Traditional management for dryland farming: lessons for modern agronomic systems development

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Summary. This paper reports observations of traditional garden management in the north central regency of Timor, eastern Indonesia. Timorese farmers have developed a complex and elegant management system for their rain-fed gardens. Leguminous trees are a key element in bush fallows and indigenous knowledge relating to their use is extensive. The spatial arrangements and phasic development of the mix of crops planted maximises use of available soil moisture, light and soil nitrogen with impressive labour efficiency. These practices minimise the risk and extent of losses due to pest and disease epidemics and rainfall fluctuations. Such traditional systems hold lessons for a modern Australian agriculture seeking better accomodations with its environment.

Introduction

Most of the world's population depends for its basic food needs on low-input, dryland crop production systems, many of which are based on shifting agriculture. Grandstaff estimated in 1981 that over 80 million people were practising shifting cultivation on 75 to 120 million hectares in Asia alone (6). Anthropological researchers report a variety of rational and responsive shifting garden food production systems (1, 2, 3, 5, 12).

However the international agricultural research and development institutions have downplayed the value of the knowledge and principles held in shifting agriculture systems, preferring to categorise them as primitive, unproductive and environmentally damaging (9, 10). Field analyses of the productivity of settled versus shifting gardens are rare in the literature and the superiority of 'settled' over 'shifting' agriculture not been convincingly argued.

Dryland food-garden management in Timor Tengah Utara

The Timorese landscape is rugged and mountainous with soils derived from marine sediments (4). While some Timor Tengah Utara (TTU) soils are well-structured with high moisture storage capacity, most are shallow, moderately fertile and highly erodible. The semi-arid tropical climate is typified by a brief, intense monsoonal wet-season. Rainfall is strongly orographic, encouraging cultivation of mountainous areas despite the better soils found on the plains associated with river depressions.

Dryland food production in TTU is based on shifting cultivation. Land is returned to bush fallow when weed burdens and low soil fertility prevent achievement of 'economic' yields of the staple cereal maize,Zea *mays.* When shading has suppressed weed populations and nitrogen fertility levels have been restored, cropping recommences. The use of leguminous tree forages is a feature of Timor's agriculture (7). The best-known species used is a cultivar of the Central American tree, Leucena leucocephala (8). The outbreak of the Leucena psyllid, Heteropsylla cubana, has decimated this species, encouraging a major effort to broaden the genetic diversity of this component of the farming system.

Inter-twined with the use of trees is a complex management system for annual crops which minimises some of the risk of annual crop failure due to climatic effects, disease, pests and weed invasion. All practices including the use of bush-fallow are adapted to maximise returns to labour. The total productivity of shifting gardens is often disputed while the total labour input into garden management is not always clear and objective data, important for evaluating alternatives, is difficult to find. While socio-cultural mores and beliefs dictate the way many farming practices are implemented, the bottom-line of survival ensures these are generally pragmatic and rational. For all this the survey and case study results reported here serve to illustrate some important principles and directions for development of extensive farming systems in Australia.

Method

Survey of multi-purpose trees in gardens-1988

A survey was conducted in TTU to obtain information on naturalised fallow/forage leguminous tree species being used in respondents' gardens. Farmers were questioned on tree characteristics relating to the latters' utility as fallow/forage species.

Case studies of garden management-1988-89

A series of case studies was conducted to provide data on aspects of families' management of food supplies. The studies covered household consumption patterns, food storage technology, species planted, garden areas and labour input to garden husbandry. Results have been used to augment observations of wet season garden management. The case study work, conducted and analysed by Suphandi (11) used ten families from five villages and a recurrent interview and observation technique.

Results and discussion

Survey of Multi purpose trees in gardens

Results (Table 1) confirm a range of native species in use. Farmers responses revealed a depth of knowledge regarding species which was often greater than that in the literature, for example the relative competitive effects of similar tree species.

Table 1. Farmers evaluation of indigenous multi-purpose tree legumes.

Species	Cattle feed value	Tolerance of fire	Increase soil fert*	Tolerance of cutting	Weed ** potential in garden
Acacia oraria	Nil	Mod.	Mod.	Nil	NK
Albizzia suponaria	High	Mod.	Mod.	Mod.	NK
Albizzia procera	Mod.	Mod.	Mod.	Mod.	NK
Albizzia lebeck	Mod.	Low	NK	Mod	NK
Albizzia chinensis	Mod.#	High	High	High	Yes
Bauhinia malabrica	Mod.	Low	Mod.	Mod.	Nil
Sesbania grandiflora	High	Nil	Mod.	Low	Nil

NK = Not Known (no experience of this use)
* As judged from growth responses of maize
** Potential to compete with maize sown following clearing
\# Toxic when cut and fed to cattle.

Several respondents ranked A. suponaria as superior to Leucena as a cattle forage and A. chinensis as an excellent bush fallow species but had found it very competitive with maize if not suppressed by heavy cutting and burning prior to planting.

Case studies of garden management

Only case study data related to labour inputs and species mixes are reported here. All family members' contributions are included.

Land preparation. Land preparation after the fallow phase entails clearing and burning although on the alluvial plains the soil is cultivated using short crow-bars or steel tipped wooden poles. Burning during garden preparation is practiced to remove shelter for rodents and snakes, to suppress weed populations, provide ash nutrients and improve ease of planting. Average size of case study gardens was estimated at 1 ha. Preparation of land for planting took an average total of 43 man-days.

Planting. Planting begins following a sustained break to the wet season. The main crop is maize. In some districts sorghum, *Sorghum bicolor,* is the principal species. Maize has been widely adopted over the past 50 years because of its superior yield potential and storage qualities compared to millets *(Pennisetum* spp.) and sorghum. The popularity of nutritionally inferior cassava, *Manihot utilissima,* introduced to Timor in the early 1900s (Ataupah, pers. comm. 1989) is evidence of a tightening of rotations due to reduced availability of land for gardens. Cassava typically out-performs maize under low-fertility regimes and as a root crop, involves lower risk in dry seasons. It is common to observe up to 15 different species of annual food crop planted simultaneously in a garden plus a number of perennial fruit, forage and 'industrial' species such as the cotton tree, *Gossypium arboreum.* Up to 18 different species have been recorded in individual gardens in southern Timor (Field, pers. comm. 1988).

Planting of case-study gardens took an average of four man-days. The most common sowing mix was four to six seeds of maize, and two seeds of climbing-beans, *Phaseolus vulgaris,* all planted in the same hole on a 1x1 m grid. Other species frequently observed in gardens, sown at various plant spacings were upland rice *Oryza sativa,* yams, *Dioscorea* spp. and *Pachyrrhizus bulbosus,* Lablab beans, Dolichos lablab, Sword-bean, *Canavalia ensiformis,* Pigeon-pea, Cajanus cajan and pumpkin, *Cucurbita moschata.*

Weeding. A single hand-weeding early post-emergent is typical requiring an average total labour input of 53 man-days. In a monoculture, additional weedings would be recommended but in mixed planting the additional labour input may not be worthwhile.

Harvest. Full-season maize is harvested in March. Stalks are broken to allow light through to pumpkins, cassava and pulses without removing support for the stems of climbing beans and yams. Remaining species will in most years rely on stored soil moisture until harvested. Maize harvest required an average of three man-days.

Sorghums grow through the maize stubble and are typically 2.5-3 m tall at anthesis. Harvest of sorghums is followed by pumpkins. Sparse plantings of pigeon-pea are harvested 180-200 days after planting, yams are harvested at various times during the mid-late dry season depending on variety and cassava is pulled from August. The overall effect is complete extraction of soil moisture reserves over the dry season. By mid-year, re-growth of forage trees is providing some vegetative cover.

Productivity. The estimated average yields of inter-cropped maize and cassava, were 1,659 and 3,500 kg/ha respectively. Contributions from minor species were not recorded. The summed figures for the staple crops indicate high productivity in mixed plantings.

Conclusions

The observations reported illustrate the complex inter-dependencies of the traditional production system of TTU. Despite the contrast between this system and that which applies in the extensive cropping/livestock areas of Australia it is possible to extract principles which apply to development of a sustainable agriculture in Australia's 'wheat-sheep' zone.

An integrative approach to farming systems development

This paper, while limited to reporting technical issues, illustrates the range and complexity of influences bearing on those planning changes to fanning systems and reinforces the importance of taking an integrative approach to development of the latter. Reductionist research has a role in farming systems development but only *as* part of a much broader approach. It is often counter-productive to separate technical detail from the complex web of influences in any farming system. Taken in isolation, 'bits' of problems and their solutions can easily become disconnected from the whole. For example, the importance of cultural beliefs for a Timorese parallel the impact of family-farm succession on an Australian farmer's decision-making. Taken in isolation, both may seem irrelevant; in a wholistic approach to systems development, they are seen as core issues.

Opportunities for inter-cropping of perennial forage stands

Examples of successful inter-cropping of annual and perennial species similar to the Timorese system described in this paper do occur in Australia, for example, cultivation of cereals in lucerne stands in northern Victoria. Only recently has the practice attracted any interest from researchers. This system allows farmers to retain the option of a winter-cereal cropping program within a perennial pasture system. The perennial component limits ground-water recharge, reduces autumn erosion-risk and stabilises soil structure and fertility regimes. The possibility of weed-suppression also exists. Concern about competition between annual crops and the perennial species is an issue for both Timorese cultivators and (the small number of) Australian farmers practicing this type of system. The wide variation in competitive effect of similar tree species reported in Table 1 suggests a research opportunity for developing the luceme\winter-cereal model in temperate Australia.

Agro-forestry for temperate Australia

The acceptance of exotic tree forages in tropical Australia owes much to the example of the eastern Indonesian farming system. In the temperate zone however, insufficient resources have been directed to identifying exotic and indigenous tree species with forage potential. Concentration on the ecological, environment-modifying and superannuation benefits of trees for temperate agroforestry has pushed it to the periphery of the agronomy research agenda. A second look at the features of agro-forestry systems such as that reported here is essential to reverse this trend.

Multi-species cropping

Multi-species plantings are the norm in temperate pasture technology. Agronomists have occasionally experimented with intercropping, for example, a short-lived program looking at lupin, Lupinus angustifolius and wheat, Triticum aestivum at Rutherglen (Boundy, pers. comm. 1980) A longer term commitment to developing understanding of inter-species relationships, plant-pest interactions and risk-spreading between species in traditional multi-species systems could ultimately produce robust technologies based on multiple species plantings, adapted to Australian agriculture.

Acknowledgements

TTU observations were made during assignment with the NTT1AD Project in West Timor. The author gratefully acknowledges the contribution of Project counterpart Ir. Wayan Supandhi and the assistance of project staff Ny. Serafin Manehat and Josefus Kefi BSc.

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