CONSERVATION FARMING

PART II. *FERTILITY REGENERATING SYSTEMS*

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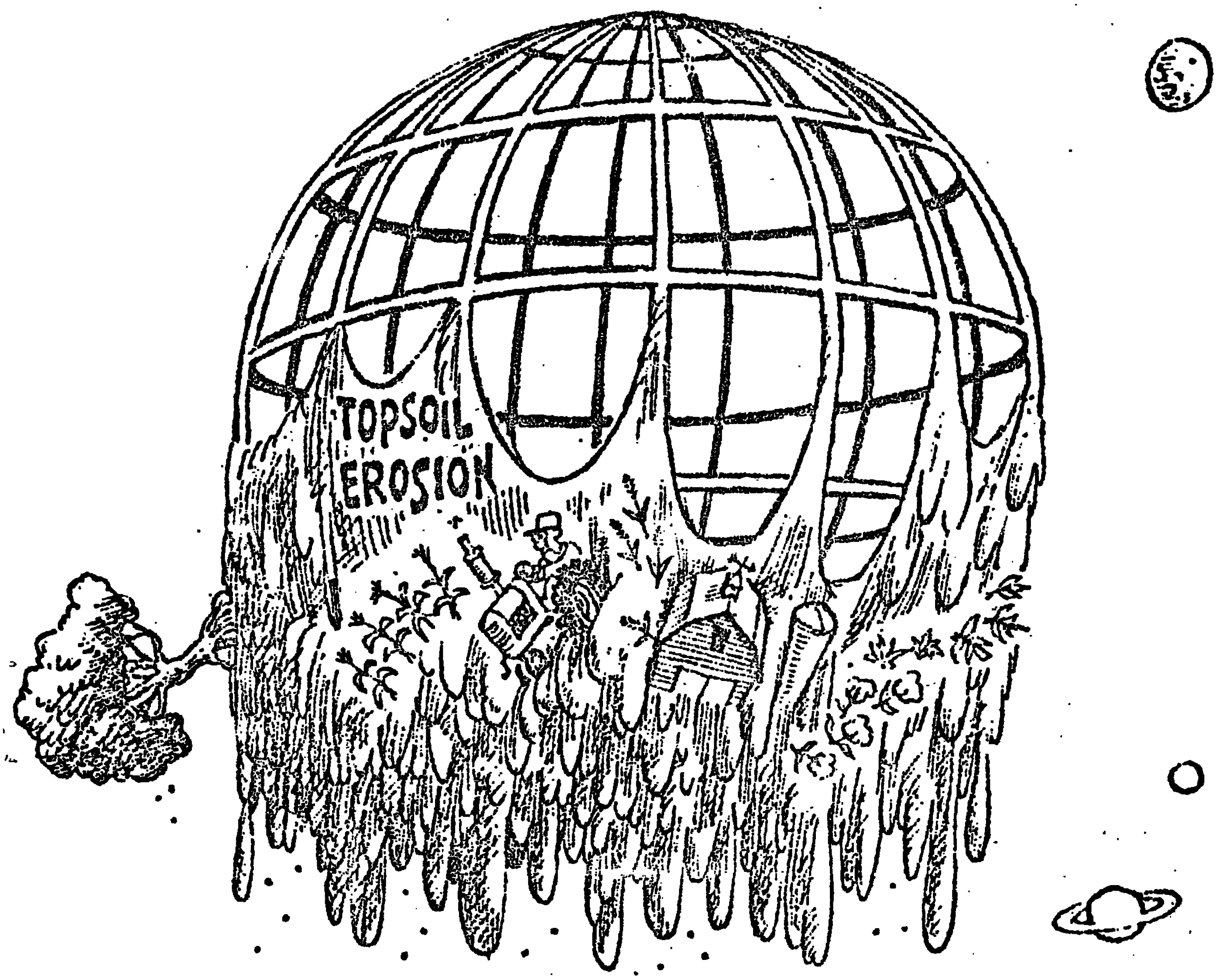
Zero or minimum tillage combined with mulching has a beneficial effect on soil structure, soil moisture conservation, fertility improvement, weed control and decreased soil temperature fluctuation (Weerakoon, Bandara and Seneviratne 1985). However, these techniques do not completely arrest soil deterioration due to continuous cropping, nutrient losses by leaching soil fixation and nutrient removal by crops. These limit sustained crop productivity. Therefore, measures to increase soil fertility in combination with other soil conservation measures are needed to develop a sustainable farming system. One method to increase soil fertility is to use green manure.



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Green manures are bulky. Therefore the use of additional labour for transport and spread green manure may be expensive or difficult due to labour shortage. This stimulated research into systems of mulch production in situ, and integrate it to develop better crop and soil management practices. This is likely to help stained crop production and minimize soil deterioration, and reduction of weed populations. To achieve this objective low growing (live-mulch cropping) as well as high growing (avenue or alley-cropping or agro-forestry) plants that can also fix atmospheric nitrogen were used (Weerakoon and Seneviratne, 1982; Weerakoon, 1982, Weerakoon 1983; Weerakoon 1984 a; Weerakoon 1984 b) Nitrogen fixing plants convert nitrogen gas of the atmosphere into soluble forms of nitogen that can be readily used by plants. Furthermore their deeper root systems can obtain plant nutrients from the sub-soil region, and recycle the same to the soil surface.

Avenue Cropping (Alley or Agro-forestry) System:

This system was developed as a long-term blend of arable farming and forestry. This involves growing arable crops between the avenues, hedges or rows of vigorous growing trees and pruning them to regulate shade.

Perennial leguminous shrubs (Example:- *Leucaena leucocephala, Gliricidia maculata) and* Leguminous trees are preferred green manure trees as they can fix sufficient amount of nitrogen to satisfy the requirements of the arable crop. Most of the nitrogen fixed by the leguminous plants are finally deposited in the leaves. These leguminous shrubs can be periodically pruned and the loppings are spread between the rows of trees as a mulch, or green manure. Chemical analysis carried out for L. leucocephala and G. maculata leaves gave the following nutrient compositition. (Weerakoon and Gunasekera 1984, Weerakoon 1984a).

Table I. Nutrient composition by (Percentage) of L. lencocephala and a maculata (dry weight basiS)

Nutrient	L. leucocephala	G. maculata
Nitrogen	4. 7	3.84
phosphourus	0.18	0.18
potassium	1 48	2.00
calcium	0 39	1.01
magnesium	0.18	0.19
carbon	43.7	44.10

Trials at Maha Illuppallama using L. leucocephala and G. maculata showed that they produce approximately 6 mt/ha of leaf dry matter per year. This is equal to 240 and 230 kg/ha of Nitorgen per year respectively.

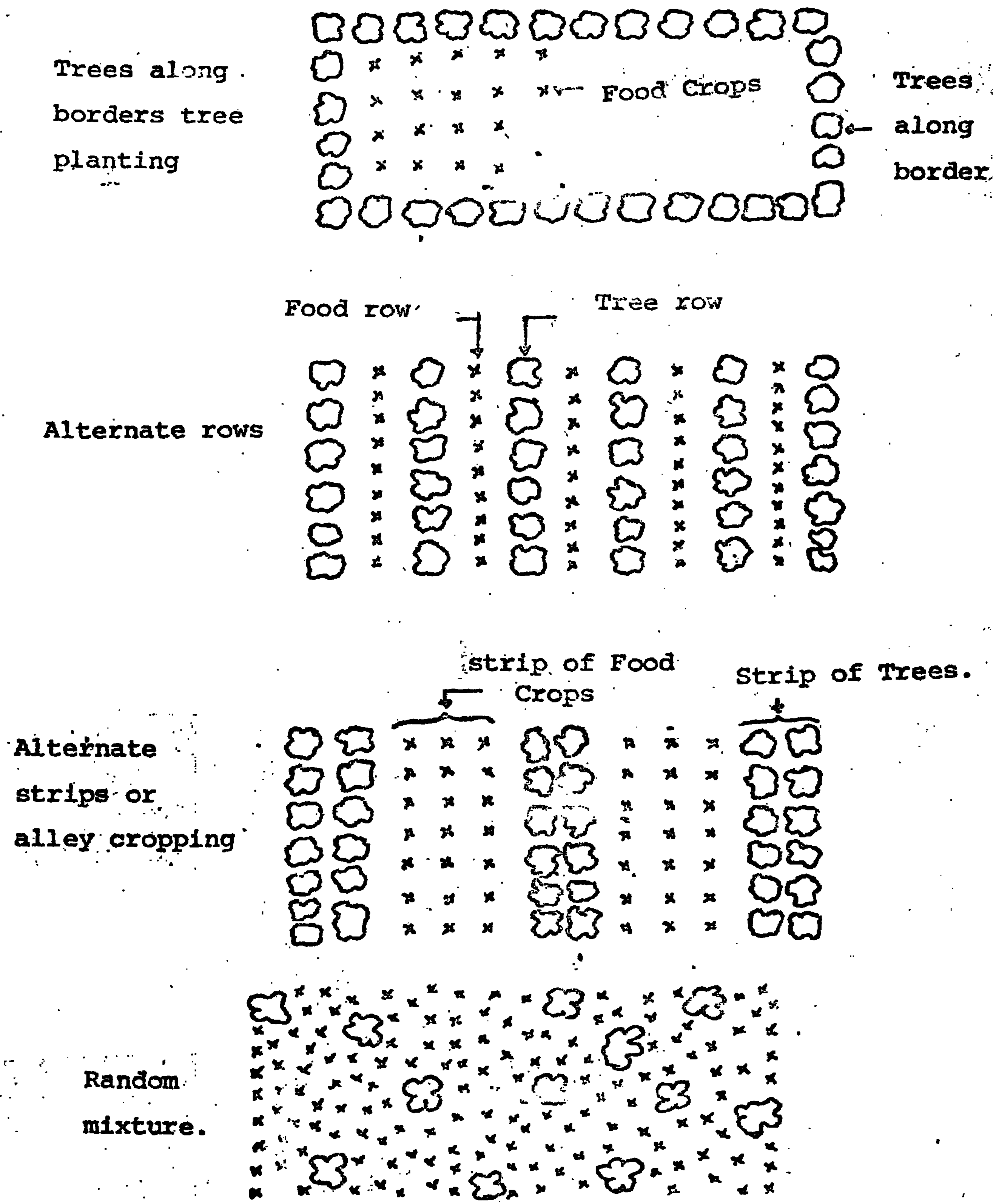

Fig.1. Spatial arrangements of crops in alley cropping.

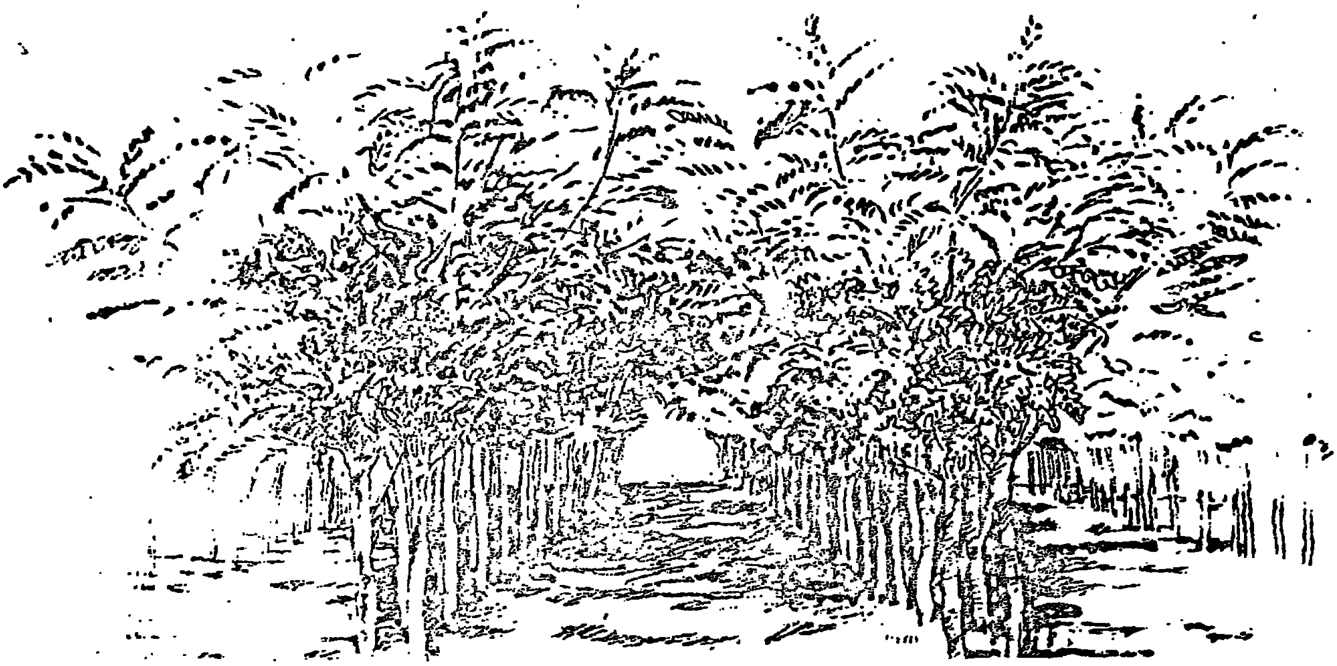

Fig: 2. Double-hedge r-ows planted in Gliricidia or **Leucanea** to form dense shade over the avenues during dry (non-farming) season.

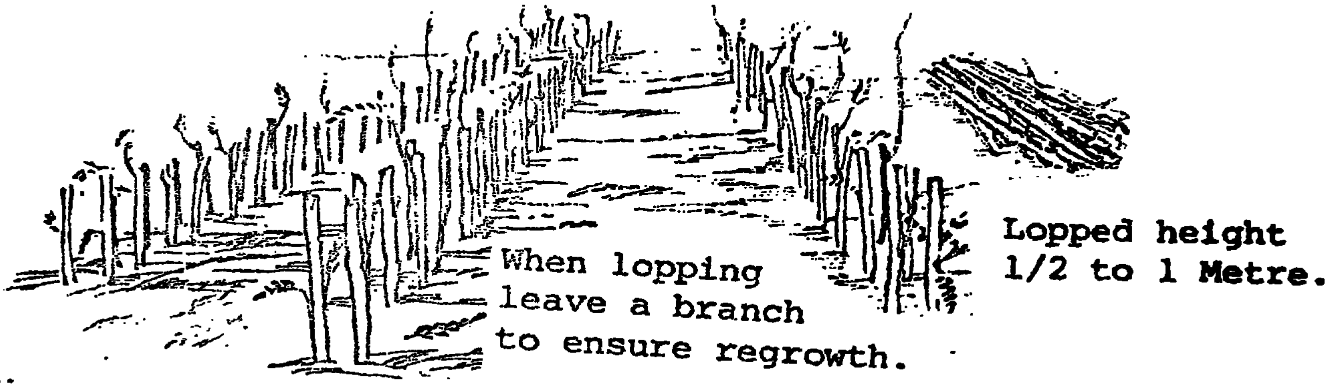

Fig 3. Hedgerows lopped, and mulch laid on avenues.

Fig 4. Crops growing in the avenues in light shade from the hedge rows that will be topped periodically for "top dressing" mulch and provide optimum light for the growing crop.

The height of pruning is important for biomass production. Foliage yields are greater when the trees are taller, as shown below in a trial with L. leucocephala and G. maculata.

Table 2. Leaf dry matter production per plant six weeks after the initial lopping.

Stump height (m)	Leaf yield (g)	
	L. Leucocephala	G. maculata
0.5	58.0	95.0
1.0	85.0	184.0
2.0	103.0	253.0

Observations in the avenue planned fields have shown a very considerable suppression in weed growth within the avenues (Weerakoon and Seneviratne, 1982). This is due to the dense shade of the over hanging branches of the hedges, that regrew during the non-arable cropping season. The branching habit of green manure trees seemed to be the major factor influencing weed development. The erect branching habit of G. maculata (erectophile) allowed a higher percentage of solar radiation to reach the ground. resulting in more weeds. The laterally branching (planophile) L. leucocephala shaded even the centre of the alleys and limited weed growth in the centre, as well as the sides of the alleys.

In the most situations C_4 weeds have been observed to be displace by C_3 types which are easily controlled. Both these factors ensures better weed control at a lower cost (Weerakoon 1984).

It has been demonstrated that the grain yield of maize planted in alleys of L. leucocephala hedge yielded up to 45% more when compared with monocropped maize. With G. maculata the maize grain yield could be increased even by 82% (Weerakoon, and Kusumawathie, unpublished data).

Avenue Cropping on Steep Slopes:

Tree - food crop interplanting should be done either in alternate rows or alternate strips. The close tree spacing along the contour rows makes each multiple row strip an effective barrier that reduces the downward movement of soil from the cultivated strip. In a few years the eroded soil settles down farming terraces naturally with the hedgerows supporting them. The hedgerows are lopped and the food crops are planned on these terraces.

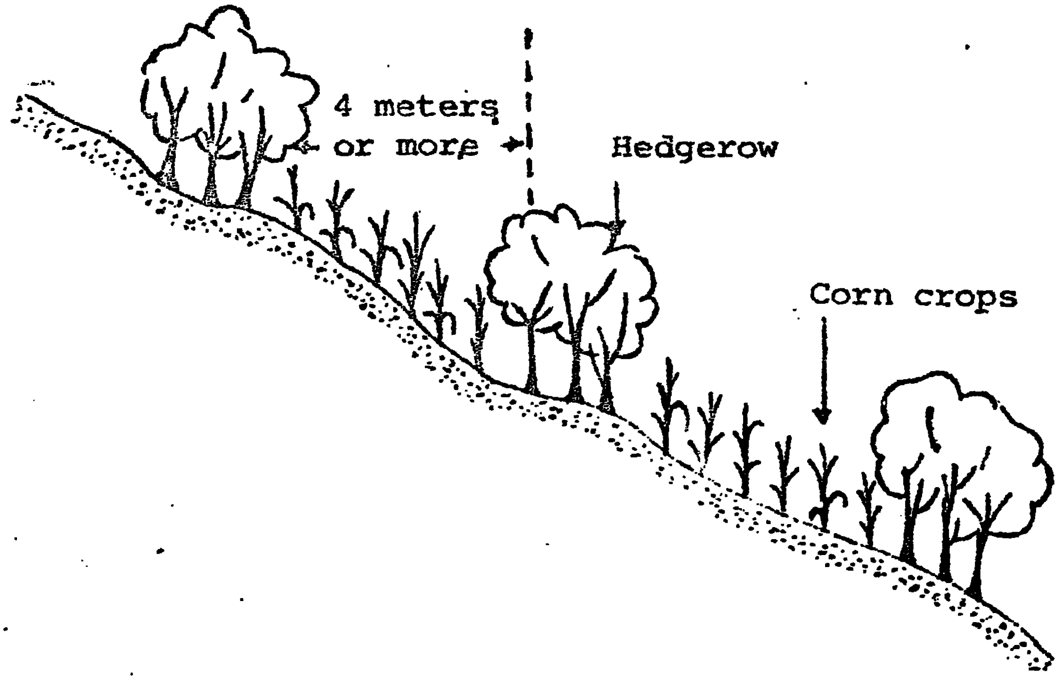

Fig. 5. Crop arrangements in alley cropping

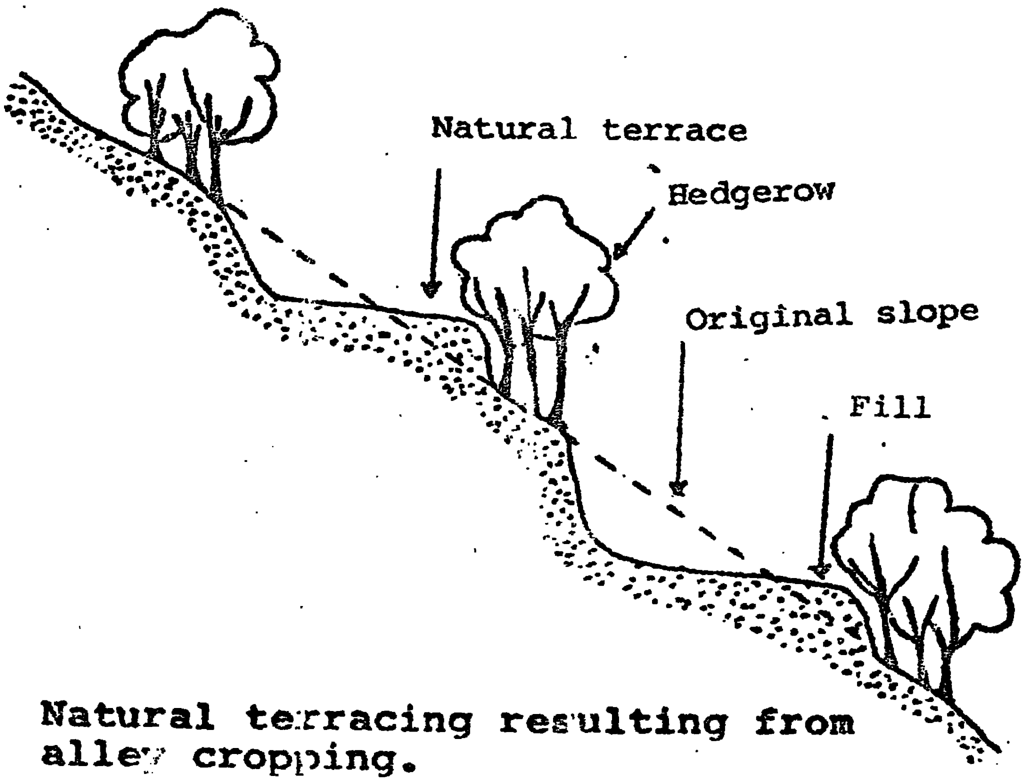

Fig. 6. Natural terracing resulting from alley cropping.

Fodder and Fuelwood Production from Legume Trees:

Many of the pasture legumes are creepers. They are sensitive to over-grazing. If not managed carefully, the legume covers disappear rapidly. Tree legumes such as L. leucocephala and G. maculata are good fodder. The obvious advantages are that while containing higher amounts of protein (27.1% and 24% respectively on a dry matter basis,) they are not too sensitive to over-grazing and are capable of producing foliage even during prolonged periods of drought.

Fodder can be harvested from legume trees by cutting off branches and leaves. They can be taken away to feed animals kept elsewhere. On the other hand, for short duration crops such as upland rice, millets an maize, inter-planting with L. leucocephala and G.maculata trees, makes animal grazing possible periodically, after the cereal crop is harvested, and prior to planting the succeeding food crop.

The main sources of energy used for household purposes in Sri Lanka are :-

a) Electricity (mainly from hydropower)

b) Oil

c) Firewood.

From the above a it is evident that firewood is the main source of energy in Sri Lanka. According to the energy coordinating team, Colombo, the average firewood consumption per head/day is 1 35 kg. Therefore, the requirement of a family of 6 person would amount to 3000 kg or 7 to 8 cart loads annually. Research at Maha Illuppallama shows a production of about 6-7 mt/ha of woody biomass/ year/ha (dry weight basis) is possible,with conservation farming. This indicates the supply of firewood in this system could meet a substantial part of the farmers firewood requirement.

LIVE MULCH CROPPING:

The concept of cover cropping with leguminous creepers in plantations such as rubber, coconut and oil palm is now being developed for use with annual crops to reduce the need for tillage, for better weed control, and improved fertility Reduced tillage would reduce cultivation costs and erosion problems.

A good legume or plant for live mulch crop production should:

- be easy to establish and have early horizontal growth and adequate vigour to cover the ground rapidly.
- be weed competitive.
- be a perennial; otherwise annual weeds which die during drought tend to re-establish during the cropping season from their seeds. A perennial cover crop can reduce growth of weeds.
- fix nitorgen at levels required for arable crops.
- withstand slashing or other cultural treatments as would be necessary for food crop establishment. It should grow with minimal competition to the food crop.
- not harbour pests or diseases effecting arable crops.
- be shade tolerant to be able to withstand shading by the food crops grown.
- produce efficient seed for re-establishment.

Amoung the desirable cover crops being investigated are Pueraria phascoloides, Phascolus artropurpureus, Ceutrosema pubesceus, Psophocarpus palustris, Mucuna utilis and Desmodium ovalifolium.

The seeds should be of good quality. Pre-planting treatments such as scarification, soaking are conducted to ensure good germination. It is also advisable to treat legume seeds with the appropriate nitoxgen fixing rhizobium bacteria.

The crop seedlings emergence through the vegetative cover may be hindered if seeded directly. Therefore, clearing of narrow strips along the row is recommended. Another alternative would be to burn narrow strips (15 cm. wide) through the live mulch cover using paraquat at 2.5 - 4.0 l/ha (formulated product . Paraquat nearly dessicates the leaves of the plant that comes in contact with it. Seeds then can be directly planted into the soil with an injection seeder or by hand with a stick, (Weerakoon 1983).

Proper management of live mulch is necessary during crop growth period, to eliminate competition with the planted crops. Therefore, the foliage of all these legumes are sprayed with a growth regulator (CGA 47283 Ciba - Geigy) at the rate of 8 kg/ha (formulated product) in order to prevent the legume from climbing and smothering the crop (Weerakoon and Seneviratne, 1982).

There is a possibility that this system can also be used where the living mulch dies of drought, provided that the mulch crop produces abundant seeds which germinate before the sowing dates of the crops

At the Agricultural Research Station, Maha Illuppallama the effect of 'different live mulches' on weed growth and crop yield was studied. In this study the least amount of weed growth was found with C.pubescens. Furthermore, the yield of maize was increased upto 148 percent, when intercropped with ground covering legumes in comparison to the control. The legume P.artropurpureus (Siratro) and P. phaseolides showed the highest beneficial effects. Studies were also made to compare several management systems namely: (1) zero tillage, (2) conventional tillage and (3) live mulches (no-till), at three livels each of nitorgen at O, 25, and 50 kg N/ha.

In the absence of applied nitrogen, the yields were strikingly higher with live mulches than under conventional or zero tillage. Particularly interesting is the evidence that maize - a crop which demands high levels of fertility yielded as much under live mulch with no nitrogen applied as under conventional tillage with 50 kg/ha of applied nitrogen, equivalent to 100 kg of urea.

A problem with live mulch is to prevent it from competing strongly with crops. Some means of discouraging mulch without impediment to the crop is necessary. Growth retardants should be a last resort if mechanical means prove inadequate.

RESEARCH FOR LOWLAND

The potential of avenue cropping techniques is also being reviewed to meet natural fertility for paddy cultivation (Weerakoon an Gunasekera, 1985).

L. leucocephala was grown on rice bunds and lopped twice before and during paddy cultivation, and applied as leaf mulch (2.6 mt/ha) on rice variety Bg.34-8. This treatment increased the grain yield by 74 percent. L. leucocephala foliage supplemented with half the recommended amount of nitrogen gave a grain yield of 2.8 mt/ha.This resulted in a 121 a percent yield increase, compared with application of half the amount of recommended inorganic nitrogen.

The nodulation of Sesbania sesban and its contribution as green manure was studied in a rice based cropping system. S. sesban is an annual legume weed that thrives in moist soils in the dry zone. It is a fast growing shurb and produces approximately 4 mt/ha green leaves (dry matter basis) at the spacing of 0.25 m^2 within a two month period. This amount of green material would contribute nearly 130 kg N/ha/ season.

Table 3:

Percent Nutrient Composition of S. Sesban
(dry wt. basis)

Nutrient	Percentage
Nitrogen	3 31
phosphorus	0.24
potassium	0.92
calcium	1.69
magnesium	0.17
carbon	43.30

About one thousand nodules (or about 1.7 gms) (dry weight) develop on the roots of a 12 week old Sesbania Seban plant. Here peak nodulation occurs at the podding stage. This is about the 12th week after seeding (Weerakoon and Senarathne, unpublished data).

Green manure can be obtained by growing S. sesban in paddy fields prior to sowing paddy. This could be achieved by broadcasting the seeds of S. sesban into a standing rice crop shortly before harvesting. Seeds can also be broadcasted into rice stubble without any cultivation. Therefore, in sita application of S. sesban as a source of green manure in rice crop could be of practical importance for farmers. Expensive inorganic fertilizer inputs may beyond their reach.

In the above study the weed infestation decreased due to shade created by S. sesban by an average of about 70 %, (0.25 m^2 spacing) compared to S. sesban free control plots. Most of the pernicious weeds listed by Weerakoon and Gunawardena (1983) could be controlled by this method. These results indicated an added advantage because S. sesban helps to reduce weed infestation without cost. This may eliminate at least one tillage operation during land preparation.

A preliminary study has shown green manuring with S. sesban increased the average grain yield approximately by 400 kg/ha which is equivalent to 50% of the yield increase over the control. Green manuring supplemented with 1/4 the recommended amount of nitrogen fertilizer resulted in a grain yield comparable to the yield from plots which received the recommended amount of N fertilizer. The above findings suggest that the use of S. sesban could replace a substantial amount of inorganic nitrogen fertilizer now being used in rice production. Besides providing nitrogen to the rice crop, a good cover of S. sesban could also suppress weed growth in the paddy fields.

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