

RESISTANCE TO THE TWOSPOTTED SPIDER MITE IN MUSKMELON

BRIAN T. SCULLY

Everglades Research Center, IFAS, University of Florida
Belle Glade, FL 33430-8003

DAVID A. EAST

Department of Entomology, Ohio State University
Columbus, OH 43210-1220

JONATHAN V. EDELSON

Wes Watkins Agricultural Research Center
Oklahoma State University
Lane, OK 74555

EDWARD L. COX

Asgrow Seed Co.
El Centro, CA 92243

Additional index words. Antibiosis, *Cucumis melo*, *Tetranychus urticae*

Abstract. The twospotted spider mite (*Tetranychus urticae* Koch) (Acari: Tetranychidae) is potentially a serious pest in muskmelon (*Cucumis melo* L.) production. Host plant resistance has not been explored as a management tactic for this pest or incorporated into the crop cultivars. The purpose of this study was to develop preliminary genetic information on new sources of resistance. Nearly 450 muskmelon accessions were initially screened for resistance to the twospotted mite in field and greenhouse environments. About 25 lines exhibited superior resistance, and 3 were selected for hybridization and further evaluation. 'BUS', an Israeli line, PI 136223, a Canadian line, and PI 179895 from India were crossed as males to 'Perlita', the susceptible check. Hybrid and parent plants were infested with 10 female mites at the fourth or fifth leaf stage. Resistance was determined by a modified whole leaf technique with density and reproductive fecundity measured 11 days after infestation of the top newly matured leaves. On the caged leaves female densities ranged from an average of 14 to 32 mites/leaf, while male and immature mites ranged from an average of 122 to 226 individuals per leaf. Deviation of hybrid means from expected mid-parent values indicated that non-additive gene action contributed to the expression of resistance/susceptibility for both female density and males/immature mite numbers.

Introduction

The twospotted mite spider (*Tetranychus urticae* Koch) (Acari: Tetranychidae) is a widely distributed agricultural pest with a host range of well over 100 species of crop, ornamental, and weed plants. The active stages of this pest are sap feeders that produce irregular patterns of small light colored spots on the leaf. Yield losses in cucurbits are primarily due to feeding on the lower leaf surfaces. In

severe infestations leaves yellow and become epinastic followed by the development of necrotic regions, and an intricate network of webs that cover the lower leaf surface and petiole region (Davidson and Lyon, 1979). Hot, dry weather typical of desert and sub-tropical climates favor the rapid growth and development of this organism. In these climates large scale commercial muskmelon (*Cucumis melo* L.) production is commonly subjected to intense mite pressure caused by over 20 generations per year. Most integrated pest management programs for mites on muskmelons have not relied on host plant resistance as a management tactic. Because mites often develop resistance to acaricides and current insect control practices reduce mite predators, the use of plant resistance is justified (Tahori and Raccah, 1970; Mansour and Plaut, 1979; Plaut and Mansour, 1980).

Within the genus *Cucumis* mite resistance research has focused mostly on the cucumber (*Cucumis sativus* L.), because of the injury caused in greenhouse production. Over 1,000 accessions of cucumbers including cultivars, breeding lines and plant introductions have been screened for resistance to the twospotted spider mite (Leppik, 1968; Tulisalo, 1969; Kooistra, 1971; and DePonti, 1978). Resistance was initially linked to the presence of cucurbitacin in the foliage, but results are inconsistent (Soans *et al.*, 1973; Gould, 1978; and De Pont, 1980a, 1980b). De Pont (1978) proposed that the heritability of mite resistance in cucumber was low, quantitative, and mostly conditioned by additive gene action. In muskmelons resistance to the carmine spider mite (*Tetranychus cinnabarinus* Boisduval) (Acari:Tetranychidae) was evaluated on 32 accessions with superior resistance found in 6 lines (Mansour *et al.*, 1987). Further evaluation of mite fecundity indicated antibiosis as a possible mechanism of resistance (Mansour and Karchi, 1990). Across a smaller, but genetically more diverse germplasm base, Tulisalo (1972) and Knipping *et al.* (1975) found wild *Cucumis* accessions with resistance to the twospotted spider mite.

From the U.S. Plant Introduction collection East *et al.* (1989) screened 426 accessions along with 22 cultivars and advanced breeding lines for resistance to the twospotted spider mite. This germplasm base was divided into 11 sub-groups for mass greenhouse screening. Mite fecundity and density of females were compared to a set of standards placed in each sub-group. They were able to identify about 25 accessions with superior resistance, and using the Spearman Rank Statistic (Snedecor, 1946) demonstrated that greenhouse results were highly predictive of field performance. In this study 3 resistant accessions were crossed to the susceptible standard in an effort to develop preliminary information on the genetic base of resistance to the twospotted spider mite.

Materials and Methods

A colony of twospotted spider mites was established from a collection made on cotton (*Gossypium hirsutum* L.) in Texas and maintained at the Watkins Agricultural Research Center, University of Oklahoma. The mites were reared in screened cages on lima bean (*Phaseolus lunatus* L.) for a period of 2 years; held at a temperature range of 20 to 30 C, ambient relative humidity (40% to 80% RH) and a 24

Florida Agricultural Experiment Station Journal Series No. N-00494.

This research was supported by a grant from the US-Israel Binational Agricultural Resources and Development Fund (BARD) and the respective institutions of each author. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hererby marked *advertisement* solely to indicate this fact.

hour photoperiod. The mites were rotated to new lima bean cultures on a regular basis.

Muskmelon seeds were planted in seedling trays and one seedling transplanted at the 2-3 true leaf stage into gallon pots filled with sterilized potting media (Terralite). Plants were grown in the greenhouse during summer of 1989 with standard practices that included an initial 20 g application of 14-14-14 N-P-K (Osmocote). At the 4-5 true leaf stage muskmelon seedlings were inoculated with 10 female spider mites placed on the terminal fully expanded leaf and the next oldest leaf. Mites were restricted to these leaves with a cotton Tanglefoot barrier located at the base of the petiole (East *et al.*, 1992). Plants were monitored twice daily to insure complete isolation from adjacent leaves and other plant tissue. After 11 days of infestation the number of adult females per leaf, and the number of immature and adult male mites were counted on four 2.2 cm diameter leaf disks from each isolated leaf.

The germplasm used in this experiment included 4 parents and 3 hybrids. 'Perlita' (Correa, 1964) was the susceptible check and the female parent in all pre-anthesis crosses. Mite resistant accessions included 'BUS' a bush type from Israel, PI 136223 from Canada, and PI 179895 from India. Parents and progeny were arranged in 2 completely randomized block design experiments with 8 replicates that were planted in June and July, and denoted as Screening 1 and Screening 2, respectively.

The mode of gene action (H) that conditioned resistance or susceptibility was estimated in each cross as:

$$H = \hat{F}_1 - \bar{F}_1$$

where:

\hat{F}_1 is the mid-parent value, determined as the average of P_i and P_j , and is the expected value of the F_1 progeny under additive gene model.

\bar{F}_1 is the observed mean performance of the progeny of parent i (P_i) and parent j (P_j).

Additive gene action was assumed as H approached 0. An \bar{F}_1 was considered significantly different from \hat{F}_1 when the standard error of \bar{F}_1 failed to overlap the \hat{F}_1 value. Significant deviation from this mid-parent value indicated additive and non-additive gene action influenced the expression of mite resistance/susceptibility; insignificant differences between \bar{F}_1 and \hat{F}_1 indicated mostly additive gene action. Positive H values indicated a more resistant response to mites, while negative H values were opposite. Parents were assumed to be unrelated, fully inbred and to follow normal diploid inheritance patterns. Cytoplasmic or maternal effects and epistasis were considered absent. Data were analyzed with the Statistical Analysis Systems (SAS, 1985).

Results and Discussion

Significant differences existed between 'Perlita', the susceptible check, and the resistant lines for the number of adult female mites in Screening 1 (Table 1). No significant differences were detected among 'BUS', PI 136223, or PI 179895. These resistant lines averaged about one-half the number of female mites per leaf compared to 'Perlita'. This trend continued in Screening 2, although 'BUS' and PI 136223 were not significantly different from 'Perlita' when separated by an LSD at $P \leq 5\%$. When these data were pooled, 'Perlita' separated from the resistant accessions

Table 1. Mean number of adult female twospotted spider mites per leaf on parents and progeny of crosses among resistant and susceptible muskmelon lines.

Line	N ²	Female mites per leaf (mean ± S.E.)		
		Screening 1	Screening 2	Pooled
Perlita (P ₁)	16	34.6 ± 7.52	29.4 ± 6.15	32.0 ± 6.88
PI 179895 (P ₂)	16	12.5 ± 3.23	15.4 ± 2.49	13.9 ± 2.92
BUS (P ₃)	16	16.3 ± 3.42	23.1 ± 3.22	19.7 ± 3.46
PI 136223 (P ₄)	16	17.6 ± 3.33	21.2 ± 2.40	19.4 ± 2.91
P ₁ X P ₂	16	15.3 ± 2.57	20.1 ± 3.66	17.7 ± 3.09
P ₁ X P ₃	16	41.4 ± 6.62	26.5 ± 3.97	34.0 ± 5.27
P X P ₄	16	18.9 ± 4.00	22.1 ± 4.46	20.5 ± 4.20

²N = 16 was split equally with eight replicates per screening.

(Table 1). For the number of adult female mites on parents and hybrid progeny in both screenings, the standard errors were of an order 4 to 5 times lower than their respective mean values. The response of the parents to infestations with the twospotted spider mite was generally in agreement with previous screening studies (East *et al.*, 1989; Mansour and Karchi, 1990).

When the mean number of male and immature mites (Table 2) were counted in Screening 1, PI 179895 and 'BUS' were significantly more resistant than 'Perlita', but PI 136223 was significantly more susceptible. This result was unexpected, although East *et al.* (1989) showed a lower rank for the reproductive rate on PI 136223, compared to the rank for adult female mites. In Screening 2, both the 'BUS' and PI 136223 data failed to show resistance greater than 'Perlita'. When these results were pooled, resistance to male and immature mite stages was only indicated in PI 179895 (Table 2). The standard errors for male and immature mites were proportionally lower than the standard errors for the adult female count, indicating more uniformity among the replicates.

The deviation of PI 136223 from resistance to the immature and male mites was not anticipated, but may be due to environmental differences or a genotype-by-environment interaction with an undetermined mechanism related to ontogeny, differential fitness or proportions of pre-adults to adults. The mass screening phase of this research by East *et al.* (1989) was conducted in the winter months, while this portion of the study was conducted under longer photoperiods and the warmer weather of June and July when greenhouse temperatures ranged up to 40 C. PI 179895 showed consistent resistance in both screenings and

Table 2. Mean numbers of immature and adult male twospotted spider mites per leaf on parents and progeny of crosses among resistant and susceptible muskmelon lines.

Line	N ²	Immature/adult male mites per leaf (means ± S.E.)		
		Screening 1	Screening 2	Pooled
Perlita (P ₁)	16	160.8 ± 20.66	179.4 ± 24.97	170.2 ± 16.03
PI 179895 (P ₂)	16	127.0 ± 17.62	134.2 ± 19.02	130.6 ± 12.77
BUS (P ₃)	16	117.9 ± 15.23	179.2 ± 41.74	148.6 ± 22.54
PI 136223 (P ₄)	16	215.2 ± 36.23	237.3 ± 33.19	226.2 ± 24.25
P ₁ X P ₂	16	126.1 ± 18.29	117.1 ± 17.30	121.6 ± 12.41
P ₁ X P ₃	16	201.2 ± 27.76	181.9 ± 20.08	191.5 ± 16.94
P ₁ X P ₄	16	159.7 ± 20.32	191.5 ± 14.86	175.6 ± 12.71

²N = 16 was split equally with eight replicates per screening.

for all stages and sexes of mites (Table 1 and 2). The 'BUS' line was reasonably consistent with expectations, and is one of a few lines that has been tested and shown to have resistance to the carmine spider mite and the twospotted spider mite (Mansour and Karchi, 1990; East *et al.*, 1989). This joint resistance may be related to taxonomic similarity; prior to 1968 both mites were united under a single epithet (Jeppson *et al.*, 1975).

In the cross between 'Perlita' and PI 179895, the progeny was significantly different from the mid-parent value for the number of adult female mites (Table 3). The positive H value suggested that PI 179895 contributed to the resistance and that partial dominance gene action appeared to condition this resistance. Resistance to the male and immature stages of the twospotted spider mite was greater in the hybrid progeny than PI 179895 (130.6 *vs* 121.6) (Table 3). This value indicated over-dominance as a component of gene action for resistance, although the hybrid was not significantly higher than PI 179895. These patterns were also apparent in Screening 1 and Screening 2 for both adult females and male/immature stages (Tables 1 and 2).

Among the crosses, the fecundity of mites was higher on the hybrid between 'Perlita' and 'BUS'. 'BUS' appeared to confer no resistance in the progeny, and overdominance gene action contributed to increased susceptibility to the adult female and male/immature mites (Table 3). For the pooled adult female count, this hybrid had a mean value of 34 mites per leaf compared to 32 for the 'Perlita' parent, but these values were not significantly different (Table 1 and 3). The average male/immature mite count was significantly higher for the hybrid compared to 'Perlita' in the pooled date (Table 3) and this result was consistent across both screenings (Table 2). The 'Perlita' by PI 136223 hybrid was significantly different from the mid-parent value for adult female mites. Partial dominance contributed to this resistance (Table 3), although the hybrid was not significantly different from the PI 136223 parent. The male and immature mite count on this hybrid was influenced by partial dominance, but in this case PI 136223 was unexpectedly more susceptible than 'Perlita' (Table 3).

In all cases the pooled response of the hybrid progeny was significantly different from the mid-parent value. This suggested that various levels of dominance gene action contributed to the expression of resistance/susceptibility to the twospotted spider mite in muskmelons. This result does not imply the absence of additive gene action but rather that both types of gene action condition this trait. These results differ from those found in cucumber where additive gene action was considered the primary genetic basis for resistance (De Ponti, 1978). Useful levels of resistance can be transmitted to a population base, but dominance gene action confounds the selection process. Dominance based resistance is ephemeral, unique to each cross and often requires the evaluation of numerous combinations.

Literature Cited

- Correa, R. T. 1964. Perlita Cantaloupe. Texas A&M Univ. Circ. no. L-641. College Station, TX.
 Davidson, R. H. and W. F. Lyon. 1979. Insect Pests of Farm, Garden and Orchard (7th edition). Wiley & Sons, New York.

Table 3. Comparison of mean values pooled for adult female (a) and male and immature mites (b) to the expected mid-parent values and the pooled means of the resistant and susceptible parent.

Cross	Pooled values (mean \pm S.E.)	Mid-parent value	Susc. parent (mean)	Resist. parent (mean)	H ²
<i>a) Adult females</i>					
Perlita X PI 179895	17.7 \pm 3.09	22.9	32.0	13.9	+5.2
Perlita X BUS	34.0 \pm 5.27	25.8	32.0	19.7	-8.2
Perlita X PI 136223	20.5 \pm 4.20	25.7	32.0	19.4	+5.2
<i>b) Males and immatures</i>					
Perlita X PI 179895	121.6 \pm 12.41	150.4	170.2	130.6	+28.8
Perlita X BUS	191.5 \pm 16.94	159.4	170.2	148.6	-32.1
Perlita X PI 136223	175.6 \pm 12.71	198.2	170.2	226.2	+22.6

²Indicates the difference between mid-parent value and pooled means for the hybrid.

- De Ponti, O.M.B. 1978. Resistance in *Cucumis sativus* L. to *Tetranychus urticae* Koch. 3. Search for sources of resistance. Euphytica. 27:167-176.
 De Ponti, O.M.B. 1980a. Resistance of *Cucumis sativus* L. to *Tetranychus urticae* Koch. 6. Comparison of near isogenic bitter and non-bitter varieties for resistance. Euphytica 29:261-265.
 De Ponti, O.M.B. 1980b. Resistance to *Cucumis sativus* L. to *Tetranychus urticae* Koch. 7. The inheritance of resistance and bitterness and the relation between these characters. Euphytica 29:513-523.
 East, D. A., J. V. Edelson, E. L. Cox and M. K. Harris. 1989. Search for resistance in muskmelon to the two-spotted spider mites TAES Progress Report, PR-4677, Texas A&M University, College Sta. TX.
 East, D. A., J. V. Edelson, E. L. Cox and M. K. Harris. 1992 (est.). Evaluation of screening methods and search for resistance in muskmelon (*Cucumis melo* L.) to the twospotted spider mite (*Tetranychus urticae* Koch). Crop Protection (In Press).
 Gould, F. 1978. Resistance of cucumber varieties to *Tetranychus urticae*: Genetic and environmental determinants. J. Econ. Ent. 71:680-683.
 Jeppson, L. R., H. H. Keifer and E. W. Baker. 1975. Mites injurious to economic plants. University of California Press, Berkeley, CA.
 Knipping, P. A., C. G. Patterson, D. E. Knavel and J. G. Rodriguez. 1975. Resistance of cucurbits to twospotted spider mite. Env. Ent. 4:507-508.
 Kooistra, E. 1971. Red spider mite tolerance in cucumber. Euphytica 20:47-50.
 Leppik, E. E. 1968. Relative resistance of *Cucumis* introductions to diseases and insects. Adv. Frontier Pl. Sci. 19:43-51.
 Mansour, F. and H. N. Plaut. 1979. The effectiveness of various acaricides against resistance and susceptible carmine spider mites. Phytoparasitica 7:185-193.
 Mansour, F., Z. Karchi and N. Omari. 1987. Resistance of melon to the carmine spider mite, *Tetranychus cinnabarinus* (Boisduval) (Acari:Tetranychidae). Bull. Ent. Res. 77:603-607.
 Mansour, F. and Z. Karchi. 1990. Evaluation of antibiosis of selected lines for resistance of melon to the carmine spider mite *Tetranychus cinnabarinus* (Acari: Tetranychidae). Bull. Ent Res. 80:345-347.
 Plaut, H. N. and F. A. Mansour. 1980. Effects of stable pyrethroid insecticides on population densities of spider mites in Israel-history, early observations, a field experiment and outlook. Alon Hanotea. 12:1-16.
 SAS Institute. 1985. SAS User's Guide, 5th Edition. SAS Institute. Cary NC.
 Snedecor, G. W. 1946. Statistical Methods. Iowa State College Press. Ames.
 Soans, A. B., D. Pimentel and J. S. Soans. 1973. Resistance in cucumber to the two-spotted spider mite. J. Econ Ent. 66:380-382.
 Tahori, A. S. and B. Raccach. 1970. Resistance to acaricides in the carmine spider mite in Israel. J. Econ Ent. 63:545-548.
 Tulisalo, U. 1969. Fecundity, development and longevity of two-spotted spider mite *Tetranychus urticae* Koch (Acarina, Tetranychidae) on cucumber varieties. Ann Ent. Fenn. 35:224-228.
 Tulisalo, U. 1972. Resistance to the two-spotted spider mite *Tetranychus urticae* Koch. (Acari: Tetranychidae) in the genera *Cucumis* and *Citrullus* (Cucurbitaceae) Ann. Ent. Fenn. 38:60-64.