nonrooting plantlet recultures, is an easier method for mass production of genetically similar material.

Literature Cited

1. Andreassen, D. C., and L. H. Ellison. 1967. Root initiation of stem tip cuttings from mature asparagus plants. *Proc. Amer. Soc. Hort. Sci.* 90:158-162.
2. Galston, A. W. 1948. On the physiology of root initiation in excised asparagus stem tips. *Amer. J. Bot.* 35:281-287.
3. Gorter, C. J. 1965. Vegetative propagation of *Asparagus officinalis* by cuttings. *J. Hort. Sci.* 40:177-179.
4. Hasegawa, P. M., T. Murashige, and F. H. Takatori. 1973. Propagation of asparagus through shoot apex culture. II. Light and temperature requirements, transplantability of plants, and cyto-histological characteristics. *J. Amer. Soc. Hort. Sci.* 98:143-148.
5. Loo, S.-W. 1945. Cultivation of excised stem tips of asparagus *in vitro*. *Amer. J. Bot.* 32:13-17.
6. Malnassy, P., and J. H. Ellison. 1970. Asparagus tetraploids from callus tissue. *HortScience* 5:444-445.
7. Murashige, T., M. N. Shabde, P. M. Hasegawa, F. H. Takatori, and J. B. Jones. 1972. Propagation of asparagus through shoot apex culture. I. Nutrient medium for formation on plantlets. *J. Amer. Soc. Hort. Sci.* 97:158-161.
8. Snedecor, G. W. 1948. Statistical methods. 4th Ed., The Iowa State College Press. Iowa, p. 445-452.
9. Steward, F. C., and M. O. Mapes. 1971. Morphogenesis and plant propagation in aseptic cultures of asparagus. *Bot. Gaz.* 132:70-79.
10. Stoltz, L. P., and R. P. Cody. 1970. *In vitro* studies on the asexual propagation of *Asparagus officinalis*. *HortScience* 5:353 (Abstr.)
11. Takatori, F. H., T. Murashige, and J. I. Stillman. 1968. Vegetative propagation of asparagus through tissue culture. *HortScience* 3:20-22.
12. Wilmar, C., and M. Hellendoorn. 1968. Growth and morphogenesis of asparagus cells cultured *in vitro*. *Nature* 217:369-370.
13. Yang, Hsu-Jen, and W. J. Clore. 1973. Rapid vegetative propagation of asparagus through lateral bud culture. *HortScience* 8:141-143.

Effect of Plant Density on Fruitworm Damage in the Tomato[1]

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Abstract. **Fruitworm damage in 3 cultivars of tomato (*Lycopersicon esculentum* Mill.) was highly correlated with plant density. Increases in damage of 31.4 to 67.1% were associated with the increase in density from 1 to 16 plants per 3 m row. This insect damage-plant density relationship will affect efficiency of selection for fruitworm resistance in tomato breeding programs.**

The tomato fruitworm, *Heliothis zea* (Boddie), is a principal insect pest of tomato. In many areas, this insect can virtually destroy the entire crop. In a preliminary experiment in 1971, we found a significant correlation between fruitworm damage and plant density. This study confirms these earlier results.

The data reported here are from a plant-density experiment conducted at the U.S. Vegetable Breeding Laboratory, Charleston, S. C., during the summer and fall of 1972 using the determinate 'Roma VF', 'Parker', and 'Walter', and the dwarf 'Epoch'. Intrarow spacings of 18.75, 37.50, 75, 150, and 300 cm in rows 2 m apart gave densities of 16, 8, 4, 2, and 1 plants per 3 m. The experimental design was a split-plot with 4 replications. The 5 density treatments were randomized within each block, and the 4 cultivars were randomized within each density plot. Each subplot consisted of a row of 10 test plants plus 1 to 5 guard plants at each end. Guard rows at the appropriate density were used on both sides of each plot.

The plants, grown from seed in the greenhouse, were transplanted to the field on August 9. A small no. of missing, weak, or "blind" plants were replaced 1 week after field transplanting to give a 100% stand. Cultivation and hand weeding were carried out as necessary, and a herbicide (diphenamid) was applied after the last cultivation. Toxaphene, at a dosage of 1.68 kg/ha, was applied weekly up to the time of the last cultivation to control southern armyworm and tobacco hornworm. *Bacillus thuriengiensis*, which is pathogenic to the hornworm, was included in the last application. The fungicide maneb was applied weekly from transplanting to the first fruit collection.

The data were obtained from 3 weekly preharvest collections of rotten fruit and a single destructive harvest on Oct. 25. The preharvest collections were necessary because fruitworm-damaged fruits have a tendency to rot and soon "disappear." A fruit was classified as damaged if a larval-feeding scar had penetrated the skin into the fruit tissue. Only fruits that had developed to the mature-green stage were evaluated for damage. It was assumed that all preharvest fruit that had not reached the mature-green stage at the time of collection would have done so by the destructive harvest date, had they not been damaged.

Preliminary analyses of yield data indicated that all 3 determinate cultivars responded to increased plant density in the characteristic manner report by Fery and Janick (2). Yields per unit area increased asymptotically with plant density, and the corresponding yields per plant decreased. The small plants of the dwarf 'Epoch', however, did not respond to the density treatments. There was no appreciable effect of interplant competition on either yield or fruitworm damage at even the highest densities. In order to reduce experimental error, data from the 'Epoch' sub-plots, were not included in the subsequent analyses.

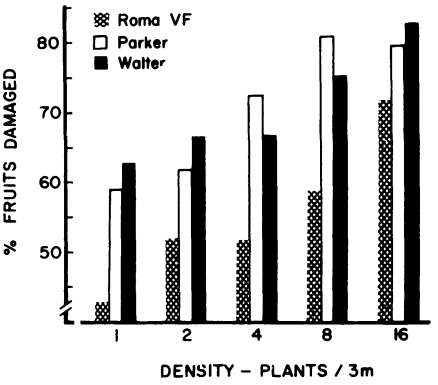

Fig. 1. Effects of plant density on fruitworm damage in 3 tomato cultivars.

The effect of plant density on fruitworm damage in the remaining 3 cultivars confirm our earlier results (Fig. 1). There were significant differences between both plant-density treatments and cultivars. As plant density was increased from 1 to 16 plants per 3 m row, the mean fruit damage for the 3 cultivars increased from 54.8 to 77.6%, a relative increase of 41.6%. The respective increases for 'Walter', 'Parker', and 'Roma VF' were 31.4, 34.1, and 67.1%. The correlation between plant density and insect damage was significant at the 0.1% level for each cultivar. 'Roma VF' was significantly less damaged than 'Parker' and 'Walter'. There was no significant interaction between plant density and cultivars.

Although there are several possible explanations for the high correlations between plant density and fruitworm damage, we can offer no single satisfactory reason for the relationship. It is possible that the moths responded to a higher "concentration" of a visual or olfactory attractant during oviposition, that the microclimate in the dense stand was favorable to egg

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hatching and/or larval growth and development, that populations of insect predators and parasites were affected by plant density, or that the nutritional value of the plant tissue was affected. Perhaps, the increase in early yield and yield concn and the decrease in plant size that results from increased plant density (2) increased the searching efficiency of young larvae for fruit tissue. This would not only increase the proportion of the fruit found by the larvae, but would also increase larval survival if fruit tissue is more palatable than leaf tissue. A similar relationship between plant density and insect damage has recently been noted in southern peas (1).

Interest in this plant density-fruitworm damage relationship arises from our desire to improve selection efficiency for fruitworm resistance. Since fruitworm resistance is of major importance in our breeding program, progress is directly related to the efficiency of selection techniques. This fruitworm-plant density relationship needs to be taken into account when evaluating resistance of single plants grown in a spaced planting. These results also suggest that the recent trends toward increased plant densities in direct-seeded tomatoes may increase the incidence of fruitworm damage.

Literature Cited

1. Fery, R. L., and F. P. Cuthbert, Jr. 1972. Association of plant density, cowpea curculio damage, and *Choanephora* pod rot in southern peas. *J. Amer. Soc. Hort. Sci.* 97:800-802.
2. ———, and Jules Janick. 1970. Response of the tomato to population pressure. *J. Amer. Soc. Hort. Sci.* 95:614-624.

Cage Size and Tomato Performance[1]

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Abstract. **Plants of tomato (*Lycopersicon esculentum* Mill. cv. Manalucie) grown in wire mesh cylindrical enclosures (cages) produced fruit with greater soluble solids content when cage diameter increased from 31 to 62 cm. Cage diameter or height did not influence juice pH, color, yield, or harvest labor input.**

Increasing labor cost has forced fresh market tomato growers to new production methods. The field production of unstaked and unpruned (ground) tomatoes is not possible in areas of high rainfall because fruit rots and soil discoloration of fruit result in low marketable yield. A production system using wire mesh "cages" to support tomato plants has received increasing attention from growers because of low labor input and high marketable yields (1, 2, 4, 5).

This study was initiated to compare soluble solids, color, juice pH and yield of tomatoes produced in varying cage sizes. Cages (cylinders enclosing individual plants) were constructed of 10 gauge reinforcing wire with 15.2 x 15.2 cm "mesh" as described by Weikel (5). The 6 cage size treatments were based on all combinations of 2 diameters (31 and 62 cm) and 3 heights (31, 62, and 93 cm). Cages were placed over each plant immediately following transplanting.

Eight-week-old greenhouse-grown transplants of 'Manalucie' tomato were transplanted into field plots fertilized with 908 kg per ha of 10–4.3–8.3 (N–P–K) fertilizer and with a soil pH 6.5. Transplants were spaced 1.23 x 1.23 m in the plots. Plots were fumigated with methyl bromide 2 months before transplanting. At transplanting, roots of the transplants were immersed in a 200 ppm solution of 20–8.6–16.6 (N–P–K) water soluble fertilizer containing minor elements.

Irrigation was applied when needed with a twin wall drip hose; all plants were sprayed weekly with an insecticide and fungicide combination. The experimental design was a randomized complete block with 4 replications. Each experimental unit consisted of 9 plants bordered by guard rows.

Two or three fruit from each plant in each block was used for quality determinations on each harvest date. Soluble solids determinations were made on a Baush and Lomb Abbe refractometer; juice pH was determined by the method of Kramer and Smith (3). Records of total yield and time required for harvest were made.

Cage size had no significant affect on juice pH, fruit color, yield, or time required for harvest (Table 1). The yield data compare favorably with those of other studies (1, 2). However, the data concerning time required for harvest do not agree with the suggestion of Carolus and Price (1) that increasing cage diameter makes early fruit harvest difficult. Increased difficulty for early fruit harvest of the wider cages was not reflected in a significantly increased total harvest time (Table 1). Soluble solids were significantly higher from 62 cm diam cages than from 31 cm diam (Fig. 1). A possible explanation is greater foliage spreading in the larger diam cages allowed better sunlight penetration to the lower leaves. Although spreading of foliage occurred, the larger diam cages did support the plants in an upright position. There was significant interaction between cage height and diameter (Fig. 1). Plants grown in cages of intermediate height (62 cm) produced fruit with the greatest soluble solids content but the reason for this is not apparent.

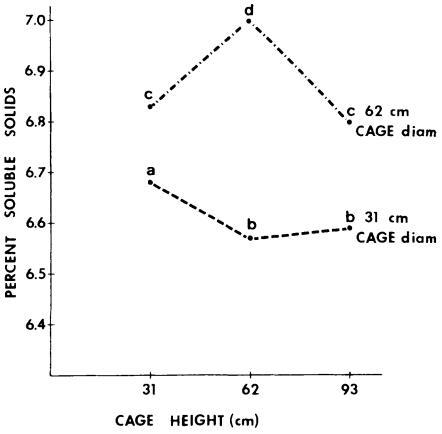

Fig. 1. The effect of cage height and width on soluble solids of 'Manalucie' tomatoes. Means followed by the same letter are not statistically different at the 5% level of probability.

Table 1. The effect of cage size on, juice pH, color, yield and time for harvest of 'Manalucie' tomatoes.

Variable	Cage size (cm): ht x diam[z]					
	31x31	62x31	92x31	31x62	93x62	62x62
pH	4.61a	4.64a	4.59a	4.60a	4.58a	4.60a
Color (% transmittance)	62.75b	63.82b	64.69b	63.63b	63.38b	62.94b
Total yield (kg/plant)	9.8a	9.4a	9.0a	9.4a	9.1a	9.7a
Harvest time (min/kg fruit)	.79a	.77a	.68a	.77a	.68a	.88a

[z]Means followed by the same letter in rows are not statistically different at the 5% level of probability.

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Literature Cited

1. Carolus, R. L., and H. C. Price. 1973. Caging tomatoes. Mich. State Univ. Agr. Expt. Sta. Res. Rpt. 221.
2. Courter, J. W., and J. S. Vandemark. 1973. Growing tomatoes in wire cages. *Ill. Res.* 50:14-15. (Ill. Agr. Expt. Sta.)
3. Kramer, A., and H. R. Smith. 1946. Preliminary investigation on measurement of color canned foods. *Food Res.* 11:14-31.
4. O'Dell, C. 1972. Cultural tips for caged tomatoes. *Amer. Veg. Grower* 20:84-85.
5. Weikel, H. 1971. Grow 'em in cages. *Amer. Veg. Grower* 19:14-44.