

# PLANT INTRODUCTION NEEDS OF THE HAWAIIAN SUGAR INDUSTRY

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## ABSTRACT

The Hawaiian sugar industry has introduced plants for three major purposes: 1) expansion of the genetic base from which new sugar cane (*Saccharum officinarum*) cultivars are developed, 2) protection of watersheds from erosion, and 3) development of new crops to supplement sugar plantation income. New, higher-yielding and disease-resistant cultivars of sugar cane were initially developed as a result of the introduction of closely related wild species of *Saccharum*. More recently, related genera have also been introduced to increase genetic diversity. It was determined early in the 1900s that, for several reasons, native plant species would not readily cover terrain devastated by the indiscriminate grazing of cattle, goats and sheep (*Bos taurus*, *Capra hircus*, *Ovis aries*). A large plant introduction program, initiated by the Experiment Station of the Association under the direction of H.L. Lyon, was aimed at the reforestation of the watersheds. The introduction of plants has also followed from programs to develop new agricultural industries in the State. These crop introductions are especially important today, with the continuing decline in sugar cane acreage and the need to supplement the income generated by the sugar industry.

## INTRODUCTION

This paper addresses the historical and current plant introduction needs of the sugar industry rather than agriculture in general. We have identified three areas that have required the introduction of alien plants: 1) increasing the genetic diversity of sugar cane (*Saccharum officinarum*), 2) protecting watersheds, and 3) developing new crops.

## INCREASING GENETIC DIVERSITY OF SUGARCANE

The earliest introductions of sugar cane to Hawai'i were made by the Polynesians. Captain James Cook recorded sugar cane on the island of Kaua'i in 1778 (Cook 1785):

We saw no wood, but what was up in the interior part of the island, except a few trees about the villages; near which, also we could observe several plantations of plantains and sugar canes, and spots that seemed cultivated for roots.

Little is known about early sugar cane introductions by the Polynesians; however, some canes were classified by Moir (1932). Early Polynesian introductions were all that were available when the first attempts were made to develop a sugar industry in Hawai'i in the mid-1800s.

Problems with diseases quickly developed in sugar cane propagated by cloning, and agriculturists attempted to hybridize sugar cane to produce disease-resistant cultivars (Mangelsdorf 1946). These attempts failed, and the planters were forced to introduce cultivars from other countries. The first recorded successful importation of sugar cane was in 1854, when the cultivar "Bourbon (Otaheite)" was introduced from Tahiti. This cane was first planted in Lahaina, Maui, and became known as "Lahaina." Many introductions followed when the "Lahaina" cultivar failed. Introductions were interrupted in 1904 for a 19-year period due to a self-imposed quarantine on sugar cane importation owing to the (probable) accidental importation of the sugar cane leafhopper (*Perkinsiella saccharicida*) from Australia on cane shipments.

In the early 1900s, sugar cane seed was found to be fertile, and a breeding program was initiated. Even with the ability to make genetic improvements with locally available material, introduction of additional sugar cane cultivars and other *Saccharum* species were required, primarily to increase disease resistance. Many additional cultivars and related *Saccharum* species were introduced in 1923 when the importation embargo was lifted. A quarantine station was set up on the island of Moloka'i to protect commercial sugar cane from accidental introduction of insects and diseases. The introduced species included *Saccharum robustum*, *S. sinense*, *S. spontaneum*, *S. officinarum*, and *S. barberi*. The Java (POJ) varieties were imported and formed the basis for the development of the modern Hawaiian varieties. Two hundred introductions had been made as of 1953, and many more cultivars have been introduced since (Mangelsdorf 1953). At present, to introduce sugar cane to Hawai'i, a three-year quarantine is required at the U.S. Department of Agriculture in Maryland, followed by a one-year quarantine at Waimānalo, O'ahu. Genera allied to *Saccharum* have also been introduced for the purpose of making wide crosses to insure genetic diversity.

## WATERSHED PROTECTION

In the late 1800s, sugar planters became increasingly aware and concerned that watershed sources of irrigation water on all the Islands were in a state of decline. The destruction of large areas of forest by cattle (*Bos taurus*) resulted in extensive runoff; heavy erosion was evident in the muddiness of streams during storms, and extensive areas of topsoil had eroded to bedrock in many instances. Dr. Harold L. Lyon, pathologist at Hawaiian Sugar Planters' Association, was asked to visit

Maui in 1909, to determine the reason for the decline of the native forests. Lyon formed an hypothesis (to be summarized below) for the decline of native forests (Lyon 1909). He became so concerned that he recommended extensive reforestation of the damaged watershed areas. The Association's Experiment Station began introducing plants for reforestation in 1909; however, no field plantings were made. Instead, the introduced seeds were turned over to the Territory Bureau of Agriculture and Forestry. According to Lyon (1918), not much was accomplished, and it was his recommendation that the Experiment Station become directly involved in planting trees for watershed protection. Lyon was also very much concerned with the conservation of the existing native forests (Lyon 1909):

What ever planting is attempted, the native trees and shrubs still clothing the slopes of the gulches should receive special consideration. Their preservation should be the main feature of any plan adopted.

In 1918, under the direction of Lyon, a forestry research program for the purpose of watershed protection commenced. This work was considered essential to the survival of the sugar plantations and the domestic water supply, especially on O'ahu.

Lyon concluded that the native species of plants in the forests could not be depended upon to protect the valuable water resources (Lyon 1918). For this reason, he recommended the planting of introduced plants. Over 8,000 species of trees, shrubs, and economic plants were introduced between 1918 and 1934. Lyon was convinced that a forest should be planted as a community of plants, including trees, shrubs, and vines, for the purpose of maximum water preservation. Associated plants would then act as a natural forest for water preservation. A forest planted in such a manner would not be used for commercial logging. Lyon was especially interested in the use of the genus *Ficus* in the watersheds due to its ability to prevent erosion and because of easy establishment and natural regeneration (with the presence of pollinating wasps). Hundreds of *Ficus* introductions were made, but only a few pollinating wasps were successfully introduced.

By 1918, Lyon was convinced that those recommending the use of native species for watershed reforestation were wrong. He was fully convinced that Hawai'i's native forests were doomed and would fall into a condition that would not afford protection of watersheds. He proposed two reasons for the forest decline:

1. The natural makai (seaward) forest frontier was destroyed by humans and uncontrolled grazing, thus exposing the interior forest to invasion by weeds and the devastating effects of the weather. Interior forests were also encroached upon from the mauka (landward) side, primarily by ranching interests, and became exposed, narrow strips deprived of natural protective barriers.

2. Native trees in the watersheds were not well adapted to poorly drained soil conditions present in the forest as a result of disturbances. Without a secondary invasion of native trees suited to the evolving soils

and poor drainage, the native forests were doomed. Establishment of native trees on denuded watershed areas was difficult to accomplish.

Lyon's recommendation was to establish conservation areas, remove cattle from watershed areas, and plant introduced trees. He was quite sure that commercial timber should not be planted in the watershed areas. For this reason, he proposed the planting of dense forest formations for one purpose only -- preservation of water.

In 1919, Lyon elaborated further on his original hypothesis and proposed again that pure culture forests were not acceptable for water conservation (Lyon 1919). He wrote:

Now, the demands on the local water supply are going to increase rather than decrease, but the available local water supply [for O'ahu] is most certainly going to decrease if the denudation of our watersheds is allowed to continue at the present rate. Oahu will suffer from periodic water famine, which will become more and more frequent until eventually drought will be a permanent condition.

Under the direction of Lyon, thousands of denuded forest acres were reforested. He continued to write about the successes and failures of the reforestation program until 1951 (Lyon 1922, 1924, 1926, 1927, 1929, 1934, 1940).

Without the pioneering reforestation work of the sugar planters, including the removal of cattle from watersheds, water would not have become available to the leeward sugar plantations and expanding cities such as Honolulu.

## INTRODUCTION OF SUPPLEMENTAL CROPS

A third reason for the continued introduction of plant material to Hawai'i arose from the need to establish new agricultural crops. Of course, the earliest introductions were brought to Hawai'i by the Polynesians. In addition to sugar cane, these included taro (*Colocasia esculenta*), sweet potato (*Ipomoea batatas*), yam (*Dioscorea alata*), arrowroot (*Tacca leontopetaloides*), mountain apple (*Syzygium malaccense*), breadfruit (*Artocarpus altilis*), banana (*Musa x paradisiaca*), wauke (*Broussonetia papyrifera*), kukui (*Aleurites moluccana*), 'ōlena (*Curcuma longa*), hau (*Hibiscus tiliaceus*, considered by some to be indigenous (Wagner *et al.* 1990)), kou (*Cordia subcordata*), kamani (*Calophyllum inophyllum*), and possibly coconut (*Cocos nucifera*). These early introductions for food, fiber, and energy, along with the clearing of large areas and the introduction of the domestic pig (*Sus scrofa*), which foraged around settlements, certainly took a toll of lowland native plants (Cuddihy and Stone 1990).

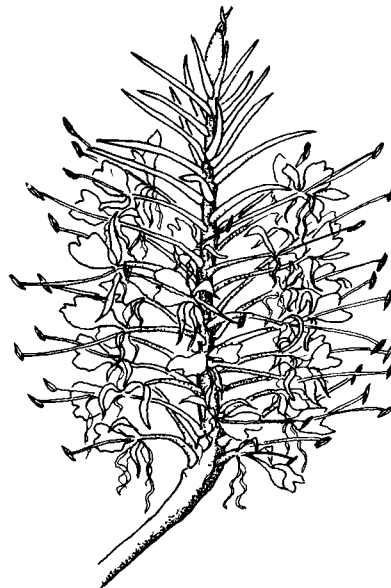
A second wave of economic plant and animal introductions came with the Europeans. These included many fruit, fiber, medicinal, forage, grain,

vegetable, and ornamental crops. Well-established crops of considerable economic importance include macadamia nut (*Macadamia integrifolia*), papaya (*Carica papaya*), coffee (*Coffea arabica*), and pineapple (*Ananas comosus*). Introductions that have become weeds in addition to crops include common guava (*Psidium guajava*) and passion fruit (*Passiflora* spp.).

Sugar planters have been especially interested in plant introduction under three circumstances: during periods of war or anticipation of war; during periods of forced agricultural acreage reduction; and during periods of poor sugar returns. During both World Wars, the Association and the sugar plantations encouraged local production of subsistence food crops and optional food plants. Many vegetable introductions were made, and some superior types were bred and selected. Most notable was the development of "Hawaiian Sugar" sweet corn (*Zea mays*) by A.J. Mangelsdorf. Many vegetable seeds were distributed to the plantations, but no new plant industry developed.

Probably the most active period for the introduction of food crops was during the period just after the enactment of the Jones-Costigan Act of 1934, which limited the tonnage of sugar that could be produced in Hawai'i. This act created 17,000 surplus acres (6,800 ha) for which crops were needed. An Hawaiian Sugar Planters' Association Diversified Crops Committee was founded in 1935 to address the new crops issue.

Today, because of low sugar prices and competition from other sweeteners, thousands of acres have been taken out of sugar cane production. Of a potential 230,000 a (93,115 ha), only 180,000 a (72,875 ha) are now in production. The Association and its member companies are now engaged in a search for alternate uses for sugar as well as new crops that can supplement low sugar returns.



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