Resistance of Tomato Cultivars to the Fruitworm, *Heliothis zea* (Boddie)[1]

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Abstract. **A collection of 1,030 accessions of tomato (*Lycopersicon esculentum* Mill.), mostly cultivars and assumed cultivars, was evaluated for resistance to the tomato fruitworm. Although no immunity was found, there were significant differences in the degree of susceptibility. The most resistant cultivar, 'Tiny Tim', was 83.1 and 57.6% less damaged than the susceptible and resistant controls, respectively. Even though the data were possibly confounded by vine-size effects, indications are that much of the variability can be used to develop less susceptible cultivars.**

The tomato fruitworm is the major pest of tomatoes in several important U.S. production areas. Multiple applications of insecticides are often required at present to control this pest. This dependence upon insecticides is undesirable for both economic and environmental reasons. The high costs of insecticide control have long been recognized as an economic problem. The adverse effect of chemical insecticides on the predators and parasites of economic pests is also often a serious problem. Both of these problems could be alleviated by the development and use of resistant cultivars.

The literature on fruitworm resistance in the tomato is limited. Although there have been reports on such aspects of resistance as the differential susceptibility of fresh market vs. processing cultivars and the relationships between damage and such factors as earliness, fruit no., vine size, and plant density (1, 2, 3), no large-scale effort to locate sources of resistance has been reported. Because of this general lack of information and the availability of a large no. of tomato cultivars, the initial phase of such an effort should be a search for high levels of resistance within cultivar germplasm. We report here the results of such a program conducted over a 2-year period, using all available tomato cultivars.

The data reported here are from fall tests conducted at the U.S. Vegetable Laboratory, Charleston, S.C., in fields naturally infested by the tomato fruitworm. All plants were grown from seed in the greenhouse and transplanted to the field. Routine cultural practices were followed. Early-season insect pests were controlled with a nonpersistent insecticide.

An attempt was made to screen all available cultivars. Sources of the 945 cultivars and assumed cultivars evaluated included the Old Varieties Collection of the National Seed Storage Laboratory, Plant Introductions, and commercial seed houses. Apparent duplicate or closely related accessions from a "cultivar family" and previously evaluated cultivars were not included. Also evaluated were 85 *L. esculentum*-type Plant Introductions that had been observed to have low levels of fruitworm damage in previous screening trials[3].

All 1,030 accessions were evaluated in a non-replicated test in 1972. Each plot consisted of a single row of 5 plants spaced 76 cm apart on beds 2 m apart. A total of 341 of the accessions were discarded before harvest as being obviously highly susceptible to the fruitworm. We evaluated the remainder of the accessions by grading for fruitworm damage the total fruit yield from 1 or 2 randomly chosen plants. Because accessions differed in maturity, the entries were evaluated in 2 groups or time periods. The first group of 464 accessions included all the entries that contained mature fruit during the first sampling period. The second group of 225 accessions was evaluated 10 days later. Immediately after these evaluations had been completed, 124 of the most promising accessions were reevaluated by a second sampling of additional plants. A fruit was classified as damaged if it possessed any sign of larval feeding.

In 1973, the 36 accessions that showed apparent resistance in the 1972 planting were evaluated, along with 3 controls, in a randomized complete-block with 4 replications. Each plot consisted of 1 row of 10 plants, spaced 76 cm apart on beds 2 m apart. The controls included the susceptible 'Parker', a resistant selection TF-2, and 'Walter', a commercial cultivar. TF-2 had previously demonstrated a significant level of resistance to the fruitworm (2). Each entry was evaluated for fruitworm damage by grading all the fruit obtained by 2 preharvest collections of ripe and rotten fruit and an early single harvest of the mature green, ripe, and rotten fruit.

The distributions within the 2 maturity groups evaluated by grading during the 1972 test were skewed toward the lower ratings (Fig. 1). The skewed distributions probably resulted from the preharvest elimination of more than 1/3 of the accessions. Had this data been collected, it would probably have "filled in" the right sides of the distributions. The damage ratings ranged from 0 to 100%. The mean ratings for the early and late sampling periods were 36.5 and 23.5%, respectively. We also noted this apparent earliness effect in a previous study, in which fruitworm damage was inversely correlated with vine size (2). In that study, a negative correlation between earliness and vine size rather than earliness *per se* was shown to be the major explanation for the association between earliness and damage.

Fruitworm damage for the accessions in the 1973 test ranged from 13.1 to 77.3% of the fruitload (Table 1). Although not all the selected accessions were resistant, several were at least equal to the resistant control, and one, 'Tiny Tim', was significantly better. 'Tiny Tim' was 83.1% less damaged than 'Parker', the susceptible control, and 57.6% less damaged than the resistant control TF-2.

In our previous study, we found that differences in observed resistance among 22 accessions disappeared when the data were adjusted for vine size (2). The earlier data, for example, indicated that much of the resistance in TF-2 was caused by its large vine size. Because data on vine size were not taken in the present study, the potential usefulness of the cultivars in the low-damage group cannot be fully determined. However, the variation of vine size within both the low- and high-damage groups suggested that other factors were also

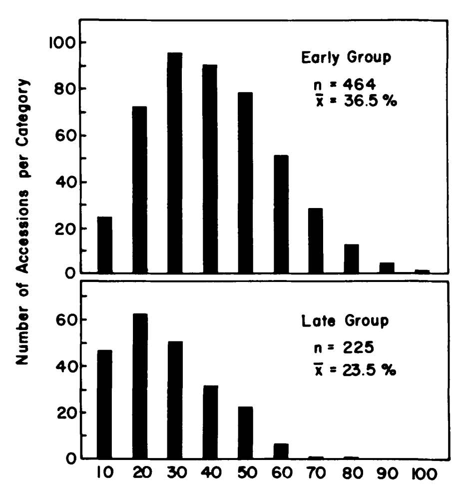

Fig. 1. Frequency distributions of tomato accessions, based on % fruits damaged by the fruitworm for the early- and late-maturity groups, 1972.

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Table 1. Fruitworm damage ratings for the tomato accessions in the lowest and highest damage groups, 1973.

Accession[z]	% Fruits damaged[y]
Lowest damage	
Tiny Tim	13.1 a
P. I. 128230 (Species type)	21.1 ab
N. S. S. L. 27260 (Watanabes)	27.1 ab
P. I. 97538 (Species type)	28.0 ab
P. I. 193415 (Pennorange E160A)	29.7 b
TF-2[x]	30.9 b
P. I. 120272 (Species type)	31.7 b
P. I. 102717 (Species type)	32.7 b
P. I. 303787 (Santa Catalina)	34.8 bh
N. S. S. L. 26876 (Abundance)	35.2 bh
Yellow Pear	36.2 bh
Highest damage	
Walter[w]	52.4 hl
KC 146	52.6 hl
P. I. 258481 (Rick LA 405)	53.6 hl
Marion	54.0 hl
N. S. S. L. 27381 (Livingston's Magnus)	56.8 l
P. I. 209974 (Peron)	57.0 l
P. I. 128293 (Assumed cultivar)	58.2 l
P. I. 270177 (Comet)	62.2 lm
N. S. S. L. 27243 (Thick Skinned)	64.1 lm
N. S. S. L. 26979 (E. Z. Peeling Salad)	70.6 lm
Parker[v]	77.3 m

[z]Names of cultivars with Plant Introduction (P. I.) or National Seed Storage Laboratory (N. S. S. L.) numbers enclosed in parentheses. Non-cultivar accessions are classified as either species type or assumed cultivar.

[y]Mean separation by Duncan's multiple-range test, 5% level (only letters pertinent to the extracted means shown).

[x]Resistant control (selection from STEP 494).

[w]Commercial control.

[v]Susceptible control.

operating. 'Tiny Tim', the most resistant accession, is a small-vined dwarf cultivar. The favorable rating of this cultivar obviously was not caused by a vine-size factor.

Though our data are possibly confounded by vine-size effects, 2 general conclusions with reference to fruitworm resistance in the tomato are possible. First, there is no immunity to the tomato fruitworm within the tomato cultivar germplasm searched. If immunity to this pest exists within the genus *Lycopersicon,* it must be found in unadapted *L. esculentum*-type material or in the related species. Second, there is a large amount of variability in fruitworm resistance within cultivar germplasm, and much of it may have potential usefulness in developing less susceptible cultivars. A tomato cultivar with even partial resistance to the fruitworm would be of considerable value in an integrated control program.

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Effect of Herbicides on Weed Control and Nitrate Accumulation in Spinach[1]

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Abstract. **Three herbicides, cycloate, alachlor and lenacil, gave acceptable weed control in spinach (*Spinacia oleracea* L.), while 7 other herbicide combinations did not. Cycloate, alachlor, lenacil, prometryne and chlorpropham + PPG 124 significantly increased the NO_3-N concentration of both spinach blades and petioles by as much as 3-4 times over weeded and non-weeded checks. DCPA significantly increased NO_3 in the petioles. Cycloate, alachlor and lenacil significantly increased total N concentration in the petioles, while none of the herbicide treatments affected total N in the blades. Lenacil significantly increased fresh weight of blades and petioles compared to a weeded check, while plant fresh and dry weights from cycloate and alachlor treatments were not less than the checks.**

Effective weed control in spinach is necessary for high yield, a high quality product and easier harvesting of the crop. Because of high labor costs and sometimes relatively low returns per acre the cost of a weed control program on spinach must be kept as low as possible. Hence, chemical weed control appears to be the answer to this production problem.

Chlorophenoxy and triazine herbicides have been shown to increase NO_3 in crops and several broadleaf weed species (1, 2, 3, 8, 9, 11, 12, 13, 17, 18, 21, 22, 25, 26). In some cases, the quantities of NO_3 found were high enough to be toxic to cattle (14, 21). Sublethal doses of herbicides, most notably triazines, can be beneficial by increasing the protein content in both vegetative and seed plant parts (8, 9, 11, 13, 14, 17, 18, 19, 20). However, in many cases, NO_3 accumulation occurred. Hiranpradit et al. (13) reported significant increase in the content of both protein and NO_3-N when atrazine was applied to corn. Fedtke (9) reported that the photosynthetic inhibitor herbicides, metribuzine and methabenzthizuron, enhanced nitrate reductase activity and increased NO_3 concn in potato and wheat up to 10,000%. The same results were obtained by growing the plants under low light intensity. Lowered light intensity has been shown to increase NO_3 concn in many plant species including spinach (5, 10). This can be related to the energy need of nitrate reductase that is derived from photosynthesis (24).

Accumulation of NO_3 is undesirable since it can be reduced to NO_2 a form of N which can be toxic to humans, especially infants. Also, high NO_3 in processed products have been connected with detinning of cans. Spinach and similar leafy vegetables can accumulate high levels of NO_3 (4, 6). Our objective was to find effective herbicides for weed control in spinach and to determine what effect the chemicals had on NO_3 accumulation.

'America' spinach was seeded on April 27, 1972, on a sandy loam soil. Rows were spaced 1 m apart and plants 10 cm apart in the row. Individual plots were 3 rows 3 m long. There were 4 replications of each treatment. Fertilizer as 10N-4.3P-8.3K at a rate of 420 kg/ha was broadcast and disked in before planting. After the crop emerged N as as NH_4NO_3 was sidedressed at 224 kg/ha to give a total fertilizer N rate of 117 kg/ha.

Treatments included chlorpropham (isopropyl *m*-chlorocarbanilate), chlorpropham + PPG 124 (p-chlorophenyl-N-methyl carbamate). cycloate (S-ethyl N-ethylthiocyclohexanecarbamate), endothall (7-oxabicyclo[2,2,1] heptane-2, 3-dicarboxylic acid), alachlor (2-chloro-2', 6'-diethyl-N-(methoxymethyl) acentanilide), lenacil (3-cyclohexyl-6,7-dihydro-1H-cyclopentapyrimideine-2,4 (3H,5H)-dione), DCPA (dimethyl tetrachloroterephtalate), CDEC (2-chloroallyl diethyldithiocarbamate), trifluralin (α α α-trifluro-2, 6-dinitro-N,N-dipropyl-p-toluidine), prometryne (2,4-bis(isopropylamino)-6-(methylthio)-*s*-triazine), and weeded and non-weeded checks. Weeded checks were maintained weed free throughout the growing season. The

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