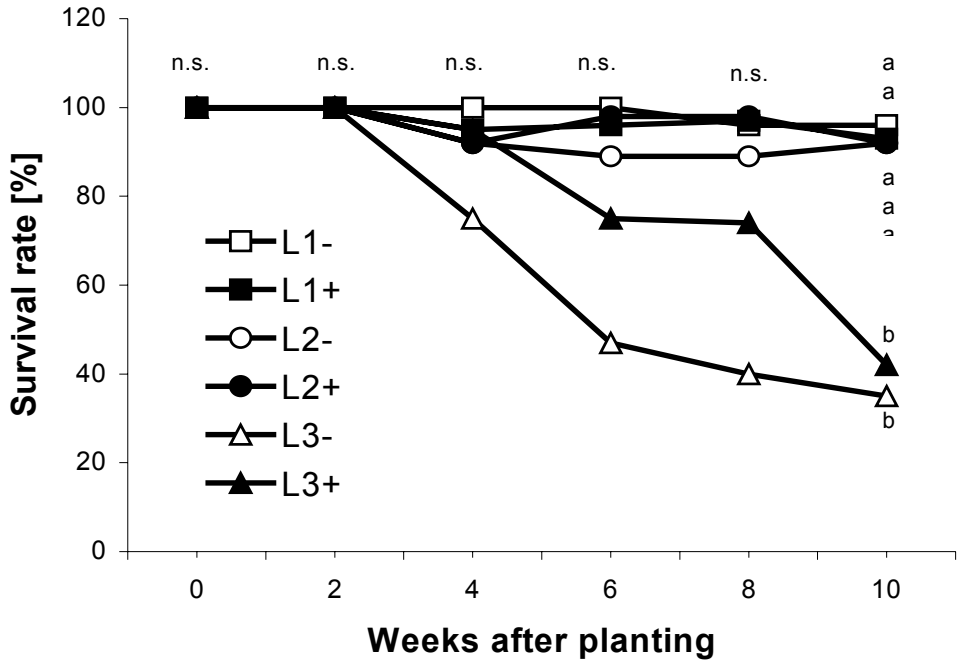


a, b = significant differences at $P \leq 0.05$, n.s. = non significant
L1 – low shade, L2 – medium shade; L3 – heavy shade; - = no NPK; + = + NPK

Fig. 4 Field emergence of *T. daniellii* propagated by rhizomes as affected by light regimes and fertilizer application. Oda-Kotoamso, Ghana, 2002.

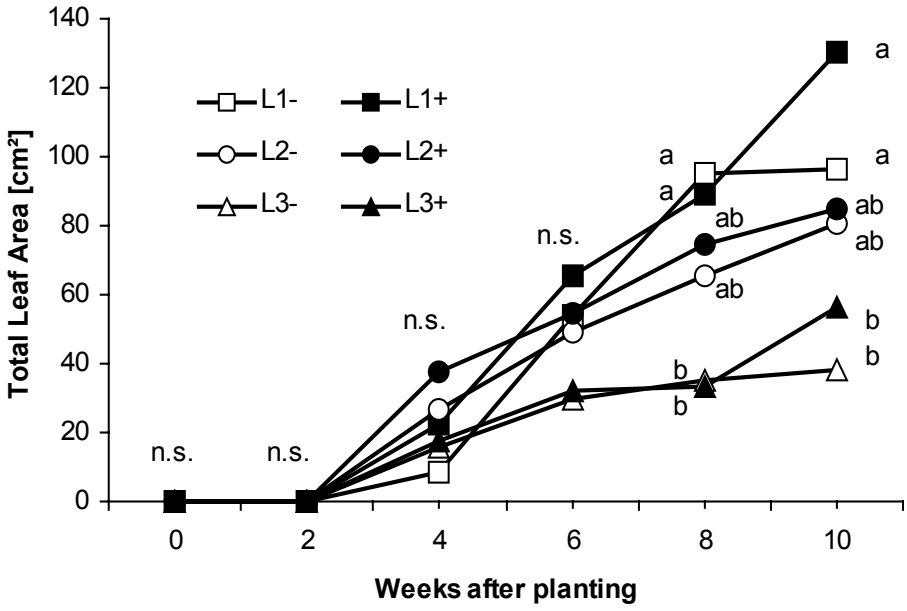
The survival rate decreased to 40% within 10 WAP in L3, while the survival rate maintained at almost 100% in the low and medium shade treatment (Fig. 5). Differences were significant at $P \leq 0.05$ 10 WAP.

Early growth of T. daniellii was best under low shade and decreased with higher amounts of shade (Fig. 6). The differences in total leaf area development were significant for the low and heavy shade treatment at 8 and 10 WAP.



a, b = significant differences at P ≤ 0.05, n.s. = non significant
L1 – low shade, L2 – medium shade; L3 – heavy shade; - = no NPK; + = + NPK

Fig. 5. Survival rate (%) of *T. daniellii* propagated by rhizomes as affected by different light regimes and fertilizer application. Oda-Kotoamso, Ghana, 2002



a, b = significant differences at P ≤ 0.05, n.s. = non significant
L1 – low shade, L2 – medium shade; L3 – heavy shade; - = no NPK; + = + NPK

Fig. 6. Total leaf area of T. daniellii propagated by rhizomes as affected by light regimes and fertilizer application. Oda-Kotoamso, Ghana, 2002.

Discussion

Due to the manufacture of polythene bags, the traditional use of leaves for wrapping food and its potential as a source of income for rural communities is gradually facing out in Ghana. However, domestication of *T. daniellii* for fruit production has a potential to generate a new source of income and, thus, to reduce forest degradation which is a major concern for the farmers in the observation area. Its adoption and cultivation can make an important contribution to poverty alleviation by improving food security, sustainable development and at the same time help in conserving biodiversity (Johnson, 1997). But this can not be achieved without educating farmers on this new potential crop and providing useful agronomic information and advice on cultivation.

Therefore, testing of crop management options under small scale farming conditions is an important step in promoting a new crop. This study gives a first blue print for growth requirements of *T. daniellii* when integrated to a cropping system. At the end of the observation period - between 8 and 10 WAP - total plant height and total leaf area generally showed significant differences for the different light regimes. The highest plants, as well as the highest total leaf area, were observed in L1 (low), the smallest in L3 (heavy shade). In general, plants that are under shade or in very low light intensities tend to be etiolated because they would like to grow tall with elongated internodes in order to capture light (Eichhorn *et al*., 1999). Contrary to this observation, the plants that were in the L3 did not become etiolated, rather they looked smaller. Therefore, it is considered that the amount of shade used in the L3 treatment was not too high, but for an adequate dry matter production less shade is better. But presently, it is not clear whether the light regime plays a role in fruit setting of *T. daniellii* or not.

Conclusions

T. daniellii seems to be suitable for integration into agroforestry systems; juvenile growth was well under low shade conditions but further research for establishing an adequate cropping system is required.

Major production constraints were not identified, but supply of high quality planting material is a major issue for improving field emergence and crop performance.

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