Flowering, Fruit Set, and Fruit Development in Birdestype Muskmelons

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Abstract. The birdestype plant type in muskmelon (Cucumis melo L. var. reticulatus Naud.) is characterized by short internodes, weak apical dominance, and concentrated yield. Flowering, fruit set, and fruit development in a birdestype were examined and compared with those characters in a vine-type muskmelon to understand how the concentration of yield is achieved. A muskmelon breeding line with the birdestype habit, D26, was compared with 'Noy Yizre'el (NY), a vine-type cultivar. Results of a greenhouse and field study indicated that the two genotypes had similar patterns of perfect flowering; however, D26 set a greater number of fruit than NY. The pattern of fruit set and fruit maturity (yield) was more concentrated in D26 than in NY. First-set fruit had an inhibitory influence on the development of later-set fruit in NY, but this effect was not apparent with D26. NY fruit were larger in size and had higher soluble solids than D26 fruit. The concentrated fruit set and yield of birdestype plants suggests a more equal partitioning of assimilates to young, developing fruit than in vine-type plants.

Most cultivars of muskmelon are andromonecious, and flower and set fruit over a period of several weeks (7, 16). Fruiting usually occurs in cycles, with first-set fruit exerting a strong inhibitory influence on the development of later-set fruit (5). A cyclic pattern of fruit production results from this cyclic pattern of fruit set, as the time from anthesis to full-slip is fairly constant (7). A more concentrated pattern of fruit production would be desirable in muskmelon so that the harvest period could be concentrated. In contrast to cucumber, attempts to improve the concentration of yield is achieved. A muskmelon breeding line with the birdestype habit, D26, was compared with 'Noy Yizre'el (NY), a vine-type cultivar. Results of a greenhouse and field study indicated that the two genotypes had similar patterns of perfect flowering; however, D26 set a greater number of fruit than NY. The pattern of fruit set and fruit maturity (yield) was more concentrated in D26 than in NY. First-set fruit had an inhibitory influence on the development of later-set fruit in NY, but this effect was not apparent with D26. NY fruit were larger in size and had higher soluble solids than D26 fruit. The concentrated fruit set and yield of birdestype plants suggests a more equal partitioning of assimilates to young, developing fruit than in vine-type plants.

Materials and Methods

'Noy Yizre'el' (NY) is a high-quality muskmelon of the 'Ha'Ogen' type (3). D26 is a BC3F3 muskmelon breeding line of the birdestype developed by the backcross-pedigree method. The donor parent of D26 was P202 and the recurrent parent was the male parent of the 'Galil' hybrid.

A greenhouse study was conducted Jan. through Apr. 1984 to compare NY and D26. Seeds were planted in a 3 perlite : 2 peatlite mix in 12-liter black plastic pots. There were six single plant replicates per genotype in a paired design. Plants were fertilized weekly with a complete (20N–20P–20K) water-soluble fertilizer. The plants were trained on strings supported by the greenhouse structure. Perfect flowers were pollinated daily by hand using a minimum of three staminate flowers per pollination. All flowers were pollinated prior to 1200 hr. Perfect flowers were tagged with the date of anthesis. Fruit were allowed to develop to the full-slip stage of growth (time of complete abscission). Data presented are only from those fruit that reached full slip. The fruit were weighed and measured for length and diameter. Percentage of soluble solids (%SS) was determined from the juice of two 1-cm plugs from each fruit using a hand-held refractometer.

A field study was conducted between May and July 1985. Seeds were planted in peatlite mix in Speedling plant trays (200 cells/tray). Three-week-old seedlings were transplanted into the field. Prior to transplanting, the soil in the experimental area was fertilized with 6N–8P–8K (N-P2O5–K2O) at a rate of 2500 kg·ha⁻¹, and beds were formed (1.83 m on center) and covered with black polyethylene mulch. Plants were spaced 1 m apart in the bed and irrigated with overhead sprinklers. Insect and disease control was conducted according to standard cultural practices. Two hives of bees were placed adjacent to the field to ensure adequate pollination.

Perfect flowers at anthesis were tagged daily for a period of 21 days (20–40 days after transplanting) on a total of 80 plants per genotype. The plants were arranged in two blocks of 40 plants per genotype. Growth rate of fruit was observed as follows. Samples consisting of five fruit each were collected at 0, 3, 5, 7, 14, 21, 28, 35, and 42 days after anthesis and weighed. All fruit sampled were from flowers that had opened 26 days after transplanting for NY or 28 days after transplanting for D26.

In a separate group of 16 plants each for D26 and NY, perfect
Days after transplanting

Fig. 1. Distribution over time of perfect flowers (A), fruit set (B), and fruit harvest (C) in field-grown vine-type NY (●) and birdsnest D26 (○) muskmelons.

Flowers were tagged daily and the fruit harvested at maturity for determination of perfect flowering, fruit set, and yield concentration.

Fruit were counted, weighed, and measured for length and diameter. Soluble solids were determined as in the greenhouse study. Fruit age was calculated by determining the number of days between anthesis (tagging) and full slip.

Concentrations of fruit set and fruit ripening were calculated based on the following formula:

\[
\text{Concentration} = \frac{\text{day}_1 \cdot \text{number}_1 + 2(\text{day}_2 \cdot \text{number}_2) + 3(\text{day}_3 \cdot \text{number}_3) + \ldots + n(\text{day}_n \cdot \text{number}_n)}{\text{total number of fruit}}
\]

where day\(_1\) is the peak day for each respective genotype of fruit set or fruit ripening, day\(_2\) is one day removed (before or after) from the peak day, and day\(_n\) is the number of fruit set days or harvest dates removed from the peak plus one. Based on this formula, the greater the concentration of set or maturity, the lower the mean number.

Table 1. Numbers of perfect flowers and mature fruit per plant for ‘Noy Yizre’el’ vine-type and D26 birdsnest-type muskmelons under greenhouse and field conditions.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Perfect flowers</th>
<th>Mature fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Greenhouse</td>
<td>Field</td>
</tr>
<tr>
<td>NY</td>
<td>14.6</td>
<td>21.4</td>
</tr>
<tr>
<td>D26</td>
<td>22.0</td>
<td>23.4</td>
</tr>
<tr>
<td>(t)</td>
<td>5.70</td>
<td>0.24</td>
</tr>
<tr>
<td>(P^c)</td>
<td>0.010-0.001</td>
<td>NS</td>
</tr>
</tbody>
</table>

\(^c\) Differences between means were not significant (NS) or significant at the indicated level.

Table 2. Concentration of fruit set and ripening for ‘Noy Yizre’el’ vine-type and D26 birdsnest-type muskmelons under field conditions.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Fruit set</th>
<th>Fruit ripening</th>
</tr>
</thead>
<tbody>
<tr>
<td>NY</td>
<td>3.79(^c)</td>
<td>3.67</td>
</tr>
<tr>
<td>D26</td>
<td>2.45</td>
<td>2.74</td>
</tr>
<tr>
<td>(t)</td>
<td>2.98</td>
<td>2.16</td>
</tr>
<tr>
<td>(P^c)</td>
<td>0.05-0.025</td>
<td>0.05-0.025</td>
</tr>
</tbody>
</table>

\(^c\) Values are means of 16 single-plant replicates.

Table 3. Relationship between order of fruit set of the first three fruit per plant and days to maturity of ‘Noy Yizre’el’ vine-type and D26 birdsnest-type muskmelons under greenhouse and field conditions.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>(r^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NY</td>
<td>48.3</td>
<td>51.0</td>
<td>58.0</td>
<td>0.53 NS(^e)</td>
</tr>
<tr>
<td>D26</td>
<td>32.7</td>
<td>32.5</td>
<td>29.0</td>
<td>-0.12 NS</td>
</tr>
<tr>
<td>Field</td>
<td>NY</td>
<td>41.9</td>
<td>45.1</td>
<td>48.7</td>
</tr>
<tr>
<td>Field</td>
<td>D26</td>
<td>36.3</td>
<td>37.6</td>
<td>36.4</td>
</tr>
</tbody>
</table>

\(^e\) Correlation coefficients were not significant (NS) or significant (**) at the 1% level.

Fig. 2. Fresh weights of field-grown NY (●) and D26 (○) fruit at various times from anthesis to full slip. Bars indicate se and, when absent, fall under the symbol.

Results and Discussion

Under greenhouse conditions, birdsnest D26 plants produced a significantly greater number of perfect flowers than did vine-type NY plants (Table 1). Under field conditions, numbers of perfect flowers were similar between the two genotypes. D26 produced significantly more fruit per plant than NY in the greenhouse and field. The increased number of fruit per plant in the birdsnest line probably was related more to the propensity of flowers that set and developed than solely to the number of perfect flowers produced. This observation was in agreement with those reported by Nerson et al. (8) and Lippert et al. (4).

Under field conditions, the timing pattern of perfect flower opening of the two genotypes was similar (Fig. 1A). Both NY and D26 had two peak days of perfect flower opening. Interestingly, the peak days of the two genotypes coincided (29 and 33 days after transplanting). The pattern of fruit setting, however, differed considerably from the pattern of perfect flowering in both genotypes (Fig. 1B). The percentage of perfect flowers that set fruit was low for both NY and D26 (~20%). In addition, early flowers had a much greater tendency to set fruit than did late flowers in both genotypes. NY showed a cyclic pattern of fruit setting, similar to that reported by others for vine-type muskmelons (7, 14, 16), whereas D26 had a concentrated single peak of fruit set.

The more concentrated pattern of fruit setting in D26 was followed by a more concentrated fruit harvest (Fig. 1C and Table 2). The number of days over which harvesting occurred was greater than the number of days over which fruit setting occurred for both NY and D26. Part of this variation can be accounted for by the data collection technique in that flowers at anthesis were tagged daily, but fruit harvesting was conducted every other day. In addition, there was a significant relationship between the order of fruit set of the first three fruit on each plant and the time required for fruit to reach full slip for NY, but not for D26 (Table 3). Under both greenhouse and field conditions, the number of days from anthesis to full slip increased with later-set fruits of NY, but not with D26. In the greenhouse, first-set NY fruit matured in 10 days less than did 3rd-set fruits; in the field this difference was 7 days, indicating that first-set fruit in NY have a strong inhibitory effect on the development of later-set fruit. This effect does not appear to be true for D26. The inhibitory effect of first-set fruit on development of later-set fruit seems to contribute to the disperse pattern of fruit development in NY.

Greenhouse-grown fruit of NY and D26 were similar to their respective field-grown fruit except that the fruit were smaller in both genotypes (Table 4). NY fruit at full slip had a greater length and diameter and higher soluble solids content than did D26 fruit at full slip under both greenhouse and field conditions. D26 fruit required significantly fewer days to reach full slip than did NY fruit. Fruit growth was similar in the two genotypes for the first 14 days after anthesis (Fig. 2). From 21 days after anthesis to full slip, NY fruit had consistently greater fresh weight than did D26 fruits. NY fruits therefore attained larger size than those of D26, since fresh weight continued to increase until full slip.

In summary, the birdsnest-type plants differed from the vine-type plants in several factors that could influence the concentration of yield. First, although numbers of perfect flowers were similar in vine-type and birdsnest plants, the number of fruit per plant was significantly greater with birdsnest plants (Table 1). Second, in birdsnest-type plants, fruit set was more concentrated than in vine-type plants (Table 2), even though the pattern of perfect flower production was similar in the two genotypes (Fig. 1). Third, the order of fruit set had a significant influence on the number of days to full slip in vine-type, but not birdsnest-type plants (Table 3).

It has been suggested that the strong sink strength of the developing fruit may play a role in the pattern of fruit development in muskmelon (1) and in cucumber (15). The fruit of birdsnest-type plants might be weaker sinks for assimilates than fruit of vine-type plants. However, this explanation appears unlikely as one birdsnest breeding line produces larger fruit than its recurrent parent and another produces fruit of equal size and soluble solids content as its recurrent parent (10). Alternatively, birdsnest-type plants might partition assimilates more evenly among young fruit than do vine-type plants. Eventually, the heavy load of fruit set on birdsnest-type plants imposes a strong drain on the resources of the plant and leads to cessation of additional flowering and fruit set (8). Additional physiological and morphological evidence is needed in order to determine the adequacy of these explanations.

Literature Cited

7. McGlasson, W.B. and H.K. Pratt. 1963. Fruit set patterns and

Table 4. Means for five characters for mature fruit of ‘Noy Yizre’el’ vine-type and D26 birdsnest-type muskmelons grown under greenhouse and field conditions.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Fresh wt (g)</th>
<th>Length (cm)</th>
<th>Diam (cm)</th>
<th>Percentage of soluble solids</th>
<th>Days to full slip</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Greenhouse</td>
<td>Field</td>
<td>Greenhouse</td>
<td>Field</td>
<td></td>
</tr>
<tr>
<td>NY</td>
<td>724.4</td>
<td>1310.7</td>
<td>11.3</td>
<td>13.7</td>
<td>52.1</td>
</tr>
<tr>
<td>D26</td>
<td>450.5</td>
<td>945.0</td>
<td>9.4</td>
<td>11.6</td>
<td>32.9</td>
</tr>
</tbody>
</table>

*Means within columns were significantly different at the 1% level.*
Identification of *Anthurium andraeanum* Cultivars by Gel Electrophoresis

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Additional index words. isozyme, enzyme

**Abstract.** The use of gel electrophoresis of different isozyme systems was investigated as a possible tool to identify *Anthurium andraeanum* cultivars. Procedures were developed to extract active enzymes from anthurium leaves. Clear zymograms were obtained from only one of three extraction methods examined. This method consisted of grinding the leaf tissue in liquid nitrogen and then adding to the ground tissue a buffer containing a phenoloxidase inhibitor, reducing agents, and polyvinylpyrrolidone (PVPP). The identification of seven anthurium cultivars was undertaken using seven enzyme systems. Bands were observed in four of these systems; glutamate-oxaloacetate transaminase (GOT), malate dehydrogenase (MDH), peroxidase (Px), and phosphoglucose isomerase (PGI). All seven cultivars were characterized by the combined data of Px, MDH, and PGI.

*Anthurium andraeanum* is the most important cut flower crop in Hawaii. New anthurium cultivars are continually being introduced, and positive identification of cultivars is becoming more problematic. Thus far, anthurium cultivars have been identified mainly through morphological measurements and descriptions of leaves and flowers. Some cytological and biochemical studies of anthurium have been conducted, but biochemical evaluations have not included isozymes (4–6, 10). Isozyme electrophoresis has proven to be a useful tool for cultivar identification in a number of plant species (3, 8, 11, 14-16, 19). Isozyme banding patterns can be used as “fingerprints” to aid in the visual identification of cultivars (13).

The purpose of this study was to develop procedures to extract active enzymes from anthurium leaves and to examine isozyme polymorphisms for possible use in anthurium cultivar identification.

**Materials and Methods**

Seven *Anthurium andraeanum* cultivars were selected for this study, including three (‘Kaumana’, ‘Kozohara’, and ‘Nitta’) developed by growers, and four (‘Manoa Mist’, ‘Marlen See-furth’, ‘Paradise Pink’, and ‘Uniwai’) developed and released by the Univ. of Hawaii. The cultivars used in this study were grown under 78% shade at the Manoa Campus of the Univ. of Hawaii. Three extraction methods and seven enzyme systems were used to study these seven cultivars. The enzyme systems surveyed included alcohol dehydrogenase (ADH), esterase (EST), glutamate-oxaloacetate transaminase (GOT), malate dehydrogenase (MDH), peroxidase (Px), phosphoglucose isomerase (PGI), and phosphoglucomutase (PGM).

**Sample extraction.** Mature leaf samples were thoroughly washed in cold water and blotted dry. Three extraction methods evaluated were: a) maceration of tissue with a mortar and pestle in 0.2 M phosphate buffer, pH 7.0, at room temperature; b) grinding of tissue frozen in liquid nitrogen (LN), followed by the addition of a 0.2 M phosphate buffer to make a coarse slurry; and c) method 2, using a 0.05 M Tris buffer containing 0.2 M sucrose, 0.002 M diethyl dithiocarbamic acid, 0.02% β-mercaptoethanol, and polyvinylpyrrolidone (PVPP). The pH was adjusted to 7.3 before adding the mercaptoethanol and PVPP.

Samples extracted by the first two methods were absorbed onto Beckman filter paper wicks. Lens paper was placed between the wick and the macerate to avoid uptake of fibrous residue. Extracts produced by the 3rd method were centrifuged at 32,000 × g for 20 min. The clear supernatant was collected and absorbed onto filter paper wicks for immediate use or frozen in LN and stored in vials at −10°C.

**Gel preparation.** Two types of gels were prepared for horizontal electrophoresis. Six percent polyacrylamide was used to evaluate the peroxidase system, and 12% starch was used for all other enzyme systems surveyed. Polyacrylamide gels were prepared following methods described by Brewbaker et al. (2). Gels were immediately poured


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