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NOTES:

THE NEED FOR FURTHER EVALUATION OF SOME POTENTIAL LOW-INPUT AGRICULTURAL CROPS FOR THE HAMAKUA COAST OF THE ISLAND OF HAWAI'I

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ABSTRACT

The collapse of the sugarcane (Saccharum officinarum) industry on the east coast (Hamakua region) of the Big Island of Hawaii (20° N lat.), has created much interest in new crops that are adapted to the region. Many potentially viable crops exist for the region. Some may be suitable for large scale corporate endeavors such as neem (Azadirachta indica), and seed production of various nitrogen fixing trees (NFT's) and legume groundcovers. Others may be suitable for the family farm such as asparagus bush (Sauropus androgynous). In addition to discussing low-input crops (crops requiring minimal inputs of fertilizers and pesticides) that need to be evaluated for potential use on the Hamakua Coast, this paper briefly reviews the soils of Hamakua, and criteria for selecting low-input crops.

KEYWORDS: *Low-input crops, Hydrudand soils, Nitrogen-fixing trees, Neem, Legume groundcovers*

INTRODUCTION

The demise of the sugarcane (*Saccharum officinarum*) industry on the east coast of the Big Island of Hawaii has brought with it much anxiety concerning the new lack of a regional economic base, along with a perceived deficit of crops to fill the void (Mathews, 1993; Klemm et al., 1994). Yet this transition has the potential of being a positive starting point for the development of a stable, diverse, permanent, and profitable agricultural system that would benefit the producers as well as the people in the region. In addition, such an agricultural system may help alleviate many of the soil erosion and water quality concerns that existed when almost all of the agricultural land was under sugarcane production (Dept. of Health, 1990; Aguilar and Waite, 1991).

This paper reviews some low-input crops that may have potential for use on the Hamakua Coast, criteria for their selection, and briefly summarizes the properties and management of Hamakua soils.

HAMAKUA SOILS

The sugarcane lands of Hamakua consist of fine textured soils (silty clay loams) that developed in geologically recent (30,000 to 50,000 yr old) volcanic ash (Wolfe et al., in press). These soils belong to the Hydrudand Great Group of the Andisol order (formerly Hydrandepts in the Inceptisol order) in the *U.S. Soil Taxonomy* system (USDA-SCS, 1973; Wambeke, 1992). Hydrudands are high in organic matter concentration, very porous, and continuously wet, but well-drained. The average topsoil (0- to 8-inch soil depth) organic carbon concentrations (5 to 6%; USDA-SCS, 1993, unpublished data) in Hamakua Coast Hydrudands that were under sugarcane production until the past year compare favorably with the average organic carbon concentration (2%) of other agricultural soils in the humid tropics (Wambeke, 1992). However, the organic carbon present may be fairly inert in terms of serving as a source of low molecular weight (LMW) organic acids that enhance phosphorus (P) availability through reactions with soil P-binding minerals (Hue, 1991). The low concentration of LMW organic acids may be attributed to the lack of soil replenishment with crop residues and green manures under the "burn, push, and grab" method of mechanized sugarcane harvest in Hawaii (Koepf, 1992). In addition, the effective cation exchange capacity (ECEC; sum of exchangeable cations in units of charge equivalents) of Hamakua soils is generally low (5 to 10 $cmol_c\ kg^{-1}$ soil).

Major soil fertility concerns with the sugarcane lands of Hamakua are P fixation (retention of fertilizer P in forms unavailable to plants), soil acidity, and potassium (K) leaching (Fox, 1980; Tamimi and Matsuyama, 1990). The extraordinarily high P-fixing capacity of Hamakua soils has been associated with the presence of high concentrations of allophane (x-ray amorphous aluminosilicates) and hydrous oxides of iron (Fe) and aluminum (Al). For some crops, this requires the application of high P fertilizer rates to obtain high yields (Fox, 1980). Efficiency of P fertilizers would increase significantly if they were applied along with LMW organic acid producing materials such as green manures or animal wastes (Hue, 1991). Near complete depletion of exchangeable K from Hamakua soils can occur if it is not reapplied periodically (Fox, 1980; Tamimi and Matsuyama, 1990) or returned to the topsoil in the residues of deep rooting plants (Elevitch, 1993). For many crops, periodic applications of liming materials also are needed to maintain a pH of approximately 6.0.

POTENTIAL LOW-INPUT CROPS FOR HAMAKUA

The emphasis on perennial species is not meant to minimize the importance of annual crops at this time. Since November 1993 when sugarcane planting operations ceased on the south Hamakua coast, a major influx of small farm operations has taken place, as farmers rushed to take advantage of the newly available lease land. Although this is a positive step, it is not without potential long term problems which must be addressed. The agricultural systems currently employed are among the highest input in the nation in terms of fertilizer and pesticide use per unit land area (Dept. of Health, 1990). Due to the proliferation of disease, for example, bacterial wilt of ginger (Hawaii Agricultural Statistics Service, 1993) and nematode infestation (Dunn, 1992), some crops can be grown only once in the same location without severe decline in production. Furthermore, the total area covered by such farming operations represents only a small percentage of the available land area owned by the sugarcane producers (Nakamoto et al., 1993).

Thus, lies the importance of evaluating alternative crops which can provide long term solutions to the above problems, while at the same time addressing the issues of soil limitations and ecosystem preservation. Factors for selecting new crops which have potential for sustainable systems (economically and environmentally viable in the long term) are as follows:

1. Species must be well adapted to the wet (2500 to 5000 mm of rainfall per year), tropical environmental conditions of the Hamakua Coast to ensure successful production and minimize the need for inputs.

2. Perennial species would be preferable as they form a stable and permanent culture, also minimizing inputs (Theng, 1991). Perennial crops are easily incorporated into systems (nitrogen fixing trees, legume covercrops, agroforestry, etc.) which are instrumental in preventing soil erosion (Theng, 1991). Soil erosion has been a severe problem on the Hamakua Coast since the advent of mechanized sugarcane production during the late 1940s (Aguilar and Waite, 1991).

3. Because of the shipping and marketing problems inherent with the Hawaiian Island situation, crops that can be processed for the value added component are likely to offer the greatest potential for profit maximization (Philipp, 1958). Crops that must be sold fresh are often not very profitable, although there are exceptions that occur such as ginger (*Zingiber officinale*), taro (*Colocasia esculenta*), bananas (*Musa* spp.) and certain local market vegetables (Hoose, 1994).

4. Due to the nature of Hamakua soils and their tendency to tightly bind P (Fox, 1980; Tamimi and Matsuyama, 1990) crops that are highly dependent on vesicular-arbuscular mycorrhizal fungi (VAMF) are very desirable (Habte et al., 1994). Such fungi are instrumental in providing P that would normally be unavailable to the host plant (Majunath and Habte, 1991). Deep rooted crops also are desirable in order to recover K which is readily leached into the subsurface layers of Hamakua soils (Fox, 1980; Tamimi and Matsuyama, 1990; Elevitch, 1993).

5. Practicality is of the utmost importance. It has been proposed that macadamia nut (*Macadamia integrifolia*) be more extensively planted on former sugarcane lands, but realistically this crop is not well adapted to the wet climate and fine textured soils, resulting in disease and extensive wind damage (Bittenbender and Hirae, 1990; Nagao and Hirae, 1992). Eucalyptus (*Eucalyptus* spp.) has also been proposed for particle board manufacture, but environmental concerns, high initial investment for a factory, and a long waiting period (6-7 years to production) make this possibility unattractive (Chumbley, 1994).

Taking into consideration the above criteria, the following crops offer potential for success at this time:

1. Neem. A voluminous data base exists on the cultivation and uses of the neem (*Azadirachta indica*) tree (Koul et al., 1989; Vietimeyer, 1993). Because of the proven effectiveness, many uses of neem products and increased public interest, a significant market exists for such products both on the U.S. mainland and Europe. Currently, three U.S. companies (*Grace*, *Safer*, and *Agridyne* Inc.) are producing a neem insecticide from imported neem materials and various other neem products are available from India (toothpaste, soap, oil, etc; Vietimeyer, 1993). However, the products from India tend to be of a low quality, or contain substances (for example, artificial colorings or animal fats) which some consumers find objectionable. Neem is highly VAMF dependent (Habte et al., 1993), requires few inputs, grows quickly, and is adapted to low fertility soils (Ahmed and Grainge, 1985). Hawaii is the only location where it may be grown commercially in the U.S. because of its high sensitivity to frost (Vietimeyer, 1993), but yield data on the vegetative material is urgently needed.

Seed production on the Hamakua Coast is probably not possible because of the high rainfall conditions. However, many products can be derived from the green, vegetative parts of the plant, such as dehydrated leaves for medicinal use (topical application or tea), home pesticide production, food preservation, cosmetics, toothpaste, soaps, etc., and wood products for soil nematode control (Koul et al., 1989). Raw materials may also be marketable to companies wishing to produce other neem products.

In order to produce the highest amount of vegetative material, neem can be planted in close hedgerows which would be periodically coppiced, similar to alley cropping (Elevitch, 1993). This also is a technique for soil erosion prevention (Kang et al., 1984) and establishment can be cost-shared (75%) by the USDA-Soil Conservation Service. Furthermore, such hedgerows are amenable to mechanical harvesting, and production of green material can begin within one year of planting, whereas seed production will take many years to reach significant proportions. The possibility also exists for intercropping of neem and nitrogen fixing tree (NFT) hedgerows. Those NFT's adapted to Hamakua conditions (to be discussed later), produce a great deal of nitrogen rich biomass (Rathert and Weraspon, 1992) which can be mixed with the neem material to produce a natural, pesticidal fertilizer/mulch for local and mainland markets (Ram, 1994; unpublished data). At this time, a joint project between *TRIADES* and *Mauna Kea Agronomics* (a subsidiary of *C. Brewer Co.*) is being initiated on a site near Papaikou in the Hamakua region to evaluate a commercial planting of combined neem and NFT hedgerows. Although some data (1 yr) exists regarding production of NFT biomass in Hamakua (Elevitch, 1993) there is an acute need for current quantitative research, evaluating production from neem hedgerows under Hamakua conditions. Further research is also necessary regarding the processing of green materials into marketable products.

2. Fruits for Processing. There are a number of species of tropical fruit trees which are well adapted to Hamakua, producing heavy, regular crops even under adverse weather conditions during fruit set (Popenoe, 1948). Some examples for juice concentrate production would be star fruit (*Averrhoa carambola*), soursop (*Annona muricata*), and guava (*Psidium guajava*). Guava is already grown commercially to a small extent, but is limited in use, probably due to low profitability per unit land area (Hawaii Agricultural Statistics Service, 1992). Both star fruit and sour sop are heavy producers which bear at an early age, with fruits high in juice content (Martin et al., 1987). When mixed together, or with other juices, a high quality product results. In some parts of the world (for example, Brazil) sour sop is a very popular juice, comparable to orange (*Citrus sinensis*) juice in the U.S.

The natural beverage industry is on an upswing, and there is a constant search for new products and flavors. The market is currently very strong for juice concentrates, flavorings and essences for use in juice drinks and sodas, as evidenced by the success of such companies as *Snapple* and *Knudsen*. An alternate possibility is to produce a local line of Hawaiian drinks for national distribution.

There are a number of other adapted fruit trees with juice potential as well as some with other potential products (Martin et al.,1987). The canistel (eggfruit; *Pouteria campechiana*) is one example. This fruit can be made into quite a number of products, including an ice cream which is cholesterol free (F.W. Martin, former director of the USDA Experiment Station, Mayaguez, Puerto Rico, personnal communication).

3. Asparagus Bush. Grown commercially in Malaysia, the asparagus bush (*Sauropus androgynus*) is one of the finest perennial vegetables of the world (Martin and Ruberte, 1979). This species is quite at home in Hamakua, enjoying high rainfall and acid soils, as well as being highly VAMF dependent (Habte et al., 1994). Asparagus bush is a very vigorous, continuously producing shrub that can be grown in close conservation hedgerows, making USDA-Soil Conservation Service cost sharing a possibility. The young, tender growing shoot is the main product, and can be eaten raw or cooked. The cooked shoots are considered a delicacy which rivals asparagus. Potential for canning and marketing would have to be explored, although it should not be difficult to develop a local market for hotels, restaurants, etc., as there is universal agreement on the quality of the vegetable (Martin and Ruberte, 1979). This vegetable would be ideal for the small family farm and could be used as part of an agroforestry system [the planting of NFT's and high value commercial tropical hardwoods or other tree crops in association with food crops (Simmons, 1990; Nair, 1993)]. Research is needed on the production systems used for asparagus bush in Malaysia, commercial development, incorporation into agroforestry systems, and possible processing strategies.

4. Nitrogen Fixing Tree Seed. Seed for tropical NFT's is difficult to obtain and is generally in short supply on the world market (Withington, 1987; C. Elevitch, 1994, *Agroforester*™ Tropical Seeds, Holualoa, Hawaii, personnal communication). Prices for seed of various species range from $40 to $350 per kilo, and there is a constant demand due to the increasing use and promotion of alley cropping systems (systems where NFT hedgerows that receive few if any nutrient inputs are pruned to mulch and fertilize food crops that are grown between the rows) by international sustainable agriculture programs (Withington, 1987). Species in high demand, both locally and internationally (C. Elevitch, 1994, personnal communication), include angustissima (*Acacia angustissima*), calliandra (*Calliandra calothyrsus*), flemingia (*Flemingia macrophylla*), gliricidia (*Gliricidia sepium*), and sesban (*Sesbania sesban*). Most developing nations do not seem to have the expertise to develop such NFT seed farms, and potential also exists for selection and improvement, which would assure continued profitability. Due to a need for drier seed conditions during seed set (Nair, 1993), some species would be better cultivated in the drier areas of north Hamakua. Nitrogen fixing trees are also highly VAMF dependent (Majunath and Habte, 1988) and as aforementioned require little if any nutrient inputs. Labor requirements during harvest would be high, but this should be more than made up by the value of the seed. Data are urgently needed on seed yield, dry matter production and nutrient concentration, and fertilizer replacement value (as a mulch or composted) of various NFT species on the Hamakua Coast (Elevitch, 1993).

5. Legume Groundcover Seed. Quality seed for nitrogen fixing groundcovers such as perennial peanut (*Arachis pintoi*), glycine (*Neonotonia wightii*), centro (*Centrosema pubescens*), and various desmodiums (*Desmodium* spp.) are also in local as well as international demand. Many farmers, as well as the USDA-Soil Conservation Service in Hawaii are very interested in the use of such covercrops for erosion control, green manuring, and sustainable systems (USDA-SCS, 1981). Prices of legume groundcover seeds range from $30 to $80 per kilo. Seeds are harvested with a small combine and cleaned for export. As with the NFT's, some species may need the drier area of the north Hamakua coast for optimum seed set. Most tropical legume groundcovers are thought to be VAMF dependent and require very little inputs, other than the possibility of added phosphorus for increased seed production (Andrew and Jones, 1978). As with the NFT's, data are lacking for legume groundcover seed production on the Hamakua Coast.

SUMMARY

There are many potentially commercially viable crops that need to be evaluated for the Hamakua region, some suitable for large scale corporate endeavors (for example, neem, fruits for processing, and NFT/groundcover seed production), and some suitable for the family farm (for example, asparagus bush in conjuction with an agroforestry system). Besides lending themselves well to low input systems, production of neem, NFT seed, and groundcover seed are considered very "green" or "environmentally friendly". Thus, they have added public relations value for the individuals or companies who are involved with them.

Other benefits can be obtained from such agricultural systems. For example, an area of sustainable agriculture and agroforestry is conducive to an ecotourism destination (Attix, 1994), similiar to the one (*AMAN Project*) currently planned near Waipio valley. In addition, such a site would be an excellent extension tool for local farmers, educators, and the training of individuals (for example, Peace Corps Volunteers and U.S. Agency for International Development employees) wishing to conduct agricultural development work in the tropics. Because the time of agricultural transition is now upon us, there is an urgent need for field research and economic analysis.

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