Abstract

Consumers in the Virgin Islands have a preference for large papaya fruits in the range of 1 kg. The large fruited papaya varieties however, tend to have undesirable characteristics as lower fruit number per plant, lower percentage total soluble solid (sweetness) and lack firmness which makes them susceptible to damage during harvest and marketing. Through breeding and selection, $F_1$ hybrid papayas have been developed. The inbred lines chosen that developed $F_1$ hybrids with commercial potential were the combination: '356-3' and 'Califlora'; 'Cariflora' and 'Solo Sunrise'; 'Puerto Rico Dwarf' and 'Yeun Nong 1'. Plant characteristics that were evaluated include production of fruit starting within 1 meter from the soil surface, stem diameter to tolerate winds fruit set, as well as tolerance to both papaya ringspot virus and high pH soils. Evaluation of fruit quality included fruit weight, length, width, flesh thickness and sugar content.

Papaya Review

Demand for locally produced papaya fruit (Carica papaya) far out weighs the supply in the U.S. Virgin Islands. Observation of local consumers in the Virgin Islands at the farmers' market and UVI sponsored production workshops have indicated a preference for papaya fruits in the range of 1 kg. The larger papayas are the first to be selected and purchased leaving behind the 400-600 g fruit. The large fruit papayas however, tend to have undesirable characteristics as lower fruit number per plant, lower percentage total soluble solid (sweetness) and lack firmness (Subhadrabandhu et al., 1989). The need exists in the Virgin Islands for large fruited papayas with early production to ensure a marketable crop.
The commercial export varieties of papayas produce fruit of about 400 g. Great effort has gone into developing the multiple small fruited 'Solo lines' of papaya, which are the standard in the export market (Subhadrabandhu and Nontaswatsri, 1997). The preference for fruit size varies for different regions of the world. While the Asian Pacific Region prefers the smaller export size fruit, the Caribbean and Mexican region tend to select the larger fruits above 1 kg (Nakasone and Paull, 1998). Papaya is a popular tropical fruit that is produced on herbaceous trees grown from seed.

Three floral plant forms in papaya occur, pistillate (female), staminate (male) and hermaphroditic (bisexual flowers with both male and female parts) (Storey, 1972). Plants with pistillate and bisexual flowers produce fruit. Pistillate flowers pollinated by staminate flowers, produce seeds of plants that will be 50% pistillate and 50% staminate while pollination by hermaphroditic flowers results in 50% pistillate and 50% bisexual plants. Bisexual flowers either self pollinated or crossed with other hermaphrodites will result in 33% female and 67% bisexual plants. However, bisexual flowers pollinated by staminate flowers produce 33% staminate, 33% pistillate and 33% bisexual plants (Mekako and Nakasone, 1975). Papayas naturally outcross via wind and insects. Protecting flowers before opening and controlled hand pollinations are required to ensure cultivar purity. Seed collection from open pollinated plants results in loss of varietal integrity and unknown fruit production and quality (Zimmerman et al., 1997b).

Recent work has indicated positive results from the development of F₁ hybrids for papayas (Chan, 1992). Subramanyan and Iyer (1984) was able to improve papaya yields by more than 100% in some hybrid combinations. For open-pollinated, dioecious varieties, the possibility of exploitation of heterosis
is also being investigated. Inbreds have also been developed for male lines through innovative methods of selection and of self-pollinated ambivalent male papaya plants (Aquilizan, 1986). F<sub>1</sub> produced these inbreds showed striking heterotic responses.

Breeding and selection of papayas has been ongoing for 7 years at University of the Virgin Islands (Zimmerman, et al. 1997). The breeding systems have used the methods outlined by Aquilizan (1987) for developing stable pistillate and bisexual papaya lines. The height at first fruit set, of papaya cultivars recommended for the Virgin Islands, ranges from 58 cm to 253 cm (Kowalski and Zimmerman, 1998; Zimmerman and Kowalski, 1999). Through progeny testing and selection distinct lines have been developed with fruit production starting at or less than 1 m from the ground. Generally, pistillate plants start setting fruit lower on the stem than hermaphroditic plants. Through breeding and selection, three papaya lines (two pistillate and one bisexual) have been developed which set fruit between 37 and 67 cm from the ground (Figure 1,2) (Zimmerman and Kowalski, 1999; Zimmerman 2000). These low to the ground early bearing selected lines have fruits ranging in size from 0.45 to 0.7 kg and soluble solids of at least 13% brix. The early selected papaya lines have floral development initiated within three months from seeding and mature fruit are harvested within nine months from seed germination. Seed germination and plant emergence are enhanced by a presowing seed priming treatment (Zimmerman, 1994a; 1994b).

These early bearing papaya lines produce fruit that are marketable one month earlier than other cultivars. This is a great advantage to growers in the hurricane-plagued Caribbean to be able to establish plants during the rainy season (Sept.-Nov.) and have mature harvestable fruit prior to the
hurricane season (Aug.-Oct.). Our research has indicated that during the first year of growth, the papayas with the early low bearing fruit have a lower center of gravity on the stem and are more resistant to stem breakage in tropical storm force and light hurricane force winds than varieties that start setting fruit above 1.7 m.

The selected inbred large fruited lines have the first fruit set between 1.13 and 1.28 m from the ground with fruits from 1.0 to 1.6 kg (Zimmerman, 2000). Though these large fruited line have flesh 2.6 to 2.8 cm thick the total soluble solids only range between 10.3 to 11.6% brix. The large fruited lines and early bearing lines will be crossed *inter se* to generate the F_1 progeny.

Objective 1. develop F_1 hybrid papaya from crossing large fruited inbred lines with early, low to the ground inbred lines.

Controlled cross pollinations will be used to develop F_1 hybrids with improved characteristics. Reciprocal crosses will be made between the selected low bearing papaya lines and the large fruited papaya lines. Flowers of pistillate plants will be bagged prior to opening to prevent uncontrolled pollination. Bisexual flowers will be emasculated prior to anthesis and bagged. Bagged flowers will be hand-pollinated at anthesis and labeled. At maturity, tagged fruits containing the F_1 hybrid seed will be harvested and the seeds washed, clean and dried.

Objective 2. Evaluate the F_1 papaya hybrids for production and fruit characteristics. F_1 hybrid progeny will be field grown with 2 x 2.5 m spacing with straw mulch and drip irrigation. A randomized block design will be used with three replications of ten plants per block. The characteristics on which data will
be collected include: days to first flower, height of first flower, circumference of trunk at one meter, height of first fruit, number of fruits per plant, fruit weight, fruit length, fruit width, thickness of flesh, total soluble solids and mass of seeds per fruit. These characteristics will be used to determine general combining abilities and significant specific combining abilities based on calculations according to Griffing's Method 1, Model 1 (Griffing, 1956; Allard, 1960).

Literature Review

Aquilizan, F.A. 1987. Breeding systems for fixing stable papaya inbred lines with breeding potential for


