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An Unconventional Alcohol Fuel Crop

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Anticipated scarcities of petroleum-based fuels and increasing energy consumption in most developing countries explain the need to examine alternative indigenous sources of energy such as fuel alcohol. Raw materials for alcohol (ethanol) production are usually sugarcane, cereal grains (principally maize, barley, and rice), grapes, and some rootcrops (cassava, sugar beet, and potato). Potentially, any source of hexose sugar can be used as a basis for fuel alcohol production. However, current realities regarding diminished energy sources appear to require somewhat more unconventional approaches towards fuel production specifically aimed at low input technologies. One such approach is the identification and cultivation on a large scale of alternative plant sources that could be used for their sugar content, such as high-yielding varieties of palms.

Nipa palm (*Nypa fruticans* Wurmb) has been the subject of much recent research because of its potential as a renewable source of fuel alcohol (Amio et al. 1979, Melana 1980, Newcombe et al. 1980, Halos 1981, Lorica and Fortes 1982, Fortes and Lorica 1982, Nyawin 1983, Pavoike 1984, 1985). It is a dominant and characteristic element of mangrove forests of Asia and Oceania (Saenger et al. 1983), and to a lesser extent in West Africa where it was introduced (Zeven 1973). It is well known that the palm traditionally provides medicines, thatching and construction materials for village dwellings, fiber for weaving of coarse baskets and sleeping mats, leaf peels for cigarette wrappers, sweetmeats and vegetable ivory; while in fishing, the petioles are used as floats for fish nets, the main axes for fish poles, and the midribs of leaflets soaked and twisted as ropes (Gonzales 1979). The sap tapped from the stalk of the inflorescence or infructescence (Fig. 2) provides sugar and alcohol, or vinegar if acetic fermentation takes place. Historically, nipa as a fuel crop has gained little headway in the world largely for economic reasons. Some attention was given to establishing nipa plantations in Southeast Asia, particularly in British North Borneo (now Sabah), Malaya (now Peninsular Malaysia) and the Philippines during the early 1920's to 1930's. In Kuala Selangor, Malaya, the processing plant, "Nipah Distilleries of Malaya Limited," with distilling capability of ca. 9,092,180 liters per annum, was disbanded before actual production began (Hinchy 1938). Competitive prices in the world sugar market and high taxes on malt and distilled beverages led to a slump in the industry at that time.

Nipa grows in natural stands sufficiently large for commercial exploitation. If planted it grows indefinitely by nature of its spreading subterranean rhizome (Fig. 1), and can be cultivated on lands, such as swamps, otherwise of marginal value for conventional agriculture. Revolutionary efforts to develop a new kind of agriculture based on seawater irrigation currently in the United States and Israel augur well for serious consideration of "petroleum plantations." In the not too distant future huge areas of hitherto "unproductive" land may become amenable to cultivation with naturally salt-tolerant plants gathered from coastal swamps around the world. Establishing and maintaining a nipa crop on marginal lands in the brackish hinterland of mangroves are not without problems.

1. Nipa palms growing in clumps. Note the 'stemless' habit with the erect leaves and inflorescences arising from a branched subterranean stem rhizome.

Harvesting nipa on soft soils presents special difficulties. Conventional heavy transport machines and sophisticated harvesting equipment would not be practical in such areas. The sap collection technique tends to be slow and labor intensive. Sap is collected once or twice a day and each stalk needs to be shaved and manipulated at each collection. Furthermore, pretreatment or *goncang* of the stalks by bending and kicking is regarded as a prerequisite for sap extraction—without pretreatment there is no sap flow. This has to be carried out two to four times a week and the pretreatment period varies from a few days to three months. Sap yields on an annual basis depend on the pretreatment period, the length of the inflorescence/infructescence stalk, and the number of tapping days in the year, the last factor being influenced by spring tides which flood the swamps. If the palm is to be successfully exploited for sugar and fuel alcohol output, development of cost effective sap collection methods is vital. One encouraging factor is that since tapping can be carried out on different stages of development of the inflorescence/infructescence stalk, production of sap can be continuous throughout the year despite the fact that flowering may be seasonal in some localities.

Another problem in maintaining a nipa crop is the control of pests and diseases. Grapsid crabs are known to cut or girdle the young seedlings (Dammerman 1929), while monkeys and wild pigs can cause serious damage to the fruit bunches (Roxas 1929). The agricultural literature of the colonial era in the Southeast Asian region includes numerous finds of insect pests on nipa palm trial plantations. In particular, at Kuala Selangor, Corbett (1931) first reported the presence of an anthomyiid fly, *Phaonia corbetti* (Mall.) that arrested the development of the female inflorescences. The lepidopteran, *Tirathaba leucotephras* (Meyr.), was later found to contribute some damage to the inflorescences

2. The mature globose fruit head of nipa.

as well (Corbett 1935); because of the close proximity of coconut the insect also utilized nipa as an alternative food plant. Nipa apparently shows very few serious insect pests; there are very few problems relating to heavy or widespread infestation on the palms. Natural enemies are present and serve to check population numbers of the pests (viz., Corbett and Miller 1933, Lever 1932, 1934). Evidence for the occurrence of pathogens or diseases attacking nipa is meagre. Tomlinson (1979) reports that cultivated nipa away from its natural habitat in Florida can succumb easily to lethal yellowing disease.

Processing Methods

New processing methods would have to be devised for some aspects of the exploitation of nipa for alcohol. The conversion process of the sap to alcohol is fairly straightforward. The powerful fermenting microflora, established in bamboo collecting receptacles through the practice of not washing them by sap collectors, ensures a rapid fermentation of the sap sugar to alcohol. The productivity, however, is limited by the tolerance of the natural yeast flora to heat and to the concentrations of sugar and alcohol produced. In the distillation process, there are limitations that must be faced before ethanol can be considered as a potential large fuel source. For every 4.55 liters of ethanol produced there are 45.46–68.19 liters of residue to be disposed of (Coombs 1980, Huff 1981). The residue has a high biological oxygen demand (B.O.D.), and can be seriously polluting if discharged into rivers without treatment. Furthermore, large amounts of cooling water are required, both for the fermentation and the distillation processes in the distilleries.

Nipa like all other renewable sources of liquid fuels, will ultimately have an economic and energy advantage over the limited supply of fossil fuels. Nevertheless, the key to overall economic improvement of the nipa swamps is the availability of capital and management, both of which are in desperately short supply in most developing countries. Currently, the strongest awareness in the region of the potential of nipa agriculture is shown in Papua New Guinea where nipa, surprisingly, according to Newcombe et al. (1980) had little significance in the subsistence activities of local people until quite recently. Management procedures associated with the constraints outlined above will need to be given serious attention by researchers concerned with developing natural resources. What is urgently needed in research is to determine the agricultural requirements and optimal conditions for the crop, to conduct a breeding program for the development of better yielding strains, since variability in stalk lengths, flowering period and sap yields are known to occur (Pavoike 1985), and to develop processing technology to optimize extraction of alcohol from the sap, thereby increasing the productivity per hectare.

The purpose of the present paper is to describe exploitation of marginal, mangrove land based on nipa palms, point out its potential value, explore possibilities and promote investigation of its feasibility, particularly in Southeast Asia and the Western Pacific. To serve as a basis for future research on *Nypa fruticans*, a bibliography of *Nypa* has been prepared. This bibliography is relatively comprehensive but additions and corrections will be welcomed. References have been arranged according to specific aspects such as botanical studies and utilization, the latter further catalogued according to type of use. It is to be hoped that this format will facilitate a more rapid inventory of relevant publications. A copy of the bibliography may be obtained by writing to the author or to Dr. Natalie W. Uhl.

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