at home with the other group members. Later on, these contact groups can be reached with other extension programmes like compost, mulching, stabling, agroforestry etc.
So before entering with other techniques we try to avoid erosion and stabilize production by terracing.
Terracing is a long term investment in land, economically profitable, very labour intensive, but not too high in comparison with the national erosion control programme, which is obligatory.
First field research has shown that men are interested in terracing, so this can lead to a reactivation of them for agricultural work. This also can have a negative influence if they only grow cash crops on terraced land where women before have cultivated food crops.
It's interesting for young people to give a certain value to their land by terracing (social status); it's also visible manifestation that they will continue to cultivate "their" land (all land is communal).
Other constraints, problems, risks, advantages and disadvantages of terracing are also discussed.
Author's Abstract.

XIV POTENTIAL CROPS

1024 91 - 14/24

Potential crops for marginal lands
Developing countries, semi-arid tropics, subtropics, study, drought tolerance, marginal conditions, nitrogen fixing, soil fertility, sustainable crop production, perennial plant, yield potential, crop management, fertilizer requirements, weed and pest control, harvesting, ICRISAT, IITA

ONG, C.K. and J.N. DANIEL

Traditional crop sparks new interest as a multipurpose tree.

Agroforestry Today, 2, No.2, 1990, pp. 4-7

Fast-growing, short-lived woody species such as pigeonpea (*Cajanus cajan*) are attracting considerable interest.
Pigeonpea is a truly multipurpose species. It provides food, fuelwood, fodder and shelter material to subsistence farmers. It is already widely grown as a food crop in south Asia, eastern Africa, central and south America and the Caribbean, and its leaves are readily accepted as livestock fodder.
Pigeonpea was one of the first species of interest in agroforestry research, specifically in hedgerow-intercropping experiments at the International Institute of Tropical Agriculture (IITA) in Nigeria.
Pigeonpea is well adapted to tropical and subtropical environments and is hardy under adverse conditions, producing at least some yield in spite of drought and poor soil fertility. In addition to multiple products, pigeonpea is a legume capable of fixing nitrogen and making a positive contribution to soil fertility and sustainable crop production.
Although pigeonpea is most often grown as an annual, this is largely because the species is highly susceptible to fusarium wilt and sterility mosaic disease, and stress from these diseases tends to build up in older stands. Mortality as high as 75% has been observed in two-year-old plants.
If pigeonpea is to be grown as a perennial, breeding for disease resistance is an important priority. The International Crops Research Institute for the Semi-arid Tropics (ICRISAT) at Hyderabad, India, has a global germplasm collection for pigeonpea. Preliminary trials started in 1985 to identify genotypes from this collection that are suitable for long-term cultivation. Now, perennial lines are available that hold promise as components for agroforestry systems, combining disease resistance with excellent agronomic traits.
These promising lines include both erect and spreading types. Both can be grown as perennials for three to four years and can also achieve high grain yields under competition from more dominant species, such as sorghum. They are slow maturing, regrow after

coppicing and have deep rooting habits, suggesting that they are not severely competitive with crops.
Pigeonpea is mainly grown as a human food. In India, the dry split seed is an important source of protein. Immature seeds are prepared and eaten as green peas in eastern Africa, the Caribbean and some parts of India.
The seeds can also be used as animal feed, and harvest trash, consisting of pod walls, leaf and stem residue, has good fodder value. Pigeonpea leaves are most often used as fodder; these are digestible and have a high crude protein content. Pigeonpea fodder is usually available during the rainy season when fodder from other sources is also plentiful, but it can be mixed with low-quality feed to improve the diet on offer to livestock. Leaves can also be returned to the soil as mulch or green manure.
Pigeonpea stems are an important byproduct at the time of harvesting. The mainstems are used as fuelwood and thin straight branches are used for roof thatching and basket making.
Future work will explore the uses of perennial pigeonpea on marginal lands, on contours and boundaries, on sloping lands and in drier regions.
The effectiveness of perennial pigeonpea for contour planting should be explored in comparison with more traditional vegetation or land configurations. An arrangement of three to four rows of pigeonpea is suggested, with 0.5 metres between the rows and 0.3 metres between plants within rows.
The potential of perennial pigeonpea as an agroforestry species is only now becoming widely appreciated. There is a need to develop appropriate management practices and to introduce perennial pigeonpea as a multipurpose species in a more organized fashion and on a wider scale.

1025

91 - 14/25

Potential crops for marginal lands
Africa, USA, Australia, Latin America, Asia, review, drought tolerance, arid region, frost tolerance, multipurpose tree, marginal conditions, yield, fodder

PERMACULTURE

Honey locust (*Gleditsia triacanthos*).

Permaculture, 17, 1984, pp. 18-19

The Honey Locust (*Gleditsia triacanthos*), is a tall fast-growing tree native to North America, surviving in all but really arid regions. It is well suited to much of Australia, tolerating both drought and frosts, with a minimum rainfall requirement of about 500 mm per annum, although growing better in higher rainfall districts. Its potential lies in the large pods which it can produce abundantly. These pods, between 300 mm and 500 mm long, being rich in both sugar and protein are relished by livestock, including pigs, although they are also suitable for human consumption.
Fast-growing, shade intolerant, long lived to 120 years or more. Open crown with spreading branches casts light to moderate shade. Late to leaf out. Strong taproot and profusely branched root system. Pods narrow flattened 6-18" long, many seeded, dark brown, twisting when mature in autumn, hang on trees until early winter. Pods 20-40% by weight total sugars, 10-11% by weight protein (improved cultivars).
The trees are tolerant of acid, alkaline or saline soils; hardy to cold, heat, wind and once established drought resistant.
They will grow on hillsides with little topsoil as they have deep, penetrating root systems. The canopy is open, allowing light to pass through to crops or pasture below.
As the tree grows it produces large spikes on its trunk thus protecting itself from stock damage and only requiring protection while young. It cannot tolerate shade and when planted in an open, uncrowded situation forms many strong branches near the ground that are rarely damaged by wind, making Honey Locust ideally suited as a windbreak tree.
Seedlings bear fruit pods from 6-10 years of age.
Highest recorded yields 600 lbs./tree from 20 year old trees in New Zealand. Yield per acre (at 40-48 trees/ac) 1-12 tons, extrapolated from measurements of individual trees.
Pods area livestock fodder; nutritional value by weight comparable to oats. Also important to deer, small mammals and some birds. Useful for erosion control, hedgerows and shelterbelts. Flowers produce pollen and nectar for honeybees. Thornless cultivars of *G.t. Inermis* widely used as ornamentals. Reddish brown heartwood tough and hard but sometimes brittle; decay resistant. Useful for fenceposts, decorative hardwood and firewood.

1026 91 - 14/26

Potential crops for marginal lands
Review, book, report, humid tropics, Asia, Indonesia, tree, management, products and applications, research needs, BOSTID

NATIONAL RESEARCH COUNCIL

Calliandra: a versatile small tree for the humid tropics.

National Academy Press, Washington D.C., 1984, 50 p.

This report describes a little-known tree legume, *Calliandra calothyrsus*.
Calliandra is a woody shrub rather than a forest tree, however, it is unknown in traditional forestry. Its stems are usually multibranched, crooked, and short, and even at maturity the trees are only 12 m tall and 20 cm in diameter, making the wood too small for most commercial forestry purposes.
In Java, calliandra is a useful plant. Its wood makes good fuel, its foliage is valued for animal feed, and bees use its nectar for producing honey.
On suitable sites this small tree grows with extraordinary speed. Nine months after planting it can be taller than a village house; in just one year it can be harvested for firewood. The remaining stump then resprouts so vigorously that within six months the new stems may rise above the houses again. Because of this rapid regrowth the trees can provide an annual firewood crop.
Calliandra is a good pioneer plant, especially for problem sites. On Java it grows well on steep hillslopes and poor soils. It adapts well to different soils, establishes easily by direct seeding or by planting seedlings, and requires little care. It grows successfully in a range of environments with widely differing altitudes, rainfall, and shade. It is, however, likely to prove useful only in the humid tropics; it is not a crop for arid or temperate regions.
Like most other legumes, calliandra forms a mutually beneficial partnership with soil bacteria of the genus *Rhizobium*.
Calliandra usually has large, prolific nodules and requires little or no nitrogen fertilizer; the rhizobia provide adequate amounts of nitrogenous compounds for normal growth. This permits calliandra to thrive in soils where nitrogen levels are inadequate to sustain the growth of most other crops.
Nitrogen is one of the principal nutrients that limit the growth of both agronomic and forest crops, accounting for a substantial proportion of crop production. And nitrogen is the single most costly industrial input to agricultural productivity - the energy needed to obtain one kilogram of nitrogenous fertilizer requires 1.8 m^3 of natural gas.
Nitrogen fertilizer is becoming increasingly expensive as the cost of natural gas rises. And as a country's foreign exchange becomes more precious, it seems probable that forestry will be allocated a lower priority for nitrogen than agriculture. Thus, although it is

important to exploit biological ways to add nitrogen to agronomic crops,it may become critical to do so for forestry crops.
Calliandra has no thorns, it is not known to be toxic to animals, nor does it seem to have other serious drawbacks. But it is a resilient and spreading plant, and the possibility of its becoming a weed should be kept in mind.
So far, the only extensive experience with calliandra has been on Java.
Calliandra seems to be an outstanding candidate for meeting village needs for fuel. Calliandra wood is too small in diameter for lumber, but it is dense, burns well, and is ideally sized for domestic cooking needs. It can also be used for firing brick, tile, and lime kilns and for fueling copra and tobacco dryers.
Calliandra is particularly promising for improving the soil and preparing the site for crops.
Calliandra's ability to thrive on steep slopes, in marginal soils, and in areas with extended dry seasons makes it a prime candidate for restoring tree cover to watersheds, slopes, and grasslands denuded through deforestation and fire. Calliandra can be established on soils dominated by coarse grasses. Its quick growth, thick canopy,and rapid regrowth leave vigorous weeds, such as *Imperata* grass, little chance to compete.
On denuded watersheds in the tropics calliandra should prove particularly valuable. Its thick canopy and extensive root system may help rainfall to penetrate the soil, thereby retarding runoff and erosion, preventing landslides, improving the perennial flow of springs, and reducing the siltation of dams.
In Indonesia calliandra is often cultivated as a border crop along roads, ravines, rivers, and village boundaries. There it may act as a fire barrier or a screen to prevent unwanted grazing - particularly where forests border villages.
Although not widely tested as a forage source, calliandra foliage contains up to 22 percent protein. It is often produced abundantly and is well liked by cattle and goats. No toxic components have been found so far, although tannin levels are high.
The tree makes good bee forage because its flowers are rich in nectar and it blooms year-round. Calliandra honey is light colored and has a pleasant, bittersweet taste.

1027 91 - 14/27

Potential crops for marginal lands
Review, developing countries, tropics, subtropics, drought tolerance, marginal soils, women, nutritional qualities, storage problems, processing technologies, disease and pest control, varieties, socio-economic research, CIP, AVRDC, IITA

GURA, S.

Sweet potatoe - no longer to be neglected.

entwicklung + ländlicher raum, 25, 1, 1991, pp. 20-23

This article concentrates on problems and prospects of sweet potato (*Ipomoea batatas*) development and makes a case for its accelerated promotion as a food security crop which additionally offers considerable potential to provide income to poor rural populations, especially to women.
With a production of 131 million tons, sweet potato ranks fifth among the major crops produced in developing countries after rice, wheat, maize and cassava.
World production is stagnant, and even has decreased during the Seventies and early Eighties.
A factor which might have led to the neglect of the crop is its generally inferior image as a crop of the poor, grown in times of economic stress and even war, and, in many places, as animal feed. Research and development efforts have often bypassed sweet potatoes, sometimes because of its adverse image.
Sweet potato grows well under a broad range of farming conditions in tropical and subtropical areas, from sea level up to altitudes of 2300 meters. It may be produced in marshy areas as well as in rather dry areas, and can withstand periods of drought or irregular rainfall to a much greater extent than cereals. It does not tolerate waterlogging. It may grow on relatively poor, even acidic soils and is considered rather tolerant to pests and diseases.
Sweet potatoes are usually grown in mounds or ridges to allow better establishment of tubers.
It needs sufficient soil moisture at the time of planting to establish the crop. Propagation is usually done by stem cuttings. Weeding is necessary only in the first stage. Fertilizer is rarely used in smallholder sweet potato cultivation. Labour input is rather low, and capital input hardly necessary.
After three to six months, when the tubers are mature, they may be harvested when needed.
Sprouting and pest attacks may occur if tubers are left in the ground for too long. However, piecemeal harvesting is possible and allows a continuous supply of food for about two months from a highly perishable crop.
Due to its short vegetation period it can be easily incorporated as an intercrop with intensive farming systems.

Since it does not exhaust the soil, sweet potato is often grown before cereals. High energy yield per unit area makes sweet potato suitable for densely populated areas where land is scarce.
Leaf development is comparatively fast, which makes it ideal as a first crop in an intercropping system to cover the soil and prevent erosion while the next, slower crop comes up. For the same reason, as well as for its rather short vegetation period and its high energy yield, sweet potato is favourably planted on freshly cleared land.
The constraints to sweet potato development are:
- Nutritional qualities
- Storage problems
- Lack of processing technologies
- Lack of pest and disease control
- Lack of improved varieties
- Socio-economic research

Concluding, sweet potato development, if oriented at small farming conditions, may help to improve food security and better overcome food crises at household level. Consumption could be increased in rural as well as urban areas, provided they become available as convenience food, and that their image as inferior food is thus improved. Therefore, processing and storage and home and village levels as well as marketing structures should receive priority in development efforts.

91 - 14/28

1028

Potential crops for marginal lands
Latin America, review, palm, tree, indigenous crop, traditional use, domestic crop potential, research needs, NGO

COMTE, M.-C.

A palm with promise.

Ceres, 127, 1991, pp. 26-29

Jessenia bataua is a massive palm that can grow to a height of 20 to 25 metres in wet zones of the Amazone valley and in areas of northern Latin America up to an altitude of about 1000 metres. It usually grows along riverbeds. The fruits form in bunches, called panicles, which hang on the smooth trunk just below the leaves. The deep purple, globe to ovoid shaped fruits vary in size from about 1.6 to four centimetres long. The oil is contained in the pulp, or mesocarp, which is a few millimetres thick and varies in colour from cream to greenish to dark pink.
Jessenia bataua, which grows wild in large areas of the tropical forests of Latin America, is also an important source of wood for construction materials. Its spines are used by Indians to make darts for their blowpipes, and the tree's soft, hairlike fibres are woven into rope. The leaves are used as thatch and for making baskets by many tribes, while the stems are cut to attract weevil larvae, a favourite local dish and first-class source of protein. The palm's edible heart weights a kilo or more and is of great value as a subsistence food in years of lean harvests.
The berry-like fruits of *Jessenia bataua* are edible and can be made into a highly nutritious milk-like beverage, comparable in fat-protein-carbohydrate composition to human milk. The pulp residue from milk production is used as animal feed.
Especially due to its potential for oil production, the bataua palm seems a prime prospect for investigation as a domestic crop. The oil extracted from its fruit, which gives off a delicate resin scent when fried, has even medicinal properties. It is used in treating bronchial and pulmonary ailments, as well as joint inflammations. Most important of all, from a development perspective, bataua palm is one of only a few crops growing in remote areas whose products could command a high enough price to justify transport from the interior.
Local populations' traditional way of extracting oil from the fruit involves use of a cassava basket press, known as a *sebucan* or *tipi-tipi*. The fruit is soaked in warm water for a few hours to soften, then transferred to a mortar and pounded until the pulp separates from the seed (endocarp). The pulp is then squeezed in the basket press, where oil oozes through the weave and is collected in a pan. The significant percentage of water still mixed with the oil is boiled off and the oil clarified. The resulting green or yellow product has a shelf life of a year or more.

A low cost extracting mill built a few years ago in the Llanos region of Colombia can extract 89 per cent of the oil. The appropriate scale mill complex, including the mill shed and foundations, was built for roughly US$ 34 000, and provides the kind of technology that could make bataua oil production commercially feasible.
To be economically realistic, a rural mill should process a minimum of 143 tonnes of fruit per year. Considering that a mature palm can produce 30 kg of fruit per year, a palm grove of 90 hectares with 25 palms per ha is needed to break even.
Except for the digester, diesel engine and press, which must be imported, the mill and its shed can be built with locally available materials.
To maximize the potential of bataua palm, more research is crucial. The pulp-to-fruit ratio for wild trees, for example, averages 41.4 per cent. Oil content ranges from 14.5 to 22.6 per cent and the oil-to-fruit ratio from 6.6 to 22.6 per cent. Consequently, even with improved processing, oil yields are relatively low. Selective breeding could develop improved varieties with higher oil-to-fruit ratios.
A complete development package, which would include research, planning, harvesting, processing and marketing, would be required, to make use of the commercial potentials of the palm.

91 - 14/29

1029

Potential crops for marginal lands
Review, Asia, developing countries, seaweeds, food production, macro-algae, row material, animal feed, bio-fertilizer, biotechnology, IRRI

ICLARM

The potential of seaweeds in food production.

Biotechnology and Development Monitor, No 7, 1991, pp. 10-11

Age-old examples of the conventional culturing of seaweed are found in many Asian countries.
In these countries, many genera are used, the two most common being Porphyra and Laminaria.
Porphyra, or green nori, are the principal maricultural food crop in Japan and China. The largest part of the harvest is dried and processed into thin sheets. It is then used in a variety of manners in cooking (for instance in soups or sushi). The nori industry in Japan alone is estimated to involve over 60,000 hectares in cultivation area and produce sales of more than US$ 730 million annually. Dried Laminaria are consumed directly, or processed into a wide range of products varying from tea to wine to bonbons.
Azolla, a small freshwater fern, also offers interesting posssibilities as an alternative for artificial fertilizer and a source of food. Azolla fixes nitrogen from the atmosphere through a symbiotic association with cyanobacteria (blue-green algae). Rice farmers in China and Vietnam have used Azolla for many centuries, either growing it alone or intercropping with rice. It is also already long used in Asian countries for animal feed. Azolla can even be consumed by humans, directly or as Azolla omelettes and Azolla burgers. It contains between 22 and 37 per cent protein. Its full potential is however not yet recognized.
The fern is used on less than 2 per cent of the world's total rice area of 150 million hectares. In some regions, farmers consider the fern a destructive weed, because its rapid growth blocks irrigation channels. Azolla is able to double its mass every three to five days. In fact, the continuous mat which it forms in rice paddies acts as a weed suppressant. Experiments at IRRI showed that it can reduce the total weed mass by 72 per cent, thereby diminishing the need for applying expensive herbicides.
In the western hemisphere, macro-algae are principally utilized as a source of phycocolloids, high-value low-volume products which include agar, carrageenan and altinate. Carrageenan is a major product from the red seaweeds and is widely used as an extender in foods and related products, ranging from evaporated milk to toothpaste. Agar is employed as a gelling agent in electrophoresis and chromatography analyses in the laboratory. Alginates derived from brown algae are found in milk products and baked goods as well as toothpaste and shampoo. They are also used in dyes and

paints. The largest part of the world's supply of alginates is utilized in the paper and textile industry.
Altogether, phycocolloids' main application is in the food industry in industrialized countries. On average, the Western consumer absorbs 100 grammes of phycocolloids annually.
Because of the low-volume high value character of its endproducts, seaweed culture offers an excellent commercial opportunity for the application of biotechnology.
The processing of seaweeds for the world market may stimulate the development of an indigenous industry.
As international markets for speciality products are limited, and most developing countries lack a home market for these products, the future use of seaweeds in these countries will be principally in food production. Seaweeds can contribute to this either directly (Porphyra, Laminaria, Azolla) or indirectly as animal feed or fertilizer (Azolla).

1. GEOGRAPHICAL INDEX

2. SUBJET INDEX

3. AUTHOR INDEX

This is the fourth edition called "Abstracts on Sustainable Agriculture". In view of the good experience made with the "Abstracts on Intercropping", GTZ intends to continue making the documentation available. Intercropping remains an important aspect of the abstracts but will now be treated as an integral component of sustainable agriculture.
These abstracts are more comprehensive than the usual type of annotated bibliography but they cannot substitute the original publication. For details it is advisable to refer to the original.
The abstracts are divided into different sections, e.g. integrated systems, agroecology, homegardens, soil fertility, water management etc. The subject index, based on key-words, the geographical indices as well as the index of authors help the reader to find abstracts on specific aspects of sustainable agriculture easily.

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