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Breeding for Cold Tolerance in Papaya (*Carica papaya* L.) Through Hybridization

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Abstract: Crossing was undertaken using papaya variety CO 2 (*Carica papaya*), as female and mountain papaya (*Carica candamarcensis*), as male. Their F_1 and F_2 progenies were evaluated for tolerance to cold. The mean performance of F_1 progenies for plant height, petiole length, leaf area and number of leaves at first flowering, average fruit weight, fruit number, fruit length, fruit circumference, fruit volume, cavity volume, pulp thickness, TSS and fruit yield per tree were found to be lower than the better parent CO 2. Variability was observed in F_2 population for the morphological, physiological and biochemical characters. Clustering analysis with KMEANS joining algorithm was also performed to narrow down the F_2 population and found that genotypes G 15, G 22 and G 27 were found to be different from the rest.

Key words: Papaya variety *CO 2, Carica papaya, Carica candamarcensis, F_1 and F_2 progenies, KMEANS joining algorithm*

INTRODUCTION

Papaya (*Carica papaya* L.) is one of the important tropical fruit crops. The fruits are rich in vitamin 'A' (2020 IU) and vitamin C (46 g). Latex is extracted from unripe papaya, which has many pharmaceutical and cosmetic applications. Papaya cultivation has many hurdles like dioecious nature, susceptibility to water logging, low temperature, papaya ring spot virus (PRSV) and leaf curl virus. Among the various problems, low temperature is one of the most important environmental factors, which affect the plant growth and productivity. Hence this study was undertaken, with the objectives of to introgress cold tolerance gene into cultivated type and to develop a cold tolerant gynodioecious papaya for table purpose.

MATERIALS AND METHODS

Research was carried out at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2003-2006 to develop a cold tolerant gynodioecious papaya line. The dioecious variety of papaya CO 2 was crossed with its wild relative *carica candamarcensis.* Seeds were collected from the crossed fruits and sown in nursery for raising F_1 population. A total of 107 seedlings were raised in F_1. Among the total population, 52 hermaphrodite and 55 female plants were observed.

Morphological, yield and quality characters were recorded in F_1 population. In F_1 hermaphrodite plants were given importance because of difficulties in maintaining purity in female plants through crossing. Best performed progenies based on morphological, yield and quality characters were selected and selfed. The F_2 population was raised at Horticultural Research Station, Thadiyankudisai, at a higher elevation of 1100 m MSL. In F_2 population, morphological characters were recorded at 9^{th} month after planting. Samples were collected from all the F_2 plants and physiological and biochemical characters related to cold tolerance were analyzed.

RESULTS AND DISCUSSIONS

The mean values of F_1 hermaphrodite plants for morphological characters were given in Table 1. The mean value of hermaphrodite F_1 plants was lower than the parents and this is a desirable character with regard to papaya. First bearing height and plant stem girth at first flowering had higher mean values than the parents. The other morphological characters including yield attributes were having lower mean values than the parents. This might be due to the wild male parent *carica candamarcensis*. Mean value is used as a primary criterion for selection in F_1 population. From the F_1 population based on higher mean values, eight elite hermaphrodite plants were selected and forwarded to F_2 population.

In general morphological characters were lower than F_1 population and parents. Generally low temperature delays the growth and development of plants. This might be the possible reason for low mean values of morphological characters in F_2 population. Leaf samples were collected from all the F_2 plants and physiological and biochemical characters

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Table 1: Mean performance of parents and progenies for morphological characters

Sl.No.	Characters	CO2	*carica candamarcensis*	Hermaphrodite F_1 plants
1.	Plant height at first flowering (cm)	172.15	305.00	167.12
2.	First bearing height (cm)	127.50	280.00	146.83
3.	Plant stem girth at first flowering (cm)	20.50	24.00	21.45
4.	Length of petiole at first flowering (cm^2)	62.42	54.00	54.72
5.	Leaf area of first flowering (cm^2)	2306.0	1152.00	2128.19
6.	Number of leaves at first flowering	27.60	35.00	16.71
7.	Fruit length (cm)	24.10	12.00	21.46
8.	Fruit circumference (cm)	47.50	17.50	37.54
9.	Fruit volume (ml)	2812.3	160.00	1672.69
10.	Cavity volume (ml)	508.35	13.00	289.80
11.	Cavity index (per cent)	18.07	8.13	17.45
12.	Pulp thickness (cm)	3.00	1.00	2.44
13.	TSS (°brix)	12.20	6.00	11.38
14.	Average fruit weight (kg)	1.95	0.12	1.29
15.	Number of fruits per tree	80.60	51.00	65.62
16.	Fruit yield per tree	172.26	4.44	85.98

Table 2: Performance of F_2 progenies for yield parameters

Sl.No.	Genotypes	Fruit bearing height (cm)	Number fruit per tree (kg)	Average fruit weight (kg)	Fruit yield (kg)	Pulp thickness (cm)	TSS °brix
1.	G15	138.00	11	0.290	3.190	2.60	11.0
2.	G22	165.00	7	0.645	4.515	2.90	9.20
3.	G27	172.00	12	0.910	10.92	3.00	1.0

were analyzed at 3rd, 9th and 12th month after planting. Under environmental stresses such as low temperature, plants produce anti-oxidant enzymes like peroxidase and catalase. These enzymes detoxify the effect of reactive oxygen compounds which are produced in plants during stress. In the present study, increasing trend was observed with increase in age of the plant. Among 62 genotypes studied in F_2, G22 exhibited he highest peroxidase activity followed by G35, G27 and G15.

Chlorophyll plays a major role in plant productivity. In higher plants, chlorophyll consists of chlorophyll 'a', 'b', 'c','d' and 'e'. In these studies, total chlorophyll, chlorophyll 'a' and 'b' were analyzed. Among the genotypes studied, G 49 had the maximum chlorophyll content and G 9 was the best with regard to chlorophyll 'a' and 'b'. Increase in soluble proteins at low temperature was reported [4]. Dehydrin proteins are induced in plants by environmental stress such as low temperature. The function of dehydrin is the preservation of structural integrity of cells [1]. Among the genotypes studied in F_2, G12, G32 and G52 were found to have high soluble protein content. During thermal stress accumulation of phenol was reported [5]. This could be considered as acclimatization mechanism of the plant against thermal stress. The genotype G22 had the maximum phenol content in all the stages of plant growth. Assessing membrane stability of plants by measuring electrolyte leakage is a reliable screening technique for cold tolerance [2]. In the present study, G 22 had the lowest electrolyte leakage among all the genotypes. Lowest electrolyte leakage is beneficial, as it relates with more membrane stability.

Flowering was delayed in F_2 population, because of low temperature prevailing at Horticultural Research Station, Thadiyankudisai. Out of 62, 41 genotypes flowered among which 26 were hermaphrodite and 15 were female plants. Fruits attained harvestable maturity after 14th month of planting, only in three genotypes viz., G15, G22 and G27. Fruits were harvested and quality parameters were recorded and presented in Table 2.

These morphological, physiological and biochemical characters were subjected to cluster analysis with KMEANS joining algorithm [3]. Clustering procedure was run thrice to get 2, 3 and 5 groups. Among all the clustering, the genotype G22 was placed in the best performed cluster, cluster 3 and G27 was in the next best cluster, G15 genotype was placed in the poorest performed cluster in all the three types clustering. But the genotype had low mean value for plant height and electrolyte leakage which are more relevant to the present study. From the study it was concluded that, the genotypes G15, G22 and G27 could be forwarded to F_3 generation for further evaluation and development of a cold tolerant papaya line.

Conclusion: The study revealed that the mean performance of F_1 progenies for plant height at first flowering, petiole length at first flowering, leaf area at first flowering, number of leaves at first flowering, average fruit weight, fruit number, fruit length, fruit circumference, fruit volume, cavity volume, pulp thickness, TSS and fruit yield per tree were found to be lower than the better parent CO 2. Variability was observed in F_2 population for the morphological, physiological and biochemical characters. Clustering analysis with KMEANS joining algorithm was also performed to narrow down the F_2 population and found that he genotypes G 15, G 22 and G 27 were found to be different from the rest.

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