OF AN ESTIMATED AREA of 1,800 million ha of forests and plantations of the tropics, smallholdings constitute a sizeable proportion. Large scale settlement programmes currently being undertaken in all the developing countries to settle landless people is substantially increasing the number of such holdings, the size of which rarely is beyond one hectare. In the tropics where the natural resources such as sunlight, rainfall, temperature and humidity are favourable right round the year for crop production, the most relevant question is whether these smallholdings can be made viable units of production. The research work currently in progress at the UNDP/FAO supported Research Project of the Minor Export Crops Department of Sri Lanka has shown that planting over a dozen crops in a 1 ha plot giving due consideration to their income generation potential, growth habits, the home needs of the farmer and amenability to pruning and shaping of canopy can generate a net income of US $2,735 per year/ha. Such crop models have the much desired characteristics of minimum tillage, good potential for production of food and cash, a balance between agriculture and forestry, and above all, a total integration of man, animal and plants. The authors suggest that until such time as adequate scientific data are collected, crop modelling with multi-species will continue to be more an art than science.

A NEW APPROACH TO SMALL-SCALE FARMING IN THE TROPICS

High intensity multi-species cropping

Dr K. V. A. Bavappa and Dr V. J. Jacob

LAND-TO-MAN RATIOS in the developing countries of the tropics are fast narrowing and have already reduced the per head availability of arable land to less than 0.25 ha in a number of countries like Bangladesh, Indonesia, Philippines and Sri Lanka. The great majority of small farmers therefore have small sized holdings and proportionately little of the total land (table 1).

There has not been any guiding principle in the choice of different species for planting in these smallholdings except the simple fact of availability of planting material and to a certain extent the home needs of the family. Millions of such homesteads indiscriminately planted with a wide variety of plant species already exist in almost all the tropical countries and look like tropical forests. In Sri Lanka, where they are rightly called forest garden farms, up to 17 different species have been observed in such holdings.[2] Due to mutual competition and wrong choice of species, the return from such gardens is extremely low.

Table 1: Proportion and size of holdings

	Small holdings as % of all holdings	Small holdings as % of total area	Average size holdings (ha)
Africa	66.0	22.4	1.0
Far East	71.1	21.7	0.7
Latin America	67.2	3.6	2.7
Near East	54.6	9.8	1.8

(World Census of Agriculture 1970)

1 Five crops (Jack, San Ramon coffee, pepper, coconut and lime) out of 14 crops, third year

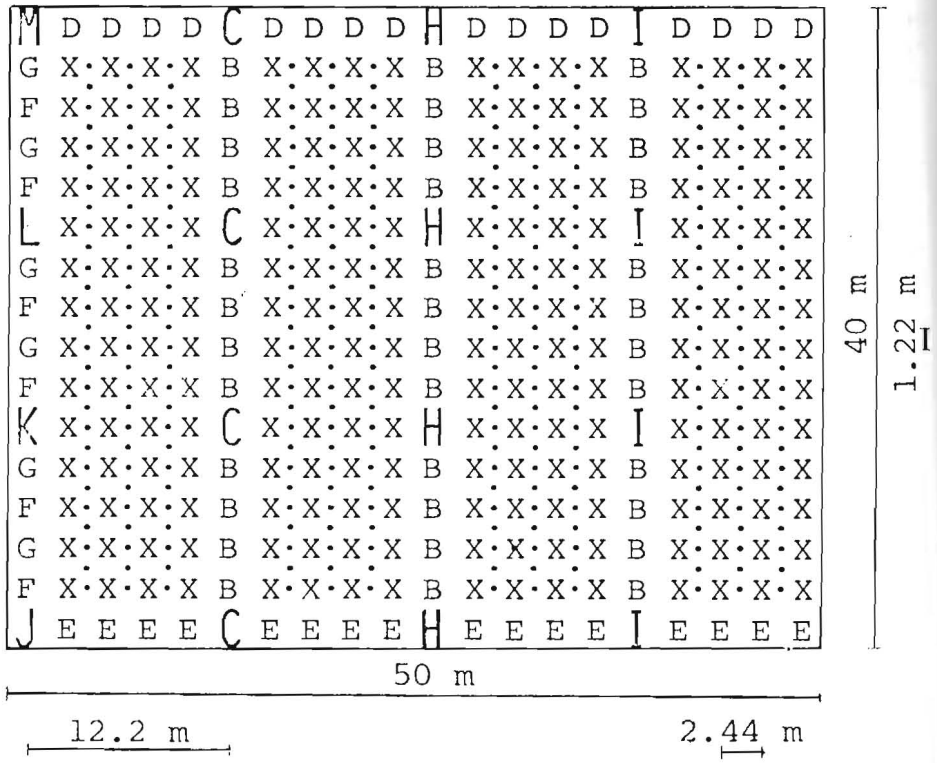
In the prevailing context of changing social outlook and land policy, these home gardens have a totally different role in the farming systems of these countries. Many of the families have no other land to farm or other sources of income to support them. In addition, the new 'home-farmsteads' (small farms where the farmer has also his house in the farm as distinct from farmsteads) which are being established under different settlement programmes in limited areas of land per holding will invariably have to support a few heads of animals and poultry this forming a micro plant-animal-human ecosystem. In most cases, the only source of income of the farmer will have to come from these smallholdings. It is therefore imperative that the productivity of these homesteads is maximised considerably.

Multi-species concept

The philosophy of multiple cropping is one of maximum crop production per unit area of land, time and inputs with minimum or no deterioration of land. The available scientific information on multiple cropping in perennials is almost exclusively based on coconut. The various factors such as

efficient use of soil both on horizontal and vertical planes, interception of solar energy at different strata of the crop canopies, choice of crops to suit mixed cropping in coconut and the general management and economic considerations of such systems are already known.[3]

In the case of cropping systems for smaller units of land (homesteads and home-farmsteads), the number of species have necessarily to be larger to meet the diverse needs (food, fuel, timber, cash, feed for animals etc) of the family. Thus multi-species cropping is essentially a combination of large number of crops so chosen as to meet the continued food, cash and other needs of the family which in their ultimate growth will utilise the airspace and soil in higher intensities and harvest solar energy at different storeys giving sustainable and increased overall yield from the land.



A high intensity multi-species model

At the UNDP/FAO supported mid-country research station of the Department of Minor Export Crops, 1 ha of marginal eroded tea land was planted during 1978 with the following 14 crops which have different canopy size and shape, table 2.

Of the above crops, coffee which has a smaller canopy occupies the lowermost strata, while coconut, arecanut, jack, mango, breadfruit, avacado, clove and nutmeg having a larger canopy grow to the top 'strorey' and others fill the space in between, fig 1.

For laying out the model, the entire area was peg marked at 8 ft (2.44 m) apart and pits of 0.8 m^3 cut at 40 ft (12.2 m) distance for trees with a large canopy and 0.4 m^3 for others. The existing cover of grass and other vegetation was kept undisturbed with only slashing at appropriate times to keep them under check. Glyricidia, a fodder-cum-green manure crop was used as support for pepper vine which was regularly lopped. This green matter and grass available in the plot was found to be adequate to feed 2–3 milch animals. Pepper and coffee flowered in the second year of planting yielding from third year onwards while banana and papaw gave the crop in the second year, fig 2. The net return from this plot at full production (20th year onwards) has been estimated to be SRL Rs. 46,500/- (US $2,735)/ha/year. When family labour is used, the income will be enhanced to US $3,000.[4] This systematically laid out, high income generating model having a total of 3,606 plants/ha is novel in many respects and is probably the only one of its kind anywhere in the tropics.

2 Model for high intensity species cropping

Code	Crop	Spacing	No/ha
Large canopy			
C	Coconut	12.2 x 12.2 m	36
H	Nutmeg	,,	12
I	Clove	,,	12
J	Jack	,,	3
K	Breadfruit	,,	3
L	Avocado	,,	3
M	Mango	,,	3
Medium canopy			
X	Pepper	2.44 x 2.44 m	1296
B	Coffee (Robusta)	,,	220
D	Arecanut	,,	24
E	Banana	,,	24
F	Papaw	,,	22
G	Lime	,,	22
Small canopy			
	Dwarf Coffee (San Ramon)	1.22 x 1.22 m	1926

Other small scale farm models

Varying settlement situations demand different types of farm models. The high intensity farmsteads described above can also be used to contain the house of the settler making it a 'home-farmstead'. Even in catchment areas, where farmers are

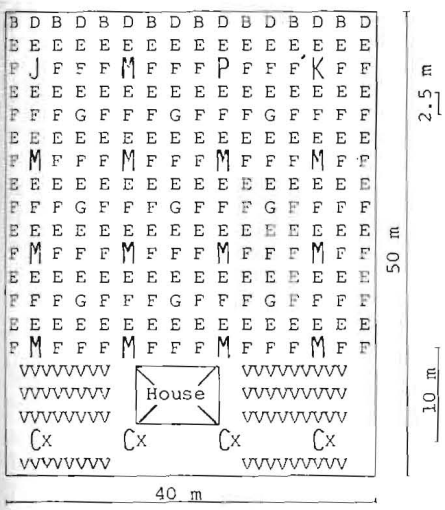
Table 2: Crops planted by the Department of Minor Export Crops

Cash crops	Crops for home need	Cash-cum-home need crops
Black Pepper	Jack	Coconut
Coffee — Robusta	Mango	Lime
Coffee — San Ramon	Breadfruit	Banana
Clove	Avacado	
Nutmeg	Papaw	
Arecanut		

being settled on paddy-based farming systems, the homesteads can be planned as income generating units in addition to meeting their home needs (fig 3). Crops such as vegetables and tubers required for any family should be important components of the crop community. Some of the area around the house has to be earmarked for these crops. Whatever may be the agro-ecological situation, appropriate multi-species crop models can be developed, keeping in view the following criteria:

1. RIGHT CHOICE OF CROPS

It is vital to choose crops of different stature and canopy architecture so as to reduce canopy competition and obtain better light interception for keeping the photo-synthetic factory operative at higher efficiency throughout the year. The type and proportion of crops in the model should be decided taking into account soil depth, water table, home needs and income generation potential. The model should also include drops with short gestation period to sustain the farmer during the initial years of establishment of the crops.



3 Model of homestead for paddy farmers

Code	Crop	Spacing	No/0.2 ha
Large canopy			
M	Mango	10 x 10 m	13
C	Coconut	,,	4
J	Jack	,,	1
K	Breadfruit	,,	1
P	Guava	,,	1
Medium canopy			
B	Coffee (Robusta)	2.5 x 2.5 m	8
D	Arecanut	,,	8
E	Banana	,,	112
F	Papaw	,,	87
G	Lime	,,	9
X	Pepper	on coconut	4
Small canopy			
V	Vegetables, Tubers etc.		

2. INCREASED USE OF AIR SPACE

Taking advantage of the tall growing habits of the perennials, it is possible to pack numbers of plants in a given area so as to occypy the air space above to varying heights depending upon the vertical growth habit of the species involved for which literally sky is the limit. In a tall growing monocrop of coconut, the air space use has been found to be less than 30–40%.[1] The total canopy area end volume of a high intensity multi-species model will be much larger exploiting sunlight to greater extents, fig 4. Because of the larger proportion of quick growing species like pepper, coffee, banana, papaw, etc, such models are able to attain this high level of exploitation sufficiently early in the growth phase.

3. PROPER PLACEMENT OF CROP SPECIES

In perennial crop farming, there is a considerable time lag between the time of planting of a crop and the full development of its canopy, during which period there is under-utilisation of the natural resources. In the multi-species model, this lacuna has been overcome by planting the entire area with other crops of short stature and gestation period at the maximum possible density. By so doing, the land and solar energy in the vicinity of a large canopy plant like jack or mango is made use of in their initial years of growth by pepper, coffee, papaw, etc. It is, however, likely that the yield of the plants surrounding a large canopy tree may decline in due course but by that time sufficient yield to justify their planting would have been obtained. It is also possible to reduce such plant interaction to some extent by proper training of the canopies.

4. CANOPY TRAINING

It is wrong to assume that most of the tree species require their full canopy growth for optimum production. In a tailored crop model of high intensity, appropriate pruning and training practices are to be followed. Removal of the lower side branches of large canopy tree species such as jack, mango, clove, etc, will facilitate growth and performance of short statured crops such as coffee, pepper and lime. Lopping of the glyricidia will not

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only permit more light penetration but also give organic matter for soil application. Species such as jack and glyricidia are also good animal feeds which will enable integration of livestock in the farming system.

While these models hold out considerable potential, they also have a number of desirable agronomic characteristics which can be exploited.

Minimum tillage

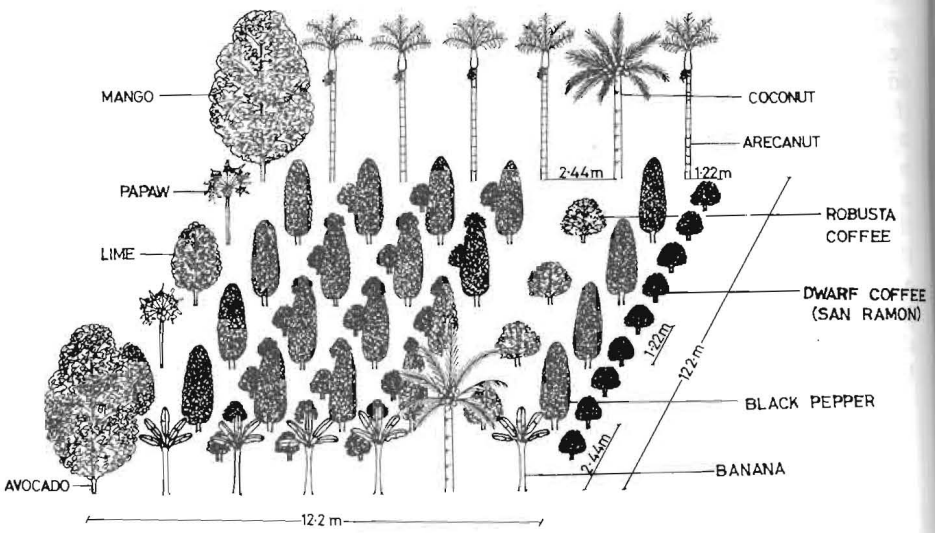
Ideally tropical soils should not be tilled and in fact the leaf fall and residue from the vegetation should be left to decay on the soil surface. These crop models can be laid out with least disturbance to soil by cutting pits of appropriate size. When the plants are established, the basins are widened to form in-situ terraces where fertiliser application is also done. The grass and other weed growth is repeatedly cut and used for mulching the base of the plants and for feeding animals. Due to this very reason, the normal soil conservation measures such as contour terracing and trenching that are required to be done on sloping lands also could be dispensed with. In general, the layered canopy arrangement will give the soil maximum protection against beating rain.

Support to forestry needs

For countries like Sri Lanka where the existing forest cover is less than even 10% of the total area and where the pressure on land is already high, it will be of considerable advantage to have future agricultural planting programmes with perennial crops to include large canopy tree species so that these communities of crops will at least partly serve the forest need of the country particularly from the ecological point of view. A concerted effort to develop such multi-species homesteads and home-farmsteads in all areas of human settlement will also be very much in line with the current efforts to have social forestry and agro-forestry as a part of agricultural activity.

A balanced plant-animal-human ecosystem

The escalating costs of fertilisers, fossil energy and firewood and inconsistent availability of even hydro power due to droughts have made it imperative that these small units of production are as self-reliant as possible. In addition to high income generation, a home garden properly planted with well chosen species can support animals and birds as well. The organic wastes of these animals and other plant residues can be cycled back to the field through a bio-gas plant generating the energy required for lighting, cooking, pumping, etc, enabling farming and living with minimum dependance on inorganic fertilisers and external sources of energy. A self-generating pollution and erosion free ecosystem integrating plants, animals and human beings at a viable micro-level has by far the greatest advantage.



4 Schematic diagram of the canopy architecture of a high intensity multi-species crop model

Restructuring of existing home gardens

The existing low productive home garden areas require restructuring to improve their productivity. This can be done by selective thinning of uneconomic trees, shade regulation of others and infilling with economically useful ones. It is also necessary to fertilise individual crops treating each as a monocrop until such time information on manurial requirements of such community of plants is available.

Future outlook

The ever-increasing small and marginal farmer settlements are continuously locking up otherwise productive arable land in the form of homesteads and farmsteads. If properly planned cropping models are used, these small parcels of land can be made agronomically efficient, socially acceptable, ecologically balanced and economically viable units of production carrying with them all the advantages conferred to the farm by multiple cropping. While this appears to be feasible, scientific data on long term interaction effects of these crops on production trends, nutrient requirements of the plant community, synergestic effects if any etc, are lacking. Varieties better suited for such community cropping have to be evolved. Intensive multi-disciplinary research efforts are required in this vital area of crop production. However, until such time adequate information on the above aspects is obtained, crop modelling for multi-species cropping will continue to be an art rather than science.

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