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ADAPTATION OF TEMPERATE CROPS TO A TROPICAL ENVIRONMENT

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ABSTRACT

Introduced cultivars of apple, peach, fig, strawberry, grapes, and other temperate fruits have grown well under lowland tropical conditions. There is variation in adaptability between species and cultivar. Continuous warmth does not trigger the fruit's chilling requirement mechanism; instead, flowering and fruiting occur after drought induced dormancy. Pollination characteristics are erratic compared to temperate conditions. Fruits tend to be undersized but of excellent quality.

RESUMEN

Selectas variedades de manzana, melocotón higo, fresa, uvas y otras frutas de clima templado introducidas en terrenos llanos en países tropicales han crecido bien. Hay diferencias en la adaptabilidad de algunas especies y variedades. El calor continuo no provoca el mecanismo que requiere el enfriamiento, sino que las plantas florecen y dan fruto después de un estado latente inducido por sequía. Las características de polinización son irregulares comparadas con las que ocurren en condiciones templadas. La frutas tienden a ser pequeñas pero de excelente calidad.

Flower induction is critical for the successful adaptation of any fruiting plant into a new environment. For tropical crops, flower induction is moisture dependent. Mangoes (3), citrus (8), Barbados cherries (Michelini, unpublished data) and other tropicals, flower and fruit when the proper amount of rain follows dry conditions. Temperate pears also fruit more heavily when water stressed (7). Moving tropical crops to the subtropics, where they receive a combination of dry and cold weather, can result in a heavy, concentrated bloom.

Temperate fruits have adapted to seasonal cold weather by the process of dormancy. Dormancy is the condition of the plant where it will not grow immediately, even though temperatures and moisture conditions are favorable (10). In temperate climates, dormancy begins with the onset of short days and cool weather. It is characterized by the slowing and eventual cessation of active vegetative growth. Prior to abscission, leaves continue to manufacture carbohydrates, storing them in the stems and roots. In many temperate-zone plants vegetative buds convert to flowering buds in a process called induction, which is then followed by vernalization, or cold induced promotion of flowering (10). Once dormant, the plant must complete its internal cycle before beginning normal "spring" growth. This cycle will be productive only after the satisfaction of the chilling requirement as measured by chilling units.

Chilling units are timing criteria set for temperate fruits. Each individual plant needs cold weather to satisfy its physiological dormancy (11). Once satisfied, the plant responds to favorable environmental conditions with growth.

The chilling requirement is essentially a protective mechanism which evolved to keep the plant dormant pending resumption of warm weather. The biochemical reaction begins when temperatures drop to about 15 degrees C, and proceeds most rapidly at temperatures between 5 and 9 degrees C (14). Interestingly, plants from extremely cold climates have lower chilling requirements than more temperate climates, due to the shortage of 0 to 10 degree C temperatures (13).

At about 15 degrees C, certain tropical and subtropical fruits exhibit another temperature sensitive reaction in the flowering process. Loquat, lychee, longan, and cherimoya (1) need cool temperatures to set bloom buds and flower. However, the Amboina

lychee does set fruit at sea level in Puerto Rico (Dr. Martin, personal communication), and cherimoya x sugar apple hybrids (atemoyas) set well at sea level.

This highlights the variability of chilling requirements. Plant breeders have selectively reduced the chilling needs of many fruits, giving plantmen increased opportunities to grow fruit under no-chill conditions.

The literature mentions very little of temperate crops responses in a tropical environment.

Plant Materials

Strawberries have no specialized winter chilling needs (2). Day length is more important, with both short day and day neutral varieties available (13). Cool weather and short days promote runner growth, and runners produce better fruit than mother plants more than one season old. While cool weather is not necessary for flowering, it is beneficial for higher production. Strawberries grown under highland tropical conditions yield up to 22,000 pounds per acre.

Florida Belle, a short day strawberry cultivar, was introduced to Barbados and planted at 250 meters elevation. Flowering was nearly continuous from mid-January through June. Production was moderate, with half pound per plant average, under inconsistent cultural practices. Runners started in early March and each set from 4 to 6 fruits shortly after establishing themselves on their own roots.

Plants grown under sprinkler irrigation produced 15 gr. fruits of excellent quality. With the retail value approaching US \$14.00 per kg. in Barbados, it appears that supplying the admittedly small market could be quite profitable. The main disease is *Mycosphaerella* sp., which is controllable at higher elevations but eventually killed 25 transplants at sea level.

Strawberries typically decline after the first year or two of production, due to excessively heavy crown formation and build-up of nematodes. Solutions are to periodically import new stock plants, move the production area, mulch heavily to discourage nematodes, or apply nematicides regularly.

Grapes have a successful history of culture in the tropics. Their flower buds are initiated in the mature wood of the current season's growth. Flowers appear when new shoots arise from axillary buds, usually

after pruning. Old, unnamed vines exist on Barbados, some fruiting on unpruned wood as the vine extends new growth. Grapes will bear twice per year. Crops are managed by pruning hardened wood, then adding fertilizer and water. Bunches may be over 30 cm. in length and weigh up to 2 kg. Berry development is small to normal. Uneven ripening is a major complaint from growers. Ethephon will be sprayed on vines this year, to assist in uniform ripening.

While good table quality fruits are grown in Barbados, the vines have not produced as well as the wine varieties. With retail prices of US \$8.00 per pound, any successful producer of table grapes will stimulate increased plantings.

Successful cultivars include Cardinal, a red grape grown in Barbados for over 100 years. Pink Chardonnay, Pinot Noir, and the Puerto Rican cultivar Fortuna Blanca have all grown well. Thompson seedless and Ribier have been prone to diseases and lacked vigor.

The "Anna", a 150 hour apple bred in Israel, and the "Dorsett Golden" a 150 hour apple found in the Bahamas, were introduced into Barbados. Both are reported to be self-unfertilized under Florida's spring conditions (Dr. Sherman, personal communication). Both exhibited erratic midsummer bloom and subsequent fruit set during rains following early summer drought.

Introduced apple trees have flowered in all parishes of Barbados. Flowering is most often associated with water induced growth following drought, usually in May or June. Fruit set is moderate to excellent, with all 15 trees in one 2 year planting setting from 10 to 35 fruit each. Leaf stripping increases flower bud formation and improves uniform bud break.

Fruits are concentrated on terminal growth and often occur in clusters. Fruits are rather small at sea level, but have been nearly normal sized (2 to 2½ ins.) in diameter when grown at 600 ft. + elevation. Parthenocarpy is common on single trees, normal color is achieved, and the flavour is excellent.

Full sun and wind protection are necessary. Occasional pests such as scale, mite and aphid infestation have been observed and controlled. Powdery mildew, fireblight, *Sclerotia rolfsii*, and *Cercospora* sp. leafspots are encountered.

The loquat (*Eriobotria japonica*) originated in south east China. It is now a very successful commercial crop in Israel and is grown around the world. There are numerous cultivars from Japan, California, India and Israel which ripen from April to June.

Isolated seedling trees found in Barbados were observed fruiting. One tree at about 150 meters elevation bore fruit every year, according to the owners. The fruits were small but tasty, and the seeds germinated normally.

"Champagne" and "Golden Nugget" cultivars were introduced along with about 300 seeds. These trees flowered and fruited within 2 years of grafting. After moving Champagne by itself to sea level, it flowers year round and only occasionally sets small, seedless fruit. Knight reported that Champagne is self-infertile (4).

Fruit set on all trees tends to take place in January or February, which coincides with Barbados' cool season. It is likely that individuals exist that will set fruit at slightly higher temperatures, allowing for production at lower altitudes than is presently possible.

Thinning has not been necessary, as is practiced in loquat producing areas. Barbados has no *Anastrepha* sp. fruitflies, an important production consideration.

Upper elevation plantings show promise to supply year round fruit for both local and markets created and maintained by other producers. Selection of locally adapted varieties is advisable.

Most blueberries need their full chilling requirement for optimum fruit set (5), but the chilling requirement varies among cultivars (6). Aliceblue and Beckyblue, two recently released rabbiteye/northern high bush hybrid blueberries, were grown in containers. Blueberries require very acid soil (pH 4.5), which is scarce in Barbados. Normal appearing flowering and ripening occurred one year after introduction. The bushes eventually declined after becoming chlorotic and losing all vigor.

Another cultivar, Sharpblue, has been found to be a good producer in Homestead, Florida, where they grow as evergreens. It would be appropriate to run field tests on some acid volcanic soils before coming to any conclusions regarding the adaptability of blueberries to the tropics.

Peaches vary considerably in their chilling requirements and in their genotype response when grown in a variety of locations and climates (11). This variability suggests that tropical peaches should be achievable.

Early introductions into Barbados have flowered and fruited, though none as well as hoped. The cultivar which was expected to flower the best, since it sets bloom very early in the Florida growing season (warm temperatures, not strongly short day sensitive) has grown well, flowered, but not fruited. As this cultivar (Flordagold) requires 350 hours of chilling, perhaps a longer dry spell will increase the number of blooms.

Okinawa, a 50 hour peach, has had little difficulty in growing or flowering. As their age increases, and given a long dry spell, it is expected that fruit production will increase. More selection will have to be practiced before an overall acceptable variety is found.

Results and Discussion

Markets do exist for the above mentioned fruits. The change in food habits, the increasing tourist trade, and the increased pressure on agricultural self-sufficiency will all stimulate interest in temperate crops. For the farmer, the high prices people are willing to pay for "imported" fruits are a definite incentive towards production. Strawberries, loquats, and grapes show the most potential for economic gain.

Strawberries will grow and fruit well under good horticultural conditions. The fruit has a high demand and high value. Florida Belle is an excellent (though small compared to the California cultivars) fruit, adapted to warmer conditions than more northern cultivars, and readily available. Small-scale plantings have been successful, but farmers are reluctant to provide all of the cultural requirements necessary for top production. These include thorough soil preparation, fumigation or nematode treatments if the soil is "old", irrigation, mulch, and training for their laborers.

Loquats should prove excellent fruits when grown above 500 meters. New, high yielding Israeli cultivars should be imported. A one to two acre trial planting at the appropriate elevation should be started. This crop will soon be grown in Martinique.

Grapes are popular, adaptable, and have had some experience in the tropics. Their production constraints are minimal. Each of the islands should begin planting some of the local vines and import new vines to establish the basis for future expansion.

Apples are a novelty, but are surprisingly easy to grow. The breeding is rather complex, so the future for them is limited by funding.

Peaches and blueberries have proven to be the most difficult to adapt to the tropical conditions. It is expected that peaches will eventually be manipulated to fruit heavily. Blueberries are marginal at best, as their chilling mechanism appears rigid.

Flowering is a hormonally controlled response of plant tissues to external stimuli. There are complex induction and feedback mechanisms, often involving minute quantities of bio-active gibberelins, auxins, abscissic acid, and the yet undetermined florigen (9). The diversity of plants and their sometimes contradictory reactions further complicates the physiologists' work.

While refraining from bio-chemical rationalization and verification, it is important to try to understand the effect of inputs on the flowering system of fruiting plants.

Cold or drought stress are both effective in slowing vegetative growth and putting the plant in a dormant or semi-dormant state. Cold weather directly affects the scion by slowing the growth process. Drought indirectly affects the scion by slowing root growth. Drought effects will be more difficult to measure accurately.

Drought stress occurs above a presently undetermined soil moisture tension value measurable with soil tensiometers. Added water may tend to reverse the effects of drought on flower bud formation much the same way that warmth affects chilling requirements. With current low-chill apple cultivars, low soil moisture conditions for periods of about six to eight weeks appear to be sufficient to set bloom buds. When no chilling occurs, yet trees grow, flower, and fruit within normal limits, it can be assumed that the plant has effectively substituted for chilling.

Through the process of dormancy, whether slight or pronounced, the internal hormonal reactions shift towards flowering response. The longer the reaction continues, the more dramatic its results. Flowering response is characterized by short or complete lack of internodal growth, the accumulation of carbohydrates in stem tissues, the near cessation of root growth, and the initiation of differentiated flowering tissues, often manifested by enlargement of flowering buds.

The application of paclobutrazol, a powerful GA synthesis inhibitor, has resulted in less vegetative growth, better flowering and higher yields (7). It appears to be effective in shifting the growth/flower reaction towards flowering.

The dormant plant is now ready for the environmental stimulation (warmth or water) necessary for the flowers to complete their development and open.

This reaction is effected by auxin levels. Trees with heavy fruit set are not likely to flower until the fruit is removed. Leaves, especially young growing terminals, produce auxins, which when translocated through the phloem tissue inhibit axillary bud sprouts. Likewise, heavy fruit set inhibits vegetative growth, and especially axillary buds. When the growing terminal is cut, or fruit removed, axillary buds sprout. On some heavy flowering tropicals, these

axillary buds often contain flowers.

It may be that high auxin levels interfere with the GA/flowering hormone equilibrium process and inhibit both reactions. Low auxin levels may allow the reaction to proceed, with a bias towards the flowering reaction.

Chilling may be an evolved practice for cold climate plants. It may be a specialized form of the hormonal flowering cycle common to all plants, that, while critical in its "native" environment, becomes superfluous in a new environment.

Considering an admittedly small number of plants, those with the greatest heterozygosity (apples, grapes, strawberries) appear most adaptable. It is hoped that by further simultaneous study of both tropical and temperate fruits, some leads into the physiology of flowering will surface.

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