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FOOD, COFFEE AND CASUARINA: AN AGROFORESTRY SYSTEM FROM THE PAPUA NEW GUINEA HIGHLANDS*

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ABSTRACT

An agroforestry farming system is described from the Papua New Guinea highlands (1400 to 2100 metres) that has been developed by village growers since about 1960 and has expanded rapidly since about 1970. Major components of the system are numerous species of annual and perennial food crops (especially bananas), arabica coffee and *Casuarina oligodon*. It provides food, a cash crop and timber for construction and fuel. It is likely that returns on labour inputs are very favourable, but no formal assessments have been made. Evaluation of the system as a whole, and research on certain key components (casurarina ecology, banana cultivars, timing of operations) are suggested as high priority areas for systematic studies.

Keywords: Agroforestry, casuarina, coffee, food crops, highlands Papula New Guinea.

1. INTRODUCTION

Within the central highlands of Papua New Guinea (PNG) live just over a million people. Most of these are village dwellers whose major cash crop is Arabica coffee (*Coffea arabica*). These smallholders produce 70-75 percent of the nation's total production of coffee, which is the major export crop. The majority of new coffee plantings made by smallholders in recent years have been in agroforestry systems that incorporate annual and perennial food crops, coffee and shade species. One such system is described here.

2. GENERAL DESCRIPTION OF THE AREA

PNG has a land surface area of 464,000 km and is located between the equator and 12°S latitude and 141-156°E longitude. The dominant natural environments are mountains and foothills of less than 1000 m altitude to peaks at 4500 m. The central highlands consist of a complex association of mountains and intermountain valleys (1).

The nation lies wholly within the humid tropics and humidity is high everywhere. The main influence on temperatures is altitude and, away from the moderating influence of the ocean, there is a very close and linear relationship between temperatures and altitude. Madang with mean maximum and minimum temperatures of 30°C and 23°C is typical of coastal locations. Mount Hagen town (1700 m) is typical of locations in the intermontane valleys with a mean maximum and minimum temperature of 24°C and 13°C respectively. Seasonal temperature variations is everywhere small to negligible. Mean annual rainfall varies from 1000 mm to over 8000 mm, but most people live in locations which lie within the range of 1500 to 4000 mm. Many locations experience a drier period between May

and September, but there are variations on this including a reversal of this pattern in some localities.

Floristically rich and luxuriant rain forests cover over 75 percent of PNG's land area. The forest types are broadly categorized into five to six sections, based on altitude, floristic composition and physiognomy of the structural forms. They include various vegetation forms of lowland (coastal, mangrove, evergreen, etc.), montane, and subalpine types (7).

The system described here is practised over an estimated 25,000 ha in PNG highlands (4) at an altitudinal range of 1400 to 2100 m where the annual rainfall varies from 1900 to 5000 mm (mostly between 2000 and 2800 mm). The soils on which the system is practised are variable, but typically contain significant amounts of volcanic ash, are high to very high in organic matter (5 to 20%) and are often poorly drained.

Sweet potato *(Ipomoea batatas)* is the staple food of both the people and their most important animal, pigs. Numerous other species are grown as food crops, often in mixed vegetable gardens that do not include sweet potato. It is these mixed vegetable gardens that form the basis of a recently developed food crop/coffee/casuarina system. At these altitudes, firewood for cooking and household heating is an important part of the ecosystem. In many highland areas it is now a scarce resource.

3. STRUCTURE OF THE SYSTEM

The major species used in the system are numerous annual and perennial food crops, arabica coffee and *Casuarina oligodon*. *C. Oligodon* is a fast growing woody species that provides shade and timber for fencing

house construction and firewood. Its timber is easy to split and it burns well. The food crops include bananas (*Musa* cvs) (mostly triploid cultivars at these altitudes), taro (*Colocasia esculenta* and *Xanthosoma sagittifolium*), sugarcane (*Saccharum officinarum*), maize (*Zea mays*), highland "pitpit" (*Setaria palmifolia*, *Amaranthus* spp., *Oenanthe javanica*, *Rungia klossii* and others. Other components which may be present are nut pandanus (*Pandanus jiulianettii*) at altitudes above 1800 metres and oil pandanus (*Pandanus conoideus*) below 1700 m. Pigs commonly graze under established coffee/casuarina/banana stands, but they are not a critical component of the system. Cassava (*Manihot esculenta*) is an important component of a similar system used on better drained soils, but not in this system on the wetter soils.

The basic structure of the system is that mixed vegetable gardens are gradually converted into coffee/banana gardens and eventually into coffee/casuarina stands. Figure 1 shows the establishment of casuarina and coffee mixed with food crops in an area where some mature casuarina trees are already existing. Figure 2 shows an established system with 3-4 year-old bearing coffee under the shade of triploid bananas and some casuarinas. Other agricultural crops are no longer cultivated at this stage.

FIGURE 1

FIGURE 2

4. SYSTEM FUNCTIONING

The first phase is that fallow vegetation is cleared, drains are established and all of the food crops are planted in the mixed vegetable garden. Most plantings are made seasonally towards the end of the drier months (September to December). Coffee seedlings may be transplanted into the garden when the food crops are planted, but usually they are not planted until the short term crops, such

as the leafy green vegetables, have been harvested. Casuarina seedlings are sometimes transplanted at the same time as coffee, but they may be established up to 12 months after coffee. Seedlings of coffee and casuarina are usually obtained from self-sown plants in older coffee gardens and along alluvial flats respectively. The food crops are planted in a mixed planting arrangement without regular spacing or species association. By contrast the coffee and casuarina seedlings are planted in a regular manner that approximates to the recommended spacing (1.5 x 2.5 m for coffee).

The timing of planting of the major components is extremely variable. Shading of young coffee is provided by different species during different periods. Initially it is done by the taller food crops, particularly maize, *Colocasia* taro and sugarcane. Once the bananas are established, they provide an increasing proportion of the coffee's shade needs. About a year after planting, they are the major shade species. After about 2 years, they are increasingly supplemented by the slower growing casuarina. Bananas and casuarina both provide shade up to about years 5-7, by which time casuarinas are replacing bananas. Depending on altitude, one or two *Pandanus* species may be significant components of the coffee/casuarina stand.

The major input is human labour. The major output of the system are the vegetables that supplement the sweet potato staple, the cash crop (coffee) and eventually timber from casuarina. Productivity and other details of the system are poorly documented.

5. SYSTEM DYNAMICS

Coffee was promoted as a village cash crop in the highland from the mid 1940s onwards. The official government recommendation was (and

still is by default) that short term shade trees *(Crotalaria micans, Tephrosia vogelii)* or permanent shade species *(Casuarina oligodon, Leucaena leucocephala* or *Albizia chinensis)* should be established prior to field plantings of coffee seedlings without any interplanting of food crops. The official system was used initially, but from about 1960 onwards the system described here and other similar ones that incorporated food crops were developed by the villagers themselves. Their systems have expanded, so that by the late 1970s, most new coffee plantings by villagers in the highlands were being established in systems similar to this one. The system described here is an extension of the traditional mixed vegetable garden system and it is the most widely practised of the recently developed integrated food/coffee/timber systems.

The overall performance of the system has not been quantified and hence not evaluated. Judging by the system's rapid expansion and widespread adoption, this system is more efficient than the officially promoted method of establishing coffee. Based on theoretical calculations of economic returns from integrated systems in comparison with the coffee/shade system, Carrad (4) concluded that the integrated one was very superior, especially from planting to year 7.

6. EVALUATION

This agroforestry system provides food, cash from coffee and some marketed food, and timber for construction and fuel. It has not been critically evaluated, but based on the author's judgement it is certain that returns on labour inputs would compare very favourably with alternative systems. Because the canopy is maintained continuously by a sequence of faster and slower growing species, the requirement for weeding is minimized.

The author does not see many major weaknesses of the system for small-holders. It is a conservation system in that the soil is protected from the direct action of the elements by continuous vegetable cover, and hence organic matter is conserved. Conversion of land suitable for mixed vegetable gardens into permanent coffee stands may be a problem in those few areas where this land type is limited in extent. Sometimes growers using the system fail to establish a good coffee stand. The reasons for this are not clear. A reasonable level of managerial ability is needed to manage the system, but this is within the capability of most village growers. The level of management may be more difficult to attain when larger plantings are being established in a limited time, for example areas larger than 3 ha.

The system provides significant quantities of perishable food. Because of poorly developed marketing infrastructure in PNG, marketing of this is likely to pose problems for larger growers.

Similar systems have been developed by villagers elsewhere in PNG for other export tree crops, including cacao (2), coconuts (5), rubber and oil palm. There is a wide variation in the details of this and other systems, especially in relation to timing of operations and species used for shade. It is very likely that some growers have refined the system; for example, selection of superior banana cultivars for shade or the timing of transplanting of coffee and casuarina seedlings. Such refinements are likely to have wider applications, at least within the PNG highlands and perhaps elsewhere. *Casuarina oligodon* is restricted to the highlands of the island of New Guinea where it grows between 650 m and 2700 m (standard deviations for the species's altitudinal limits are 60 m and 55 m respectively). Casuarina is known to fix

atmospheric nitrogen, although the amount is yet to be quantified. The species's useful characteristics and agroforestry potential are widely recognized within PNG (8) and it may have potential as a shade and timber species in other subtropical and tropical highland environments.

8. RESEARCH NEEDS

The research needs for this system are numerous and urgent, given that this farming system and similar ones are the most important ones that are used to establish new plantings of PNG's major export crop. There is no published formation to the author's knowledge on the potential of different food species and patterns of admixture of their species or cultivars to provide shade for coffee as well as to produce food; particularly so for bananas which are a critical component of this system. The timing of the various operations appears to be important, but this has not been formally evaluated. The first priority is to study the system and its variations as presently practised by village growers. Some studies have commenced (3, 6) and these need to be expanded.

Once farmer practices have been documented, innovations and potentially superior techniques need to be evaluated in controlled experiments. The growth pattern, nitrogen fixing ability and ecological requirements of *Casuarina oligodon* also require immediate study.

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CAPTIONS

Captions for prints to accompany paper "Food, coffee and casuarina: an agroforestry system from the Papua New Guinea Highlands".

1. Young coffee and casuarina seedlings in a mixed planting with food crops (highland "pitpit", *Colocasia* taro etc.) and some mature casuarina trees (Ambum Valley, 2000 metres).

2. Young bearing coffee (ca 3-4 years) shaded by triploid bananas and some casuarina. Other food crops have all matured by this stage (Nembi Plateau, 1700 metres).