normal. F_1 plants were readily backcrossed to PI 140471, but repeated attempts to backcross to *C. metuliferus* failed except for 1 plant grown from embryo culture. The cross was not repeated via standard pollination procedures. Deakin et al. (1) employed special techniques but failed to hybridize PI 140471 and *C. metuliferus*. However, Fassuliotis (3) reported that cross fertilization occurred when *C. metuliferus* was treated with *C. melo* pollen. Partial compatibility between the 2 species was indicated by a small percentage of *C. metuliferus* ovules being fertilized by *C. melo* pollen tubes. High fertility of the F_1 and its compatibility with *C. melo* may be due to the possible close evolutionary relationship of the two species.

Flower studies. All PI 140471 and *C. metuliferus* plants studied were monoecious. Of 250 F_2 plants, 178 were monoecious and 72 were unexpectedly andromonoecious.

Results of this study confirm that a cross of *C. melo* (PI 140471) × *C. metuliferus* (PI 292190) was made since:

1. The lobed leaf character which occurred in *C. metuliferus* and the F_1 progeny.
2. The similarity in structure of the trichomes of *C. metuliferus* and the F_1 progeny.
3. Recovery of the *C. metuliferus* type fruit in the F_2 progeny.
4. Seed surface of the F_1 exhibited netting and pubescence from *C. metuliferus* and ribbing from *C. melo.*
5. Resistance to *Meloidogyne incognita acrita* was recovered in the progeny from the cross (5).

Unexpected characteristics of the cross were: larger fruit in F_1 and F_2 populations than from either parent; ribbing and netting of fruit of some of the F_2 progeny; andromonoecious flowers occurring in the F_2 but in neither parent; and high fertility of the F_1 progeny.

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Response of Progeny from Interspecific Cross of *Cucumis melo* x *C. metuliferus* to *Meloidogyne incognita acrita*

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Additional index words. African horned cucumber, cantaloupe, root-knot nematode

Abstract. **Progeny from a hybridization of *C. melo* L. (PI 140471), a feral *Cucumis melo*, with the nematode-resistant African horned cucumber (*C. metuliferus* E. Mey.) (PI 292190) were screened for resistance to *Meloidogyne incognita acrita* Chitwood. Although *C. metuliferus* exhibited resistance, no resistance was observed in PI 140471 nor in the F_2 generation after inoculation with a larval suspension having 600 larvae/ml. However, when grown in contact with chopped galled roots, certain progeny appeared to be resistant. Evaluation of egg mass production revealed that the resistant plants produced significantly fewer eggs than susceptible plants.**

The African horned cucumber possesses genes for resistance or tolerance to *Meloidogyne incognita acrita* (1). Norton (8) reported hybridizing PI 140471, a feral *C. melo,* with *C. metuliferus* (PI 292190) in the greenhouse. Since PI 140471 crosses readily with muskmelon, it has been suggested that the hybrid would make it practical for breeders to develop root-knot resistant cultivars (4). The objective of this study was to evaluate the progeny from the cross for resistance to *M. incognita acrita.* Additional characteristics of the progeny are discussed in a separate publication (9).

Materials and Methods

Cucumis melo (PI 140471), a small, smooth fruited, wild type plant which crosses readily with *C. melo* cultivars, was selected as the seed parent (Fig. 1). A homozygous line was developed through repeated selfing of this monoecious selection of *C. melo. C. metuliferus,* a spiny-fruited plant which possesses resistance to *M. incognita acrita,* was utilized as the pollen parent (Fig. 2). No variation was observed in repeated plantings of this selection of *C. metuliferus.* Nematode resistance was determined by three methods: larvae suspension, chopped galled roots and nematode egg procedure.

Nematode larvae suspension procedure. Mist-incubation and the "Scottie" filter technique (11) was used to collect *M. incognita acrita* from roots of 'Rutgers' tomato (*Lycopersicon esculentum* Mill.). Standardized suspensions of second stage larvae were used as inocula. Screening tests involved 120 F_2 plants (24 plants from each of the 5 F_1 types), and 10 plants

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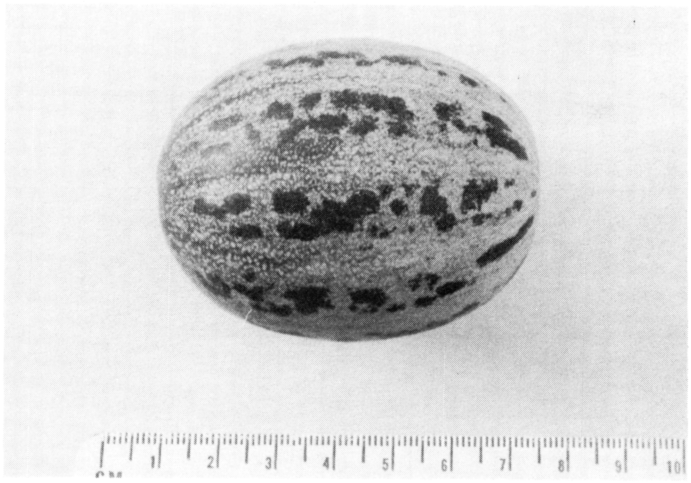

Fig. 1. *Cucumis melo* (PI 140471).

each of *C. metuliferus,* PI 140471, and 'Rutgers' tomato (nematode virulence check).

At the first leaf stage, 10 ml of an aqueous suspension containing 600 root-knot larvae/ml were distributed over the soil surface around the stem of each plant. Thirty days after inoculation roots were gently washed and rated for root-knot symptoms using a 0-5 index: 0 = no galls, no stem reaction; 1 = stem reaction only; 2 = few small galls and no stem reaction; 3 = few small galls and stem reaction; 4 = many prominent galls and few gall masses; 5 = many prominent galls and many gall masses. Ratings 4 and 5 designated susceptible plants.

Chopped galled roots procedure. Heavily galled tomato roots were detached washed, chopped into 1-3 cm segments, and uniformly incorporated into a 1 sandy loam soil: 1 peat mix that had been steam sterilized. This mixture was then placed in standard greenhouse flats to a depth of 10 cm. Immediately afterward, 7.6 cm peat cups containing steam sterilized soil mix and a single plant of either *C. metuliferus,* PI 140471, F_1, F_1 × *C. metuliferus,* F_1 × PI 140471, F_2, F_3, 'Southland' or 'Chilton' were placed in the flats on top of the infested soil. Forty plants of each cultivar, parent, or progeny were included in the test. Within 3 to 5 days, roots had grown through the peat cups and penetrated the infested soil.

After 30 days, protruding roots were washed free of the soil-chopped roots mixture and rated for root-knot symptoms

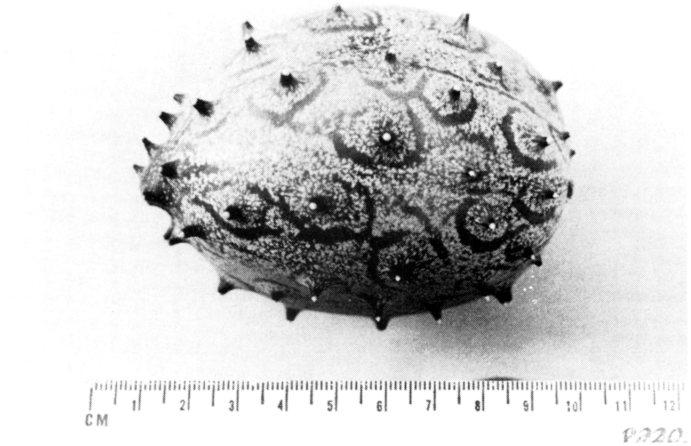

Fig. 2. *Cucumis metuliferus* (PI 292190).

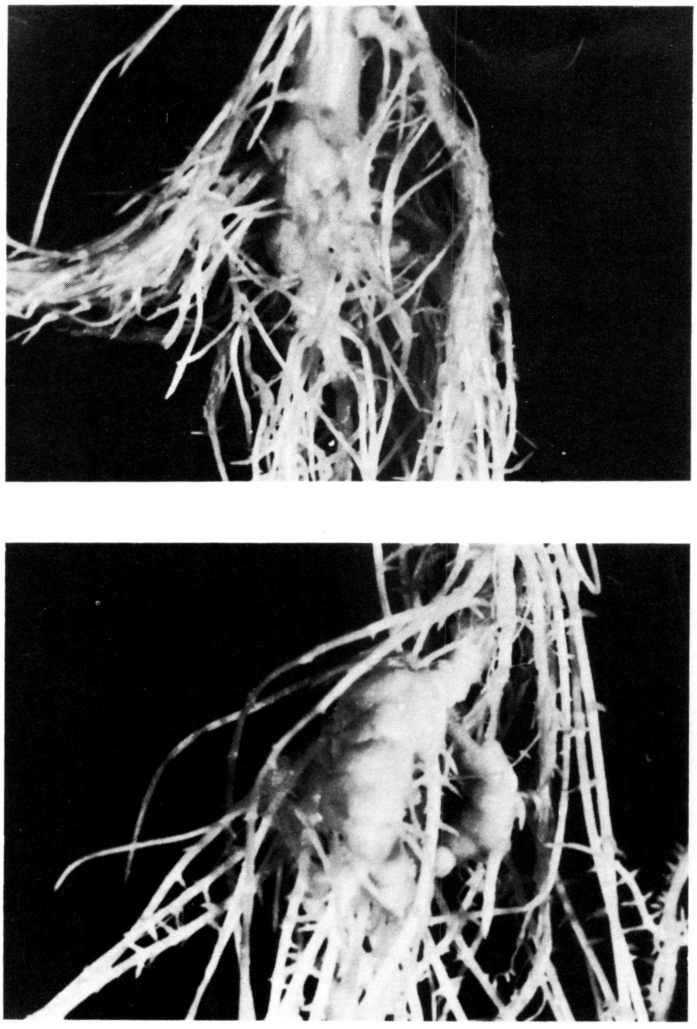

Fig. 3. Nematode injury: (top) Stem-reaction or stem-galling on *C. metuliferus.* (bottom) Root-galling on *C. melo* from nematode injury.

using a 0 – 5 index; 0 = no galls; 1 = few small galls with the majority of roots gall free; 2 = one to 50% of roots heavily knotted with no roots greatly enlarged; 3 = over 50% of roots heavily knotted with no roots greatly enlarged; 4 = one to 50% of roots greatly enlarged, others heavily knotted; and 5 = more than 50% of the roots greatly enlarged. Ratings 0, 1, and 2 designated resistant plants whereas 3, 4, and 5 designated susceptible plants.

Nematode egg procedure. A modification of the Shepherd's Method (12) was utilized to produce root-knot nematode galls and eggs on test plants. Plastic pots (7.6 × 7.0 cm) were filled with screened, methyl bromide-fumigated, dry loamy fine sand of pH 6.0 to 6.5. The soil was wet 24 hr before use. Pots were recessed in soil in greenhouse benches to avoid rapid temperature fluctuations. A 4-ml aliquot of 8,000 root-knot nematode eggs in the single strength Heller's solution described by Loewenberg (7) was deposited into holes 2 cm deep in the center of each pot. The eggs were then covered with severed, dry soil which was wet immediately. Eggs for inoculum were produced on Southland which was grown in every tenth row of each test.

To allow egg hatching, pots were covered for 7 days with a layer of plastic (6 ml) overlaid with a layer of paper, and 50% shading was placed about 30 cm above the paper. The plastic prevented excessive soil drying and the paper and shade prevented excessive soil temperature.

Table 1. Distribution of plants of *Cucumis metuliferus*, PI 140471, F_2, and 'Rutgers' tomato to root-knot nematode.

Entry	Distribution: Root knot galling index[z] 0	1	2	3	4	5	Total plants
C. metuliferus	–	2	–	8	–	–	10
PI 140471	–	–	–	–	3	7	10
F_2 (*C. metuliferus* × PI 140471)	–	–	–	–	42	78	120
'Rutgers' tomato	–	–	–	–	8	2	10

[z]Gall index: 0 = no galls; 1 = few small galls with the majority of roots gall free; 2 = one to 50% of roots heavily knotted with no roots greatly enlarged; 3 = over 50% of roots heavily knotted with no roots greatly enlarged; 4 = one to 50% of roots greatly enlarged, others heavily knotted; 5 = more than 50% of the roots greatly enlarged.

Seeds were planted in sand that had been passed through as a 1.5 mm mesh screen. After emergence and cotyledon expansion, but before lateral root formation, seedlings were removed from the sand with radicles intact. Radicle tips were excised 5.5 cm below the hypocotyl-radicle junction the permit transplanting to normal depth into the pots of soil. A seedling was transplanted into the center of each pot and maintained under 50% shade for 3 days after transplanting. Greenhouse temperature was maintained at 25–35°C.

Forty days after transplanting, root-soil balls 1 replicate at a time were removed from the pots and transferred into a 3.2 cm mesh wire basket that fit inside 18.9 liter containers. Root-soil balls were then immersed in water.

An egg-mass count and root-knot index were determined concurrently on individual plant roots viewed under a binocular microscope with 7 × magnification. The root-knot index scale used was the same as that reported by Shepherd (12).

To collect root-knot nematode eggs, infested roots were excised from stems, drained of excess water, pressed to uniform dryness, and weighed. The method utilized by Shepherd (12) for dispersing eggs with NaOCl, a modification of methods previously reported (6, 7, 13) was used for the study.

To collect eggs for inoculumn, the procedure described above was used with exceptions described by Shepherd (12), a modification of a method previously reported (6, 7, 13).

To facilitate egg counting, samples were diluted 1:10 serially until they contained between 10 and 50 eggs/ml. Eggs in three 1 ml aliquots/sample were counted under 30 × magnification with a binocular microscope, and counts were averaged. This average was used to calculate total eggs/replicate, eggs/plant, eggs/root. Egg count and root-knot index ratings were made 40 days after transplanting seedlings into pots. The test was designed as a randomized complete block with 12 plants/entry.

Table 2. Nematode ratings of PI 140471, *C. metuliferus*, F_2, backcrosses, and F_3 lives compared to Southland and Chilton muskmelon.

Entry	Distribution of plants: Gall index[z] 0	1	2	3	4	5
PI 140471[y]					31[x]	9
C. metuliferus		34	5	1		
(PI 140471 × *C. metuliferus*)F_1				1	35	4
F_2 (spotted fruit)		2	4	5	29	0
F_2 (solid green fruit)				3	28	9
F_1 × *C. metuliferus*		5	14	1	9	11
F_1 × PI 140471				6	32	2
F_3-1		2	4	5		29
F_3-2		3	2	6		29
F_3-3		2	1	6		31
F_3-4		2	2	3		33
'Southland' muskmelon						40[x]
'Chilton' muskmelon				1	27	12

[z]Gall index: 0 = no galls; 1 = few small galls with the majority of roots gall free; 2 = one to 50% of roots heavily knotted with no roots greatly enlarged; 3 = over 50% of roots heavily knotted with no roots greatly enlarged; 4 = one to 50% of roots greatly enlarged, others heavily knotted. 5 = more than 50% of the roots greatly enlarged.

[y]*C. melo*.

[x]Number of plants.

Table 3. Root galling and egg production of parents, progeny, and backcrosses of cross of *Cucumis melo* (PI 2140471) × *C. metuliferus* (PI 292190).[z]

Entry	Mean egg no/plant (× 10^3)	Mean root-knot index[y]
C. metuliferus (PI 292190)	0.3a	1.0a
C. melo (PI 140471)	38.0c	3.0d
C. melo × *C. metuliferus* F_1	37.5c	3.0d
C. melo × *C. metuliferus* F_2	24.1b	2.1c
C. melo × *C. metuliferus* F_3-1[w]	8.3a	0.7a
C. melo × *C. metuliferus* F_3-2[v]	35.6c	2.6c
C. melo × *C. metuliferus* F_4-1	7.8a	0.5a
C. melo × *C. metuliferus* F_4-2	36.5c	2.6c
(*C. melo* × *C. metuliferus* F_1) × *C. metuliferus*	1.5a	1.5b
'Southland' muskmelon	114.6d	5.0e

[z]Determined 40 days after transplanting into pots with 8,000 eggs each.

[y]Gall index: 1 = none or very light galling, 2 = light galling, 3 = moderate galling, 4 = heavy galling and 5 = very heavy galling.

[x]Mean separation in columns by Duncan's multiple range test, 5% level.

[w]Progeny from resistant plants F_3-1, Table 2.

[v]Progeny from susceptible plants F_3-2, Table 2.

Results and Discussion

By measuring egg production on the roots, *Cucumis* species, F_2 and F_3 progeny exhibited a range of levels of resistance to egg production (Table 3). Egg counts were correlated with root-knot index.

Selection of individual F_2 plants was based on egg mass counts and root-knot index when selected plants were to be replanted because egg collection procedures destroyed roots. Even among F_2 selected with lowest root-knot index and egg-mass count levels, a high percentage were susceptible based on egg counts in the F_3 progeny. This demonstrated the need for F_3 progeny testing based on egg counts for detecting lines with highest resistance.

Plants selected in F_2 showing high resistance based on egg counts in the progeny tests may be substantially increased by selecting those with no more than 1 and 2 root-knot index and egg masses respectively.

Resistance to root-knot nematode reproduction was shown when fewer eggs were obtained from resistant plants than from susceptible plants. Earlier research by Elmstrom (3) which showed that 'Chilton' and 'Gulfcoast' muskmelon enhibited a level of field resistance to the root-knot nematode. Since PI 140471 was one of the parents of both cultivars, this research indicates that a level of field resistance was inherited from the plant introduction.

In view of this resistance, egg counts appear much more appropriate than root-knot indices as a selection criterion for

muskmelon. Egg count is a measure of the nematode's response to the plant that indicates the nematode's ability to complete its life cycle. If this sycle can be broken, the nematode would cease to be a problem regardless of galling response. Egg count is also determined more precisely than root-knot index.

Egg count is determined objectively and is quantitated, whereas root-knot index and other indices reported (3, 5, 10) for assessing galling and egg mass production are relative ratings determined subjectively by judging degrees of galling and estimating relative egg mass numbers among entries or against standards.

Resistant progeny from the interspecific cross *C. melo* × *C. metuliferus* provide high potential for developing resistant cultivars capable of preventing economic loss from root-knot nematodes.

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Influence of Apple Bloom Date on Maturity and Storage Quality of 'Starking Delicious' Apples[1]

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Additional index words.

Abstract. **Tree cages were used to modify temperature around 'Starking Delicious' apple (*Malus domestica* Borkh.) trees and to establish 4 bloom dates: April 2, 15 and May 7, 22. Determination of soluble solids, acid, firmness and chlorophyll indicated that the time from bloom to maturity was longer for fruit from earlier than normal bloom. Fruit from delayed bloom accumulated less soluble solids than that from normal or earlier bloom dates. Ultimate fruit size decreased with each successive bloom. Fruit from the 2 early bloom dates apparently was harvested before the preclimacteric minimum. Fruit from delayed bloom was harvested after initiation of the climacteric. Loss of fruit firmness in storage increased with successive harvests. Storage scald and green fruit color were associated with warm night temperatures just before harvest rather than with length of growing season.**

Fisher (6) and Blanpied (3) made comparative analyses of heat unit accumulation and the number of days required to mature stone and pome fruits at several experiment stations in Canada and the U.S.A. Their findings indicated that growing areas with late bloom required fewer days from bloom to harvest and fewer heat units for maturity, and that fruit maturity may not depend entirely on postbloom temperatures. By hand pollinating apple blossoms at various times, Sullivan (11) was able to compare the effect of the time of bloom on size, shape, and maturity of apples at harvest. Fruit from early pollinated blossoms was larger, softer, juicier, contained higher soluble solids and less acidity. Earlier bloom also resulted in longer fruits with larger, more prominent calyx lobes. The latter data corroborated the report of Shaw (10) that summer temperatures did not affect apple shape while temperatures 2-3 weeks following bloom did.

The authors cited above concluded that use of data from different geographical areas is complicated by differences in tree age and the undetermined variation among subjective ratings of bloom, fruit set, fruit load, tree vigor, and harvest indices. In an effort to offset those variables, temperature-controlled tree cages were used in these studies to manipulate bloom and to compare fruit growth and development in the same orchard and under the same handling procedures.

Preliminary experiments were conducted to determine the conditions necessary to advance bloom and to observe possible variations in the fruit at harvest and after extended storage. An 8-day advance of bloom appeared to alter the normal pattern of fruit maturation as indicated by reduced internal chlorophyll, higher soluble solids and less storage scald in

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