# Shea (*Vitellaria paradoxa*) intercropping systems in northern Ghana: Effect of cultural practices and crop combinations on the performance of shea seedlings

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SUMMARY

The effects of cultural practices including two methods of land preparation (conventional and zero-tillage), five intercrop sequences and two levels of NPK fertilizers on shea seedling growth (girth and height) were evaluated in a split-split plot experiment at Bole from 1984 to 1986. Conventional tillage significantly promoted seedling growth over zero-tillage (pre-planting herbicide application). Shea seedlings intercropped with rotations involving cowpea and maize such as cowpea-yam-maize and maize-cowpea-sorghum, were relatively bigger and taller than those intercropped with rotations that did not involve cowpea and maize. There was a positive residual effect of NPK fertilizers applied to the food crops on shea seedling growth especially on ploughed and harrowed land whereas there was no effect of zero tillage.

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RÉSUMÉ

OSEI-BONSU, K., APPIAH, M. R., AMOAH, F. M. & OPPONG, F. K. : *Les systémes intercultures du Karité au nord du Ghana : Effet de pratiques culturelles et les combinaisons culturelles sur la performance des semis de Karité.* Les effets de pratiques culturelles y compris deux méthodes de la préparation de terroir (labourage-zero et conventionel), cinq séquences d' interculture et deux niveaux des engrais NPK sur la croissance (circonférence et taille) de semis de Karité étaient évalués en une expérience de lotissement réparti-réparti à Bolé de 1984 à 1986. Le labourrage conventionnel augmentait considérablement la croissance de semis sur le labourage-zero (application de herbicide de préplantation). Les semis de Karité interplantés avec les rotations entraînant la dolique et le maïs telles que dolique-igname-maïs et maïs-dolique-sorgho étaient relativement plus gros et plus grands que ceux qui n'ont pas entraîné la dolique et le maïs. Il y avait un effet résiduarie positif des engrais NPK appliqués aux cultures vivriéres sur le champ de semis de Karité surtout au terroir labouré et hersé tandis qu'il n' y avait pas d' effet sous le labourage-zero.

## Introduction

The shea butter tree, *Vitellaria paradoxa* (Gaertn) Syn. *Butrospermum paradoxum* (Gaertner) Hepper is one of the few tree species indigenous to the Sudan savanna region of West Africa (White, 1983). In Ghana, this area is marked by a unimodal rainy season of 7 months from April to October, and a dry season for the rest of the year (Wills, 1962).

The tree grows to a height of about 12 m and girth of 1.5 to 1.8 m at 1m above ground. It fruits between March and June. The fruits which contain 1-2 or sometimes 3 nuts from which shea butter is extracted is of immense local importance and international commerce. In Europe, America and Japan, shea butter is used for the manufacture of soap, candles, cosmetic and pharmaceutical products and also as cocoa butter substitutes.

Shea is best planted at stake due to its peculiar germination strategy described by Jackson (1968) as cryptogeal. The seed germinates readily in a good medium and produces a long, deeply penetrating tap root that enables the seedling to adapt to drought and fire before the plumule emerges from below the ground. Irvine (1961) suggests that the tree should be grown more extensively under proper cultivation and protected from annual devastating fires which usually destroy the seedlings. This is supported by his observation that large well-grown trees occur on farmlands in the periphery of villages where they are protected from the periodic bush fires (Irvine, 1961; Okafor, 1980; Bonjoungou, 1987).

Under natural conditions, the tree takes 12-15 years to reach full bearing, making the cultivation of the crop unattractive and frustrating. Consequently, no proper agronomic attention is given to the trees. Growth and yield are seriously affected by the seasonal drought and bush fires. The devastating effects of bush fires on woody vegetation in the Sudanian Isoberlinia woodland of Ghana has been demonstrated by Brookman-Amissah *et al.* (1980).

The large-scale cultivation of *Vitellaria paradoxa* requires the adoption of suitable cultural practices that will give protection to the young seedlings against bush fires. A method for achieving this result is to intercrop shea with food crops during its early stages of establishment. Returns from the intercrops will provide incentives for the farmer to maintain the shea trees up to the full-bearing stage. In cocoa, Glendining (1960) noticed a strong positive correlation between seedling girth and tree vigour and yield. Moses & Enriquez (1979) have also confirmed that trunk diameter can be used to predict pod yield in cocoa. It will, therefore, be interesting to establish the indicators for mature shea tree performance from the seedling studies.

This paper reports the effects of two tillage methods and four intercropping systems on the establishment of *Vitellaria paradoxa*.

## Materials and methods

The trial was conducted at the sub-station of the Cocoa Research Institute, Bole in the Sudanian Isoberlinia woodland of Ghana where the tree grows wild. An area of about 7 ha was prepared for this trial in 1983 by felling and stumping all savanna trees other than mature *Parkia biglobosa* and *Vitellaria paradoxa*. Fresh nuts from selected high-yielding trees were planted at stake at 8.8 m triangular in May 1984. Two nuts were planted per hole.

Seedlings which did not survive the dry season of 1984 were replaced in 1985. Except in a few cases, there were two seedlings per stand. The farm was maintained by regular brushing and had a clean, 10 metre-wide fire belt around the perimeter of the 7 ha block.

In 1986, a split-split plot experiment replicated four times was imposed on approximately 4 ha of the plot. The main plot consisted of two methods of land preparation, which were zero tillage of one spray application of Paraquat at 500 g a.i. in 300*l* of water per ha to control weeds and conventional tillage (ploughing followed by harrowing the land). *Imperata cylindrica* weeds on parts of the plot were controlled with Dalapon at 4 kg in 300*l* of water per ha followed 14 days later by Paraquat at 500 g a.i. per ha. Weeds were controlled in all treatments after planting the food crops by hoeing as and when necessary. The sub-plot treatment consisted of four prevalent crop rotations (crop sequences) in the area and a control of no inter-cropping, namely:

Yam - Groundnut - Millet (Crop sequence 1)
Cowpea - Yam - Maize (Crop sequence 2)
Maize - Cowpea - Sorghum (Crop sequence 3)
Groundnut - Cowpea - Yam (Crop sequence 4)
No inter-cropping: Sole crop of shea (Crop sequence 5)

The sub-plot was 0.068 ha whilst the sub-sub-plot was 0.034 ha. Fertilizer application was done at the recommended rate for the particular inter-crop in the sequence being cultivated as a split-split plot treatment. Recommended fertilizer rates per hectare for the various crops were as follows: 22.2 kg: 26.8 kg: 4.0 kg NPK for maize; 6.2 kg: 27 kg: 8.0 kg NPK for groundnuts; 14.4 kg: 35.8 kg: 10.6 kg NPK for cowpeas; 17.8 kg: 33.8 kg: 5.4 kg NPK for yams; 61.2 kg: 35.8 kg: 9.0 kg NPK for millet and 23 kg: 20.6 kg: 0 kg NPK for sorghum. Fertilizer application for yam was by banding but by broadcasting for the other crops. Yam setts (cv. Lareboko) weighing between 0.6 to 1.1 kg were used for planting at the spacing of 2 $m^2$. Yam mounds were raised in September/October of the previous year and the "seed-yams" planted in early March with the first rains. Maize (cv. Laposta) was planted at 90 cm × 30 cm. Cowpea (cv. Blackeye) and groundnuts (cv. Chinese) were planted at 45 cm × 15 cm. A trailing type of cowpea was planted in 1986; thereafter, the erect white black-eye cowpea was seeded. Cowpeas and groundnuts were usually planted in May and harvested in August. However, maize was usually sown in June and harvested in October/November using the late-maturing varieties for good natural drying. Sorghum (cv. Local type) and millet (cv. Local type) were planted at 60 cm × 90 cm and 90 $cm^2$ respectively. Maize, cowpea and groundnuts were sown at two seeds per stand. Sorghum and millet were sown at four-six seeds per hole and later thinned to two seedlings per stand. Sorghum was cropped between June and November, whilst millet was cropped between July and January. Growth measurements on eight shea seedlings from four paired stands per sub-sub-plot were taken in April and October, and the growth increments analysed on annual and cumulative basis. Climatic data for Bole is presented in Fig. 1.

Shea seedling performance was evaluated on the basis of the crop sequence as listed above and also on the following four cropping systems:

1) Zero tillage with fertilizer application
2) Zero tillage without fertilizer application
3) Conventional tillage with fertilizer application
4) Conventional tillage without fertilizer application

## Results and discussion

Fig. 2a and Fig. 3a show the effects of the various cultural practices on the growth of shea seedlings. Shea seedling growth was significantly ($P < 0.01$) influenced by the method of land preparation. Conventional ploughing and harrowing, as opposed to zero tillage, caused shea seedlings to grow better. This could have been due to the loosening of the cloddy soils in this area and the incorporation of litter into the soil by the ploughing treatment (Wills, 1962). The growth of seedlings in the zero tillage treatment appears similar to the slow growth of shea seedlings in the wild under competition with the natural vegetation (Kater, Kante & Budelman, 1992; Irvine, 1961). In fact, comparable seedlings from this experiment which were left in the wild and subjected to occasional bush fires were very stunted (Osei-Bonsu, unpublished). However, it would only be possible to plough and harrow through a plantation of shea seedlings only when the spacing was appropriate as occurred in this experiment.

The cultivation of cowpea and maize in the crop sequence helped to produce taller shea plants in 1986 ($P < 0.001$) than intercropping shea seedlings with yams, groundnuts or from the control (Fig. 3c). The effect of the previous crop of maize on shea seedling height was still significant ($P < 0.05$) in April 1987.

Shea seedlings in Crop sequence 2 were also significantly bigger ($P < 0.05$) in April 1987 when

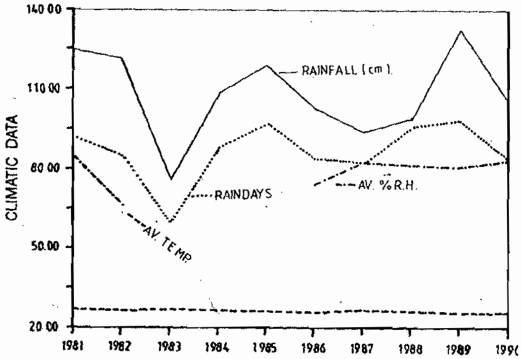


Fig. 1. Bole meteorological data (1981-1990): –rainfall (cm), .... rain days, - - - average temperature, and, -.- average per cent relative humidity

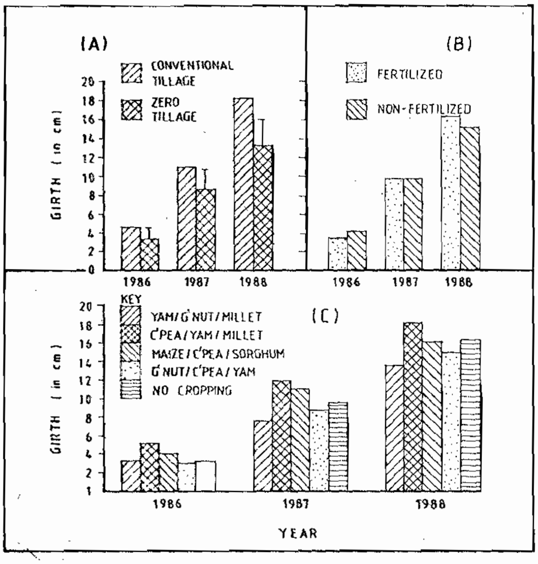


Fig. 2. The effect of (A) land preparation, (B) fertilizer application and (C) crop sequence on shea growth in girth (cm)

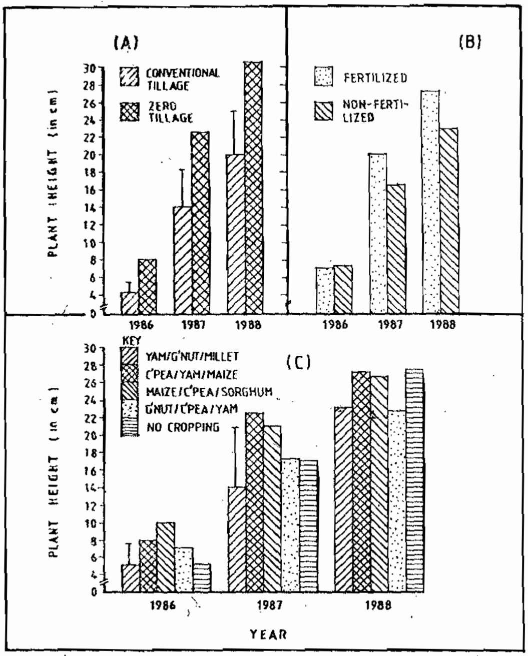


Fig. 3. The effect of (A) land preparation, (B) fertilizer application and (C) crop sequence on shea growth in height (cm)

yam had just been planted (Fig. 2c). Considering the climatic conditions in the area which cause shea seedlings to shed their leaves and stop growing between November and March, one would infer that the girth increment could only result from the residual beneficial effect of the cowpea in 1986 (Sharma, Bhandari & Rana, 1985). Shea growth in Crop sequence 1 was not better than the control treatment (Fig. 2 and Fig. 3) indicating that this rotation does not enhance shea seedling growth probably on account of the yams impoverishing the soils. There was a significant interaction ($P < 0.05$) of tillage with the crop sequence in April 1987 (Fig. 3). This confirms our previous suggestion on the benefit to be derived from the use of cowpea. When the trailing type of cowpea was fertilized, a lot of vegetative growth was produced which could have gone to enrich the soil for the effect noticed on the shea seedlings (Sharma, Bhandari & Rana, 1985).

The application of fertilizer to the food crops did not have any significant residual effect on the shea seedlings. However, there were significant positive effect of tillage × fertilizer interaction on the girth ($P < 0.05$) and height ($P < 0.01$) of the shea seedlings in 1987 and 1988 respectively (Fig. 5). Under conventional ploughing and with the application of fertilizer to the food crops, bigger and taller shea seedlings were produced. This contrasts with the production of smaller seedlings when fertilizer was applied under zero tillage conditions (Fig. 5). The poor performance of shea seedlings on fertilized zero tillage plots could have been due to severe competition from fertilized weeds which grew luxuriantly. In fact, unlike the intercropped plots where weeding the food crops protected the shea seedlings, plots not carrying any food crop were not weeded after the application of the initial treatment. There were no other interaction effects on the growth of shea seedlings. Wide fluctuations in rainfall during the period (Fig. 1) caused the failure of the maize crop in 1988 and affected the performance of the food crops in their response to fertilizer application.

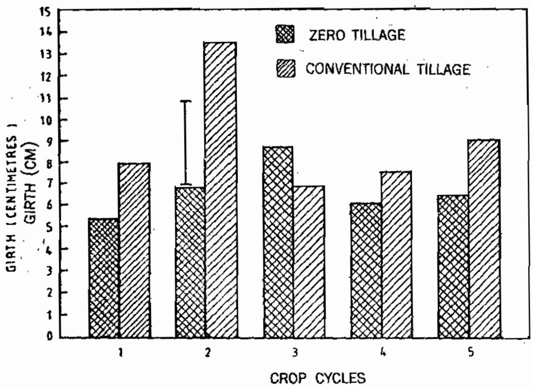


Fig. 4. The effect of tillage and crop sequence on the girth of shea seedlings in April 1987

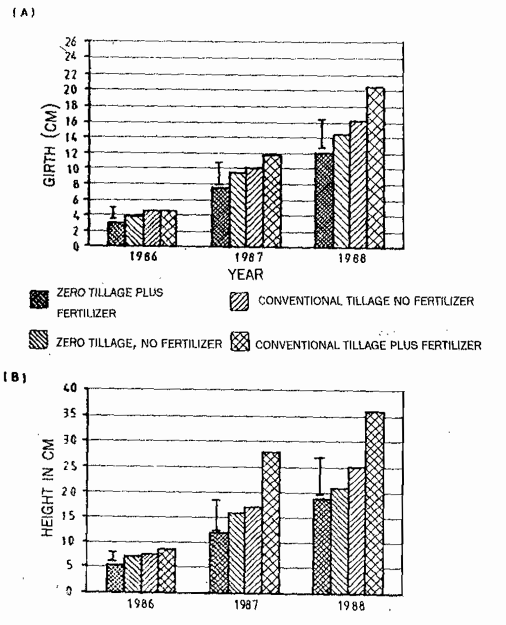


Fig. 5. The interaction of land preparation and fertilizer application on (A) Girth, and (B) Height of shea seedlings

## Conclusion

The results of the experiment reported here demonstrate that the application of proper agronomic measures such as conventionally tilling the land and intercropping with rotations involving cowpeas enhance the establishment and growth of shea seedlings. Conventional tillage is commonly practised for cereal cultivation and is recommended during the establishment of shea plantation.

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