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Traditional and Contemporary Propagation of Hawaiian Crops

Noa Lincoln
University of Hawaiʻi at Mānoa, 3190 Maile Way, St John 102, Honolulu, Hawaiʻi 96822, USA

nlincoln@hawaii.edu

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Abstract

Native Hawaiian horticulturalists introduced a suite of crops to Hawaiʻi that were cultivated in the diverse climates represented by the archipelago. The crops represent an endpoint of a unique selection process resulting from repeated sub-selection and diversification that occurred during the island hopping across the Pacific. Among the many results was decreased fertility and resulting asexual propagation of the vast majority of crops. Despite this, Native Hawaiians created a highly diverse collection of cultivars. Furthermore, they developed a high level of skill in vegetative propagation techniques. Today, revived interest in traditional crops, along with new challenges, has resulted in multiple efforts to improve vegetative propagation techniques.

INTRODUCTION

Island drift of crop cultivars

As Pacific voyagers colonized the vast area of Polynesia over the last 5,000 years, they carried with them important plants for crops and resources. Each departing voyage could only carry a small subset of the genetic diversity of each species, which was subsequently re-diversified upon arrival at a new island home. This process was repeated multiple times, resulting in a unique and rapid genetic drift. Among the many traits selected for was seedlessless, which for many of the crops increases predictably as a distance from Papua New Guinea, where many of the crop wild relative still occur. As seedlessness (and by extension, vegetative propagation) increased miotic defects and resulted in increased infertile propagules, asexual propagation techniques became necessary for many of the crops. Of the 21 edible crops introduced to Hawaiʻi, 12 are entirely sterile. Even the few crops that remained fertile to some degree were often propagated vegetatively in order to maintain elite cultivars that were true-to-form, although some evidence exists that eastern Polynesian farmers deliberately set and scattered seed in order to produce new varieties that, if favored, would be maintained through vegetative propagation. Of the 21 crops mentioned above, only 5 were commonly propagated by seed.

VEGETATIVE PROPAGATION: TECHINQUES, CONSEQUENSES, AND EXPERTISE

A range of vegetative techniques were used for vegetative propagation of Hawaiian crops, including shoot cuttings, rhizomes, tubers, and root runners. For the primary staple, kalo (*Colocasia esculenta*), a hybrid method was used in which a small portion of the tuber was used along with the defoliated stalk of the plant. At the joint of the stalk and the tuber a brightly colored seam is found, known in Hawaiian as the kohina; if this seam is intact, a new plant will grow.

There are multiple advantages and disadvantages to clonal propagation. Advantages include the assurance of favorable genotypes, avoidance of inbreeding depression, preservation of highly specific chemical compounds, ability to quickly propagate favorable mutations, reduction of gene-flow from wild populations, ease of propagation, and, in some cases, higher yields produced when compared to plants grown from seed. Disadvantages include the loss of certain components of diversity, deleterious mutations, competition between propagules and use, and accumulation of pathogens that are passed down through the vegetative propagule.

As stated by Dr. Craighill Handy, one of the first ethnographers to examine traditional Hawaiian agriculture, "in the matter of shrewd observation of varieties and careful, conscious selection of mutants in the creation of subvarieties of their plants, the Hawaiians were truly experimental horticulturalists (Handy et al., 1972)." From a handful of introductions, the Hawaiians developed over 650 names, likely representing over 200 cultivars of kalo (Winter, 2012), with similar diversification of other crops. This exemplifies a poorly studied phenomenon – that under strict clonality evolution is more dynamic than is usually thought, and that somatic mutations are so frequent that genetic identity of clones becomes virtually impossible. This can be seen in Pacific breadfruit, where exclusively clonally propagated plants in the eastern Pacific exhibit nearly 50% unique genotypes from their clonal ancestors in the western Pacific (Zerega et al., 2015).

The accumulated diversity of cell lineages drives significant expression of phenotypic diversity, even with minimal genotypic diversity. Somatic mutations could be an important source of genetic variation in clonally propagated plants, with diplontic selection accelerating the accumulation of favorable alleles in clonal lineages. However, empirical study of these aspects has been uncommon.

One reasonably well documented example is leaf variegation, where cells bear both chlorophyllous and achlorophyllous cell lineages, with specific manifestations empowered by human selection of propagules, environment, or chance. Over time, the achlorophyllous lineages are typically eliminated by diplontic selection when human selection in not maintained. This is again seen in the Hawaiian examples, with the term ʻāweu describing kalo that has escaped plantations and reverted back to its "wild form," loosing many of the desirable traits maintained during its cultivation.

In addition to the cultivation of cell lineage expression, epigenetic inheritance in vegetatively propagated plants plays a significant role in the expression of clones. In propagating plants, Native cultivators considered the selection of vigorous material to be of the upmost importance, with specific growth for each crop used for propagules. For kō (sugarcane, *Saccharum officinarum*), Hawaiians has a specific term, ʻēlau, referring to the upper portion of the stalk from which cuttings were taken (Lincoln, in press). A simple student experiment using the ʻēlau compared to other propagules for sugarcane shows that the usage of this propagule produced stalk volumes twice as great as lesser propagule material in a single generation. Presumably, this effect would be amplified with selections from multiple generations. This poorly explored aspect of the biology of clonal crops has been demonstrated well in forestry, where cuttings from vertical or horizontal growth manifest growth traits from those axes in the next clonal generation.

CONTEMPORARY SETTING OF HAWAIIAN CROP PROPAGATION

Hawaiʻi is ripe for study in the realm of clonal propagation. Cultivation of traditional crops and methods have revived rapidly and taken hold in a new generation of farmers that blend indigenous observation with new tools. Facebook groups support highly detailed discussions of minute morphological and phenotypical differences of crop varieties, driving intense debate on what drives those manifestations.

Bringing intensive genetic and quantitative study to this arena rich with ethnographic documentation could provide a wealth of knowledge into the poorly studied realm of evolution in clonally propagated plants.

The challenges of today are different, and in particular a need for clean propagation material, access to traditional varieties, and the ability to create larger quantities of propagules is present. Some solutions have been emerging. Tissue culture is a powerful tool for creating clean material and large quantities; however, there have been some pushback as some traditional farmers feel that they have observed changes in the somatic mutations associated with tissue cultured plants. More growers favor the higher volumes, but more stable propagation through single-node (vs. traditionally multiple-node) cuttings and adventitious shoot cuttings. However, gaining sufficient volume with these techniques remains challenging without dedicated facilities. Growing private and public germplasms have helped with access to varieties, but more impactful have been farmer-to-farmer connections fueled largely by social media platforms.

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