Table 1. Cold hardiness (LT_{50}) of 2 onion cultivars as affected by age and size of plant, December 11–13, 1979. Las Cruces, New Mexico.

Age (days from seeding)	Wt per plant (g)	Avg leaves per plant	LT_{50} (°C)
90	1.06	3.9	−10.8 B[z]
74	0.18	2.8	−10.5 B
58	0.05	2.0	−8.7 A

[z]Mean separation within columns by Duncan's Multiple Range Test, 1% level.

Roots are regenerated from the stem plate. Death of the stem plate results in loss of rooting capability. The below ground tissues, including the stem plate, appear to be less hardy than the leaves. Many plants at intermediate temperatures retained healthy appearing leaves for several weeks, but failed to regenerate roots.

Assuming the observed hardiness variability is controlled genetically, plant populations of these 2 cultivars offer potential for hardiness improvement through selection. Plant survival, as related to age, following lavoratory freezing was similar to field observations that smaller plants are more susceptible to winter plant losses. This suggests that our technique, growing plants in the greenhouse after controlled freezing of seedlings, can be used to predict field hardiness and can be used in selection programs to improve overwintering capability.

Literature Cited

1. Bittenbender, B. C. and G. S. Howell. 1976. Cold hardiness of flower buds from selected highbush blueberry cultivars (*Vaccinium australe* Small). J. Amer. Soc. Hort. Sci. 101:135–139.
2. Chaplin, C. E. 1948. Some artificial freezing tests of peach fruit buds. Proc. Amer. Soc. Hort. Sci. 52:121–129.
3. Dennis, Jr., F. G., W. S. Carpenter, and W. J. MacLean. 1975. Cold hardiness of 'Montmorency' sour cherry flower buds during spring development. HortScience 10:529–531.
4. Jones, H. A. and L. K. Mann. 1963. Onions and their allies. Interscience, New York.
5. Proebsting, Jr., E. L. and H. W. Fogle. 1956. An apparatus and method of analysis for studying fruit bud hardiness. Proc. Amer. Soc. Hort. Sci. 68:6–14.
6. Proebsting, Jr., E. L. and H. H. Mills. 1972. A comparison of hardiness responses in fruit buds of 'Bing' cherry and 'Elberta' peach. J. Amer. Soc. Hort. Sci. 97:802–806.
7. Young, R. H. 1966. Freezing points and lethal temperatures of citrus leaves. Proc. Amer. Soc. Hort. Sci. 88:272–279.

HortScience 16(6):774–775. 1981.

Inheritance of Resistance to Trifluralin Toxicity in *Cucurbita moschata* Poir[1]

Adeoye A. Adeniji and Dermot P. Coyne[2]
Department of Horticulture, University of Nebraska, Lincoln, NE 68583

Additional index words. butternut squash, calabaza squash, Treflan, herbicide injury, genic interaction, inhibitor

***Abstract.* The inheritance of response to trifluralin (Treflan) at 1.12 kg/ha was studied in the field, using transplants of parents, F_1, F_2, and BC_1 generations of the *Cucurbita moschata* crosses 'La Primera' with 'Butternut Ponca' and 'Waltham'. Parents and F_1s were susceptible. Based on segregation data in the F_2 and BC_1 generations it is hypothesized that a dominant gene *T* determines resistance but is inhibited by a dominant *I-T* gene. Proposed genotypes for 'La Primera' and the 2 'Butternut' cultivars are *I-T I-T T T* and *i-t i-t t t*, respectively.**

Several workers have reported that some herbicides are selective in cucurbits when soil-incorporated (4, 7) including the dinitroanilines such as trifluralin. Trifluralin and nitralin were reported to be selective in muskmelon and watermelon, and nitralin was tolerated by squash (7). Menges et al. (6) reported that preplant soil-incorporated applications of benefin and trifluralin decreased watermelon yield. LeBaron (5) observed severe injury to squash and other cucurbits from preplant soil-incorporation of trifluralin.

There is no satisfactory herbicide treatment to control weeds in Butternut squash (*Cucurbita moschata* Poir) at present (R. D. Sweet, Cornell Univ., personal communication). Several researchers (2, 3) have reported that squash was tolerant to amiben, but LeBaron (5) reported that amiben gave poor weed control in cucurbits. Butternut squash cultivars resistant to trifluralin would permit the use of this dependable herbicide. In this paper we report a serendipitous finding of resistance and inheritance of resistance to trifluralin injury in progeny derived from crosses of susceptible *C. moschata* parents. The crosses were made to study the inheritance of resistance to powdery mildew (1).

Three *C. moschata* parents, susceptible to trifluralin injury, were Butternut squash cultivars, 'Ponca' and 'Waltham' and a calabaza cultivar 'La Primera'. 'La Primera' was crossed to each of the 2 Butternut cultivars in 1978. The F_1s were grown in the field in 1979 and selfed. The F_1s were also backcrossed to each Butternut cultivar.

Seeds of the parents, F_1, F_2, and BC_1 generations of each cross were planted in Jiffy 7's pellets (1 seed per pellet) in the greenhouse under 30°C (day)/22° (night) on May 9, 1980 and transplanted in the field, Lincoln, Nebraska, May 22, 1980. Progenies from the 'La Primera' x 'Ponca' cross (Expt. 1) were transplanted in one field (2.2% organic matter, 38.2% clay, pH 7.3). Those from the 'La Primera' x 'Waltham' cross (Expt. 2) were transplanted in an adjacent field (2.63% organic matter, 40.8% clay, pH 6.4). The soil type in each field was a Sharpsburg silty clay loam (Typic Arguidoll). Butternut squash was grown in each field the previous year and amiben was used for weed control (transplants covered with milk cartons during application). A randomized complete block design with 3 replications was used in each experiment. Four single-row plots of the F_2 population and 1 single row plot of the other populations were used in each replicate. Each row contained 8 single-plant hills spaced 1.8 m apart in rows spaced 2.4 m apart. The plots were irrigated by means of overhead sprinklers about every 2 weeks from date of planting until mid-September. Trifluralin at the rate of 1.12 kg/ha was soil-incorporated a day before transplanting the squash seedlings.

All parents and F_1 progenies were injured by trifluralin and exhibited restricted root growth, severe wilting on hot days, and stunted growth (Table 1). Many of these injured plants died later. 'La Primera' was slightly less susceptible than the Butternut cultivars. Plant injury was slightly less severe in the field (Expt. 2) containing the 'La Primera' x 'Waltham' progeny than in the other field (Expt. 1). This may have been due to the slightly higher organic matter content in this field.

Clear bimodal distributions of susceptible

[1]Received for publication March 16, 1981. Published as Paper No. 6538, Journal Series, Nebraska Agricultural Experiment Station. Research was conducted under Project 20-14. Part of a thesis presented by A. A. Adeniji to the faculty of the Graduate College, University of Nebraska, in partial fulfillment of requirements for the PhD degree.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.
[2]Graduate student, and Professor, respectively.
We appreciate seed of 'La Primera' squash from R. B. Volin, Agr. Res. and Educ. Center, University of Florida, Homestead; the field assistance of Mr. Charles Boyes, Mr. H. K. Leyna, and Miss Cheryl Campbell; and the typing assistance of Mrs. David Morningstar, Lincoln, Nebr.

Table 1. Frequency distributions of response to trifluralin herbicide in parents, F_1, F_2 and BC_1 generations of crosses of *Cucurbita moschata* cultivars.

Generation	No. of plants in injury classes[z]									
	1	2	3	4	5	6	7	8	9	10
Expt. 1										
La Primera (P_1)									10	6
Butternut Ponca (P_2)										15
F_1 (P_1 x P_2)									2	21
F_2 (P_1 x P_2)	12	1					7	2	20	54
BC_1 (P_1 x P_2) x P_2	2							2	1	19
Expt. 2										
La Primera (P_1)						1	1	1	7	1
Butternut Waltham (P_3)								1	13	5
F_1 (P_1 x P_3)							1	5	11	4
F_2 (P_1 x P_3)	9	1	1				1	3	57	20
BC_1 (P_1 x P_3) x P_3	4	2	1				2	3	8	3

[z]Plant injury rating scale: 1 = no injury; 2, 3, 4 = slight; 5, 6 = moderate; 7, 8, 9 = severe; 10 = complete kill.

and resistant plants occurred in the F_2 and BC_1 generation of each cross (Table 1). A considerable number of plants in these F_2 and BC_1 progenies showed either no injury, or were only slightly injured by the herbicide, indicating resistance to trifluralin. A satisfactory fit to a 13:3 ratio of herbicide-susceptible and herbicide-resistant plants was observed in each F_2 of the 2 crosses (Table 2). The BC_1 progeny of both crosses and the combined progeny, showed a satisfactory fit to a 3:1 ratio of the herbicide susceptible and herbicide-resistant plants (χ^2 = 0.56, P. 0.3–0.5) (Table 2). There was no evidence of heterogeneity in either the F_2 families (χ^2 = .08, P. 0.7–0.8) or the BC families (χ^2 = 2.29, P. 0.1–0.2). However, the combined F_2 data did not satisfactorily fit a 13:3 ratio due to a slight deficiency of resistant plants.

These results suggest that a dominant gene, designated *T*, was primarily responsible for resistance to trifluralin toxicity, but was not expressed in the presence of a dominant inhibitor gene symbolized as *I-T*. It is hypothesized that resistant plants are homozygous recessive *i-t i-t* in the presence of dominant *T*. Any other state of the alleles at these 2 loci would determine susceptibility. It is hypothesized that the genotype of 'La Primera' is *I-T I-T T T* and 2 Butternut cultivars are *i-t i-t t t*. The Butternut cultivars would have to be homozygous recessive at both loci in order to obtain a 3:1 ratio of susceptible and resistant plants in the backcross progeny derived from the backcross of the F_1 to these cultivars.

These results suggest that the major gene *T*, present in 'La Primera', and determining resistance to trifluralin injury could be transferred to susceptible Butternut cultivars by means of a backcross program. We did not detect any unfavorable association of traits in the segregating generations. In order for this resistance to be more generally useful, it would need to be expressed in direct field-seeded-plantings. The introduction of trifluralin resistant Butternut cultivars, either grown from transplants or from field-sown seeds, would permit the use of this herbicide to overcome some of our present grass weed control problems in squashes.

Table 2. Segregation for response to trifluralin in progenies derived from crosses of *Cucurbita moschata* cultivars.

Generation	No. plants observed		Expected ratio[z]	χ^2[y]	P
	Susceptible	Resistant			
Expt. 1					
La Primera (P_1)	16				
Butternut Ponca (P_2)	15				
F_1 (P_1 x P_2)	23				
F_2 (P_1 x P_2)	83	13	13:3	1.40	.10–.20
BC_1 (P_1 x P_2) x P_2	22	2	3:1	2.72	.05–.10
Expt. 2					
La Primera (P_1)	11				
Butternut Waltham (P_3)	19				
F_1 (P_1 x P_3)	21				
F_2 (P_1 x P_3)	81	11	13:3	2.36	.05–.10
BC_1 (P_1 x P_3) x P_3	16	7	3:1	0.13	.7–.8

[z]Assuming the following genotypes, where the dominant gene *T* confers resistance to trifluralin and *I-T* is a dominant inhibitor.

La Primera *I-T I-T T T*
Butternut Ponca *i-t i-t t t*
Butternut Waltham *i-t i-t t t*

[y]Corrected chi-square obtained by subtracting 0.5 from the absolute value of each deviation prior to squaring the deviation.

Literature Cited

1. Adeniji, A. A. and D. P. Coyne. 1981. Inheritance of reaction of powdery mildew (*Erysiphe cichoracearum* D.C.) in crosses within *Cucurbita moschata* Poir. HortScience 16:411. (Abstr.)
2. Cialone, J. C., N. J. Smith, and B. L. Pollack. 1969. Herbicide evaluations in muskmelon (*Cucumis melo* L.) and squash (*Cucurbita maxima*) grown on clear polyethylene mulch. Weed Sci. (Abstr. 46.)
3. Ivany, J. A. and R. D. Sweet. 1969. Response of cucurbits to certain analogs of amiben (3-amino-2, 5-dichloro benzoic acid). Weed Sci. (Abstr. 44.)
4. Lange A., D. May, B. Fisher, and F. Ashton. 1968. Weed control in cucurbits. Calif. Agr. 22(3):8–9.
5. LeBaron, H. M. 1964. Chemical weed control in cucurbits. Proc. East. Weed Contr. Conf. 18:45–51.
6. Menges, R. M., T. D. Longbrake, and S. Tamez. 1972. Effects of soil incorporation on selectivity, movement and persistance of herbicide in watermelon plantings. J. Amer. Soc. Hort. Sci. 97:168–172.
7. Talbert, R. E. 1969. Evaluation of herbicides for weed control in cucurbits. Weed Sci. (Abstr. 45.)