

# Cucurbit Genetics Cooperative

Report No. 12  
May 1989

University of Maryland  
1122D Holzapfel Hall  
College Park, MD 20742-5611 USA  
Tel: (301) 454-2463

## Chairman

Timothy J Ng  
University of Maryland  
Department of Horticulture  
College Park, MD 20742-5611 USA

## Coordinating Committee

Gary W. Elmstrom (muskmelon)  
Univ. Florida Agr. Res. Ctr.  
5336 University Avenue  
Leesburg, FL 32748 USA

Warren R. Henderson (watermelon)  
Dept. Hort. Sci., Box 5216  
North Carolina St. Univ.  
Raleigh, NC 27650-5216 USA

J. Brent Loy (Cucurbita spp.)  
Dept. Plant Sciences  
Univ. New Hampshire  
Durham, NH 03824 USA

Richard W. Robinson (other genera)  
Dept. Horticultural Science  
New York Agr. Expt. Sta.  
Geneva, NY 14456 USA

Todd C. Wehner (cucumber)  
Dept. Hort. Sci., Box 7609  
North Carolina St. Univ.  
Raleigh, NC 27695-7609 USA

## Gene List Committee

Cucumber  
Todd C. Wehner  
Dept. Hort. Sci., Box 7609  
North Carolina St. Univ.  
Raleigh, NC 27695-7609 USA

Muskmelon  
Michel Pitrat  
Centre de Rech. Agron. de Avign.  
Stat. d'Amelior. des Plantes Mar.  
Domaine St.-Maurice  
84140 Montfavet, France

Watermelon  
Warren R. Henderson  
Dept. Hort. Sci., Box 5216  
North Carolina St. Univ.  
Raleigh, NC 27650-5216 USA

Cucurbita spp.  
Other Genera  
Richard W. Robinson  
Dept. Horticultural Science  
New York Agr. Expt. Sta.  
Geneva, NY 14456 USA

## Gene Curators

Cucumber  
Todd C. Wehner  
Dept. Hort. Sci., Box 7609  
North Carolina St. Univ.  
Raleigh, NC 27695-7609 USA

Muskmelon  
Edward L. Cox  
Texas Agric. Expt. Station  
2415 East Highway 83  
Weslaco, TX 78596-8399 USA

Watermelon  
Billy B. Rhodes  
Clemson University  
Edisto Res. & Educ. Center  
Blackville, SC 29817 USA

Cucurbit spp.  
Richard W. Robinson  
Dept. Horticultural Science  
New York Agr. Expt. Sta.  
Geneva, NY 14456 USA

**The Cucurbit Genetics Cooperative (CGC) was organized to develop and advance the genetics of economically important cucurbits. Membership to this Cooperative is voluntary and open to workers who have an interest in cucurbit genetics. Membership is on a biennial basis.**

**CGC Membership and Subscription Rates:**

<b>Biennium</b>	<b>Member</b>	<b>Library</b>
1989-90	\$13.00 US*	\$24.00 US
1990-91	\$14.00 US	\$24.00 US

\*airmail subscription rates for the Report are also available.

Reports of the Cooperative are issued on an annual basis. The reports include articles submitted by members for the use of the members of the Cucurbit Genetics Cooperative. None of the information in the annual report may be used in publications without the consent of the respective authors for a period of five years. After five years, the information may be used in publications without the consent of the authors.

## Table of Contents

vi	Comments from the CGC Coordinating Committee
vi	Comments from the CGC Gene List Committee
vi	Comments from the CGC Gene Curators
vii	Report of the Twelfth Annual CGC Business Meeting
viii	CUCURBITACEAE '89: Evaluation and Enhancement of Cucurbit Germplasm
viii	Report from the 1989 Watermelon Workshop
ix	US Cucurbit Crop Advisory Committee Update
ix	Future Cucurbit Meetings for 1989-90
x	Corrigenda

### I. Cucumber

1	<i>Alternaria alternata</i> f. sp. <i>cucurbitae</i> on cucumber and other cucurbits D.J. Vakalounakis
5	Toxins: potential screening aid for selecting anthracnose resistance in cucumbers D.C. Linde, J.M. Shively and B.B. Rhodes
7	Tolerance of cucumber to chloramben herbicide J.E. Staub and L.K. Crubaugh
9	Cucumber yield improvement through breeding in the Southeast U.S.A. T.C. Wehner
11	Source-sink relationships in cucumber J.E. Staub
15	Delayed pollination successful for cucumbers in North Carolina greenhouse T.C. Wehner and R.R. Horton, Jr.
16	Seed weight of cucumber cultivars T.C. Wehner and R.R. Horton, Jr.
18	Electrophoretic examination of <i>Cucumis sativus</i> L. and <i>Cucumis melo</i> L. V.S. Sujatha and V.S. Seshadri
20	Improvements of in vitro growth of cucumber J.B.M. Custers and E.C.P. Verstappen
22	Haploid gynogenesis in <i>Cucumis sativus</i> induced by irradiated pollen A. Sauton
24	Preliminary data on haploid cucumber ( <i>Cucumis sativus</i> L.) induction K. Niemirowicz-Szczytt and R.D. de Vault
26	Isolation and culture of <i>Cucumis metuliferus</i> protoplasts W.H. McCarthy, T.C. Wehner and M.E. Daub
29	Isolation and culture of protoplasts of <i>Cucumis sativus</i> and <i>Cucumis metuliferus</i> and methods for their fusion F.A. Tang and Z.K. Punja
35	Transformation of cucumber with <i>Agrobacterium rhizogenes</i> F. van der Mark, J.H.W. Bergervoet and J.B.M. Custers

## II. Muskmelon

- 37 Tolerance reaction of muskmelon to inoculation with *Fusarium oxysporum* f. sp. *melonis* races 0 and 1  
D. Gabillard and M. Jacquet
- 39 Resistance to *Sphaeroteca fuliginea* (Schlecht. ex Fr.) Poll. in Spanish muskmelon cultivars  
M.L. Gómez-Guillamón and J.A. Torés
- 40 Transmission of the causal agent of muskmelon yellowing disease  
C. Soria and M.L. Gómez-Guillamón
- 42 Search for sources of resistance to yellowing disease in *Cucumis* spp.  
C. Soria, M.L. Gómez-Guillamón, J. Esteva and F. Nuez
- 44 Resistance to yellowing disease in muskmelon  
J. Esteva, F. Nuez and M.L. Gómez-Guillamón
- 46 A screening procedure for ZYMV resistance in muskmelons  
A.J. Raffo, I.A. Khan, L.F. Lippert, M.O. Hall and G.E. Jones
- 50 Low temperature germination in muskmelon is dominant  
H. Nerson and J.E. Staub
- 51 Ethylene production by germinating seeds of different sexual genotypes of muskmelon (*Cucumis melo* L.)  
J. Alvarez
- 53 Flesh calcium content of group Inodorus and group Reticulatus muskmelon (*Cucumis melo* L.) fruits  
T. J Ng and V. Carr
- 55 Direct and indirect regeneration of *Cucumis melo* L. from cotyledon culture  
W.A. Mackay, T. J Ng and F.A. Hammerschlag

## III. Watermelon

- 58 A second look at the glabrous male-sterile (gms) character in watermelon  
B.B. Rhodes, B.A. Murdock and J.W. Adelberg
- 59 Inheritance of orange flesh color in watermelon  
W.R. Henderson
- 64 Influence of handling and nitrogen nutrition on flowering and growth of watermelon transplants in the greenhouse  
R.N. McArdle
- 67 Studies of watermelon germplasm resources and breeding. III. Correlation between parents and their F<sub>1</sub> hybrids, phenotypic correlation among characters, and path analysis  
Zhang Xingping and Wang Ming

#### IV. *Cucurbita* spp.

- 68 *Cucurbita moschata* half-sib families collected in Puerto Rico and the Dominican Republic  
L. Wessel-Beaver and M.W. Carbonell
- 70 Inheritance of mottled leaf in *Cucurbita moschata* Poir  
A. Ribeiro and C.P. da Costa
- 72 List, description, and interactions of the genes affecting fruit color in *Cucurbita pepo*  
H.S. Paris
- 75 Relationship between the *B* genes of two *Cucurbita* species, II.  
O. Shifriss, R.B. Volin and Tom V. Williams
- 79 Relationship between gene *B* and gene *Ses-B* in *Cucurbita pepo* L.  
O. Shifriss
- 82 Control of chlorophyll during plant development: Hypothesis  
O. Shifriss
- 84 Determination of molecular weight of chloroplast DNA of *Cucurbita pepo* L. using different restriction enzymes  
H.T. Lim and C. Boyer

#### V. Other genera

- 86 Taxonomic position of round melon (*Praecitrullus fistulosus*)  
V.S. Sujatha and V.S. Seshadri
- 89 Allozyme studies in the Benincaseae  
D.S. Decker-Walters and T.W. Walters

#### VI. Appendices

- 91 Gene List for Cucumber  
L.K. Pierce and T.C. Wehner
- 104 CGC Cumulative Index [Reports 1-11 (1978-880)]  
T. Ng
- 115 Membership Directory
- 122 Covenant and By-Laws of the Cucurbit Genetics Cooperative
- 124 Financial Statement

### Comments from the CGC Coordinating Committee

The Call for Papers for the 1990 Report (CGC Report No. 13) will be mailed in August 1989. Papers should be submitted to the respective Coordinating Committee members by 31 December 1989. The Report will be published by June 1990.

As always, we are eager to hear from CGC members regarding our current activities and the future direction of CGC.

It is a pleasure to acknowledge CGC members Marisa Maiero and Wayne A. Mackay for their assistance in assembling CGC Report No. 12 (1989).

Gary W. Elmstrom (muskmelon)  
Warren R. Henderson (watermelon)  
J. Brent Loy (*Cucurbita* spp.)  
Richard W. Robinson (other genera)  
Todd C. Wehner (cucumber)  
Timothy J Ng, Chairman

### Comments from the CGC Gene List Committee

Lists of known genes for the Cucurbitaceae have been published previously in HortScience and in reports of the Cucurbit Genetics Cooperative. CGC is currently publishing complete lists of known genes for muskmelon (*Cucumis melo*), watermelon (*Citrullus lanatus*), cucumber (*Cucumis sativus*) and *Cucurbita* spp. on a rotating basis.

It is hoped that scientists will consult these lists as well as the rules of gene nomenclature for the Cucurbitaceae (HortScience 11:554-568, 1976; CGC Report 5:62-66, 1982) before choosing a gene name and symbol. Thus, inadvertent duplication of gene names and symbols will be prevented. The rules of gene nomenclature were adopted in order to provide guidelines for the naming and symbolizing of genes previously reported and those which will be reported in the future. Scientists are urged to contact members of the Gene List Committee regarding questions in interpreting the nomenclature rules and in naming and symbolizing new genes.

Cucumber:	Todd C. Wehner
Muskmelon:	Michel Pitrat
Watermelon:	Warren R. Henderson
<i>Cucurbita</i> spp.:	Richard W. Robinson
Other Genera:	Richard W. Robinson

### Comments from the CGC Gene Curators

CGC has appointed Curators for the four major cultivated groups: cucumber, muskmelon, watermelon and *Cucurbita* spp. A curator for the Other Genera category is needed. Anyone wishing to take on this responsibility should contact the Chairman.

Curators are responsible for collecting, maintaining and distributing upon request stocks of the known marker genes. CGC members are requested to forward samples of currently held gene stocks to the respective Curator.

Cucumber:	Todd C. Wehner
Muskmelon:	Edward L. Cox
Watermelon:	Billy B. Rhodes
<i>Cucurbita</i> spp.:	Richard W. Robinson

# Report of the Twelfth Annual CGC Business Meeting

10 August 1988

Michigan State University, East Lansing, MI

The 12th Annual Business Meeting of the Cucurbit Genetics Cooperative was held on 10 August 1987 in conjunction with the 85th Annual Meeting of the American Society for Horticultural Science at Michigan State University in East Lansing, MI. The meeting was called to order by J.D. McCreight, Chairman. Twenty-six members and guests were in attendance.

CGC Report No. 11 (1988) was mailed to members on 25 July 1988. The cost of printing and mailing CGC 11 was \$1443.95. Twenty-two new members joined in 1987, making a total of 182 active members by the end of the year. Current CGC cash reserves totaled \$3,089.64.

J.D. McCreight provided a summary of the Cucurbitaceae '88 EUCARPIA meeting. A meeting of European CGC members was convened there, and members expressed an interest in having the CGC Report list international meetings as well as those in the U.S. They expressed interest in the cucurbit gene collections and encouraged geneticists to increase their activity in this area. They also expressed a desire to have an airmail option for the CGC Report in order to receive it in a more timely fashion.

Two CGC Coordinating Committee changes were announced. J. Brent Loy replaced Jack Juvick as Coordinating Committee member for *Cucurbita* spp. and Tim Ng replaced J.D. McCreight as CGC Chairman.

Tim Ng assumed chairmanship of the meeting, introduced himself, and expressed his appreciation for the efforts of J.D. McCreight on behalf of CGC over the years. He next had those in attendance introduce themselves and mention their affiliations and research interests.

The subject of content of the CGC Report was brought up. Although the content of papers in the Report now extends beyond the original concept of having only genetic studies with cucurbit species published, the subject matter currently being accepted was agreeable to those present and the present policy will be continued. The policy of not allowing citation of CGC research reports without the author's permission for a period of five years was retained, as was the policy of publishing a complete gene list for each major cucurbit crop/species every four years. The 31 December deadline for submission of articles to CGC was also retained, and every effort will be made in 1989 to have CGC Report No. 12 mailed by April. A subsequent mailing will be made during the Summer of 1989 informing members of upcoming meetings of interest to cucurbit workers.

The cost of publishing the CGC Report increased in 1988. Also, U.S. postage rates increased substantially in April 1988 for books and printed materials, including the CGC Report. To offset the increased costs, it was moved and accepted that membership dues would rise by \$1 per year effective in 1990. Hence, members renewing for 1989-90 would be billed \$13 and those renewing for 1990-91 would be billed \$14. An airmail op-

tion for non-U.S. subscribers would also be available beginning with renewals for 1989-90.

An announcement was made about the international meeting on "Evaluation and Enhancement of Germplasm of the Cucurbitaceae" which will be hosted by the U.S. Vegetable Laboratory, USDA-ARS, in Charleston, South Carolina, in November 1989. This meeting will be in conjunction with the joint meetings of: the Vine Crops Crop Advisory Committee, the National Muskmelon Research Group, the Watermelon Research Group, the Squash Breeders, and the Pickling Cucumber Improvement Committee. It will directly precede the Biennial Collaborators' Conference on Vegetable Breeding in the Southeastern United States. All Federal, state, and private industry scientists involved or interested in research on cucurbit crops are invited. Tentative dates are 12-14 November 1989. Further announcements will be published through CGC. ASHS, EUCARPIA, and the individual working groups. CGC members can also be placed on a mailing list for further announcements by contacting: C.E. Thomas, USDA-ARS, U.S. Vegetable Laboratory, 2875 Savannah Hwy., Charleston, SC 29414.

Joe Norton displayed a honeydew melon developed in Iran, described its properties and availability, and sliced pieces for sampling as the CGC meeting was adjourned.

**Cucurbitaceae '89**  
**Evaluation and Enhancement of Cucurbit Germplasm**

Location: Omni Hotel, Charleston, South Carolina USA

Dates: November 29 - December 2, 1989

The purpose of Cucurbitaceae '89 is to provide a forum for the presentation and exchange of scientific information about germplasm evaluation and enhancement research activities on cucurbit crops (cucumber, muskmelon, pumpkin, squash, and watermelon). All persons engaged or interested in these research areas are invited to participate. Cucurbitaceae '89 will be hosted by the USDA - U.S. Vegetable Laboratory, and the official language will be English.

The scientific program will consist of invited papers by recognized authorities on topics related to evaluation and enhancement research in cucurbit crops, contributed presentations by meeting participants, and meetings of the following groups:

Cucurbit Crop Advisory Committee  
Cucurbit Genetics Cooperative  
National Muskmelon Research Group  
Watermelon Research Group  
Squash Breeders Group  
Pickling Cucumber Improvement Committee

For further details, including registration materials and information on travel and accommodations, guidelines for abstracts and posters, etc., contact: Dr. C.E. Thomas, USDA-ARS, U.S. Vegetable Lab, 2875 Savannah Highway, Charleston, SC 29414 USA.

**US Watermelon Research Group**

The 9th annual meeting of the Watermelon Workshop was held on 7 February 1989 in Nashville, Tennessee, with over forty participants in attendance. Doyle Smittle discussed the status of non-destructive measurement of maturity and quality of melons; it appears that availability of a commercially available unit is still sometime in the future. Don Hopkins discussed his work with growing watermelons in a monoculture, and Ray Martyn reviewed his work on induced resistance to Fusarium wilt. Lively discussions were also held on the topics of "Hollow Heart of Watermelon" and "Pollination of Triploids." The Watermelon Research Group will hold its next meeting in conjunction with Cucurbitaceae '89 in November-December of 1989, and will meet in Little Rock, Arkansas, on 4-6 February 1990.

Gary W. Elmstrom, Chair



## US Cucurbit Crop Advisory Committee Update

The Cucurbit Crop Advisory Committee (formerly Vine Crops CAC) met in Madison, Wisconsin, in conjunction with the Pickling Cucumber Improvement Committee on 9 November 1988. In 1988, the Cucurbit CAC recommended that the National Plant Germplasm System (NPGS) fund four germplasm evaluation proposals and one germplasm enhancement proposal. These proposals included: verification of the species identity of *Cucurbita* accessions in the Regional Plant Introduction Stations; evaluation of cucumbers, muskmelons and *Cucurbita* for disease resistance; and transferring virus resistance from wild to cultivated muskmelon. In 1988, the committee completed and updated the five major sections (cucumber, muskmelon, watermelon, squash and pumpkin, and exotic species) and submitted its report to NPGS on the status and needs for cucurbit germplasm collection, storage, evaluation, and enhancement. NPGS requested a statement on the applicability of the Core Concept to cucurbit germplasm evaluation. The Core Concept addresses the problems of maintenance and efficient evaluation of large germplasm collections and proposes the creation of a carefully selected subset of the germplasm collection for routine evaluation; subsequent evaluation would focus on accessions in the larger collection indicated by the core evaluation as being likely sources for the desired traits. The Core Concept is controversial and remains to be proven. The major concerns of the committee were the integrity of the accessions (relative to the original seeds) and the information in the Germplasm Resource Information Network (GRIN), and the acquisition of additional germplasm before the Centers of Origin and Diversification are lost to development.

James D. McCreight, Chair

### Cucurbit Genetics Cooperative Meetings in 1989

The Thirteenth Annual Business Meeting of the Cucurbit Genetics Cooperative will be held in conjunction with the 86th Annual Meeting of the American Society for Horticultural Science (ASHS) in Tulsa, Oklahoma, 29 July - 3 August 1989. Further information will be available in the Program & Abstracts issue for the ASHS Annual Meeting (HortScience vol. 24(4)) when it is published. The Cucurbit Genetics Cooperative will also hold a meeting in conjunction with Cucurbitaceae '89 in Charleston, South Carolina, in November- December of 1989.

Other meetings of interest to CGC members:

Group (s)	Date & Location	Contact Person
Cucurbit Crop Advisory Committee National Muskmelon Research Group Watermelon Research Group Squash Breeders Group Pickling Cucumber Improv. Committee	29 Nov - 2 Dec 1989 Charleston, South Carolina (Cucurbitaceae '89)	Dr. C.E. Thomas USDA-ARS, U.S. Veg. Lab. 2875 Savannah Highway Charleston, SC 29414 USA Tel: (803) 766-3761
Watermelon Research Group	4-6 February 1990 Little Rock, Arkansas	Dr. Gary W. Elmstrom Univ. Florida Agr. Res. Ctr. 5336 University Avenue Leesburg, FL 32748 USA Tel: (904) 787-3423

### Corrigenda

In the article "Reactions of Muskmelon Genotypes to Races 1 and 2 of *Sphaerotheca fuliginea* in Israel," by Y. Cohen and H. Eyal [CGC 11:47-49, 1988], severity ratings in Table 1 for the genotype Charantais-T should be "+ + +" and "+ + +" for races 1 and 2, respectively, not "-" and "-" as they appeared.

In the abstract "Studies on Watermelon Germplasm Sources Resistant to Fusarium Wilt Disease at the Seedling Stage," by Wang Ming and Zhang Xian [CGC 11:68, 1988], in paragraph 1, sixth line, " $5 \times 10^3$  spores" should read " $5 \times 10^5$  spores."

*Alternaria alternata* f. sp. *cucurbitae* on Cucumber and Other Cucurbits

Demetrios John Vakalounakis

Plant Protection Institute, Heraklio, Crete, Greece

During the 1979 to 1980 crop season, a severe leaf spot disease of cucumber (*Cucumis sativus* L.) was noticed on greenhouse crops grown in some plastic houses in the Sitia area, Lasithi, Crete, Greece, along the coastal strip between Koutsouras and Goudouras (10). Since then, it has spread to most of the cucumber growing areas in Crete, causing severe losses.

Symptoms appear in late autumn, mainly on the leaves of the middle and upper part of the plants. Necrotic flecks, surrounded by a chlorotic halo, appear on the leaf, and these enlarge to spots which may coalesce to form lesions up to 5 cm or more in diameter. The lesions appear circular in shape and bear black-brown fructifications of the pathogen. Severely-infected leaves become yellow, senescent, and die. No other part of the plant is affected. During the winter, when relative humidity in the plastic houses is high and plant vigor is reduced due to fruit bearing and unfavorable climatic conditions (reduced illumination and average air temperature lower than 15°C), infection progresses rapidly throughout the crop resulting in severe damage within a few days (11).

A long-chained *Alternaria* spp. with small spores was always observed on the old lesions of infected cucumber leaves. The same fungus was consistently obtained from samples taken from different plastic houses when pieces of infected tissue or spores from the spots were plated out on Petri dishes containing potato dextrose agar (PDA). The cultures of the fungus on PDA at 25°C under "daylight" fluorescent lamps have a dirty white color at the beginning, while later the center becomes grey. In a few days, the entire surface is covered with an abundance of spores. The spores on infected leaves or on cultures on PDA are produced in long chains on short conidiophores. They are brown but, when many of them have been produced on PDA, they look black with a velvety appearance. The dimensions of the spores either *in vivo* or *in vitro* (Table 1) agree fairly well with published descriptions of *Alternaria alternata* (Fr.) Keissler (8) and its synonym *Alternaria tenuis* Auct. (6,7). The pathogen of the present disease is also similar to *A. alternata* f. sp. *lycopersici* which causes a stem canker of tomato (2). *Alternaria* infections similar to those described in this paper are very common on cucumber but are caused by *Alternaria cucumerina* (Ellis & Everh.) Elliott (synonym *Alternaria brassicae* f. *nigrescens* Pegl.) (1,5) or *Alternaria pluriseptata* (Karst. & Har.) Jorstad [synonyms *Alternaria cucurbitae* Let. & Roum., *Stemphylium ilicis* Tengwall, *Ulocladium cucurbitae* (Let. & Roum.) Simmons, *Ulocladium atrum* Press] (3,9). However, both these fungi are morphologically distinct (1,4,5,6) and are readily distinguishable from *Alternaria alternata* (11).

Of 62 cultivated and weedy species in 16 botanical families artificially inoculated and naturally infected in greenhouse experiments, 27 species belonging to the Cucurbitaceae were found to be susceptible to the pathogen (Table 2).

Table 1. Morphological characteristics of conidia of *Alternaria alternata* f. sp. *cucurbitae* from cucumber leaf spots in comparison with those of published descriptions of *A. alternata*, *A. cucumerina* and *A. pluriseptata*.

Spore measurements ( $\mu\text{m}$ )	Body length	Body width	Beak length	Spores (% with beaks)	Total length	No. of septa	Spores/chain
<b><i>A. alternata</i></b>							
Cucumber leaf spot	38.4 $\pm$ 12.0 <sup>z</sup> (15-68) <sup>y</sup>	14.6 $\pm$ 3.3 (9-24)	6.3 $\pm$ 4.4 (1-21)	75	42.2 $\pm$ 14.3 (15-73)	2-8	4-5
PDA	20.1 $\pm$ 4.8 (12-29)	9.7 $\pm$ 2.0 (6-14)	5.1 $\pm$ 2.3 (3-12)	57	25.3 $\pm$ 4.5 (17-34)	2-5	8
<b><i>A. alternata</i> (Simmons, 1967)</b>							
Neotype specimen	30.9 (18-47)	12.6 (7-18)	up to 25	-	-	3-8	-
<b><i>A. tenuis</i></b>							
Medium	25.7 (7-70)	11.2 (6-20)	5 (1-58)	80	7-72	1-6	8
<b><i>A. alternata</i> f. sp. <i>lycopersici</i></b>							
Tomato	32.3 $\pm$ 2.8 (18-50)	12.4 $\pm$ 2.8 (7-18)	6.8 $\pm$ 6.0 (2-20)	72	18-68	1-5	3-4
<b><i>A. cucumerina</i> (Jackson, 1958)</b>							
Host	57-87	18-21	106-135	-	-	5-9	-
<b><i>A. pluriseptata</i> (Hervert et al., 1980)</b>							
Host	19-66	8-16	-	-	-	2-9	-
<b><i>Ulocladium atrum</i> (Simmons, 1967)</b>							
Medium	18.6 16.5-19.8	16.0 13.2-18.7	no beaks	-	-	1-3	1; sometimes 2

<sup>z</sup>Mean  $\pm$  standard deviation.

<sup>y</sup>Numbers in parenthesis indicate extreme values.

Table 2. Susceptibility of cucurbitaceous species and some belonging to other families to infection by *Alternaria alternata* f. sp. cucurbitae.

Species	Disease severity	Species	Disease severity
<b>CUCURBITACEAE</b>		<b>AMARANTHACEAE</b>	
<i>Benincasa hispida</i> (Thunb.) cogn.	+++	<i>Amaranthus retroflexus</i> L.	-
<i>Citrullus lanatus</i> (Thunb.) Mansf.	++++	<i>Gomphrena globosa</i> L.	-
<i>Cucumis africanus</i> L. f.	+	<b>CHENOPODIACEAE</b>	
<i>Cucumis anguria</i> L.	+++	<i>Beta Vulgaris</i> L.	-
<i>Cucumis dipsaceus</i> Ehrenb.	+	<i>Chenopodium album</i> L.	-
<i>Cucumis ficifolius</i> A. Rich.	++	<i>Spinacia oleracea</i> L.	-
<i>Cucumis hardwickii</i> Royle	++++	<b>COMPOSITAE</b>	
<i>Cucumis longipes</i> Hook.	++	<i>Aster squamatus</i> (Spr.) Hier.	-
<i>Cucumis melo</i> L.	++++	<i>Cichorium endivia</i> L.	-
<i>Cucumis pustulatus</i>	++++	<i>Cichorium intybus</i> L.	-
<i>Cucumis sativus</i> L.	+++++	<i>Erigeron canadensis</i> L.	-
<i>Cucurbita ficifolia</i> B.	+	<i>Lactuca sativa</i> L.	-
<i>Cucurbita foetidissima</i> Kunth.	+	<i>Lactuca serriola</i> L.	-
<i>Cucurbita lundelliana</i> Bailey	++	<i>Sonchus asper</i> (L.) Hill.	-
<i>Cucurbita maxima</i> Duch.	+	<b>CONVOLVULACEAE</b>	
<i>Cucurbita mixta</i> Pang.	+++	<i>Convolvulus arvensis</i> L.	-
<i>Curcurbita moschata</i> (Duch.) Duch. ex Poir.	+++	<b>CRUCIFERAE</b>	
<i>Cucurbita palmata</i> Wats.	+++	<i>Brassica oleracea</i> L.	
<i>Cucurbita pepo</i> L.	+++	var. <i>capitata</i>	-
<i>Cucurbita sororia</i>	+++	<i>Raphanus sativus</i> L.	-
<i>Cucurbita texana</i> A. Gray	+	<b>CYPERACEAE</b>	
<i>Ecballium elaterium</i> (L.) A. Rich.	+	<i>Cyperus longus</i> L.	-
<i>Lagenaria leucantha</i> Rusby var. <i>clavata</i> Makino	+++++	var. <i>badius</i> Desf.	-
<i>Lagenaria siceraria</i> (Mol.) Standl. ssp.		<b>GERANIACEAE</b>	
asiatica (Kob). Heiser	++++	<i>Erodium malacoides</i> Willd.	-
<i>Lagenaria vulgaris</i> Ser.	+++++	<b>GRAMINAE</b>	
<i>Luffa cylindrica</i> Roem.	++	<i>Setaria viridis</i> P.B.	-
<i>Momordica charantia</i> L.	+++	<b>LEGUMINOSAE</b>	
<b>SOLANACEAE</b>		<i>Glycyrriza glabra</i> L.	-
<i>Capsicum annuum</i> L.	-	<i>Medicago polymorpha</i> L.	-
<i>Lycopersicon esculentum</i> Mill.	-	<i>Melilotus indica</i> All.	-
<i>Nicotiana tabacum</i> L.	-	<i>Phaseolus vulgaris</i> L.	-
<i>Nicotiana glutinosa</i> L.	-	<i>Vicia faba</i> L.	-
<i>Solanum melongena</i> L.	-	<b>LILIACEAE</b>	
<b>UMBELIFERAE</b>		<i>Allium cepa</i> L.	-
<i>Apium graveolens</i> L.	-	<b>OXALIDACEAE</b>	
<i>Daucus carota</i> L.	-	<i>Oxalis corniculata</i> L.	-
<b>URTICACEAE</b>		<b>ROSACEAE</b>	
<i>Urtica urens</i> L.	-	<i>Fragaria vesca</i> L.	-

- no disease; + to ++++ increasing amount of disease.

#### Literature Cited

1. Ellis, M.B., and P. Holliday. 1970. *Alternaria cucumerina*. C.M.I. Descriptions of pathogenic Fungi and Bacteria. No. 244.
2. Grogan, R.G., K.A. Kimble, and I. Misaghi. 1975. A stem canker disease of tomato caused by *Alternaria alternata* f. sp. *lycopersici*. *Phytopathology* 65:880-886.
3. Hervert, V., L. Marvanova, and V. Kazda. 1980. *Alternaria pluriseptata* on cucumbers and remarks to its classification. *Ceska Mycologie* 34:13-20.
4. Jackson, K.R. 1958. Taxonomy and host range of *Alternaria cucumerina*. *Phytopathology* 48:343-344 (abstr.).
5. Jackson, C.R., and G.F. Weber. 1959. Morphology and taxonomy of *alternaria cucumerina*. *Mycologia* 51:401-408.
6. Groves, J.W., and A.J. Skolko. 1944. Notes on seedborne fungi. II. *Alternaria*. *Can. J. Res.* 22:217-234.
7. Neergaard, P. 1945. Danish species of *Alternaria* and *Stemphylium*. Oxford University Press, London. 560 pp.
8. Simmons, E.G. 1967. Typification of *Alternaria*, *Stemphylium*, and *Ulocladium*. *Mycologia* 59:67-92.
9. Simmons, E.G. 1982. *Alternaria* themes and variations (11-13). *Mycotaxon* 14:44-57.
10. Vakalounakis, D.J. and N.E. Malathrakis. 1982. A cucumber disease caused by the fungus *Alternaria alternata*. 2nd Conf. Protected Veg. Flowers. Heraklion, Crete, Greece.
11. Vakalounakis, D.J. and N.E. Malathrakis. 1988. A cucumber disease caused by *Alternaria alternata* and its control. *Z. Phytopathology* 121:325-336.

Toxins: Potential Screening Aid for Selecting Anthracnose Resistance in Cucumbers.

D.C. Linde, J.M. Shively and B.B. Rhodes

Clemson University Edisto Research and Education Center, Blackville, SC 29817 (first and third authors); and Department of Biological Sciences, Clemson University, Clemson, SC 29632 (second author)

Anthracnose (causal agent = *Colletotrichum lagenarium*) is one of the most important diseases of cucumbers, and cucurbits in general. An *in vitro* or greenhouse screening aid for selecting anthracnose resistance could be valuable if it saved time and money. Toxins are one class of screening aids investigated increasingly for selecting host resistance.

The chlorotic halo sometimes observed around the necrotic lesion caused by *C. lagenarium* suggests that one or more toxins may be involved in its pathogenesis. On the basis that lipid toxins have been isolated from liquid cultures of *C. nicotianae* (1,2) and *C. capsici* (3), we attempted to isolate lipid toxins from shake culture of race 2 *C. lagenarium*.

The fungus was grown in modified (40 g/l) sucrose) Czapek Solution liquid medium (4L) for 2 weeks on a shaker run at 150 rpm. Standard partition chromatography methods with ethyl acetate were used to obtain acidic and neutral lipid fractions from the hyphae, culture broth, and culture pellet. Only the acidic and neutral lipid fractions from the culture broth were found to inhibit cucumber and, to a greater extent, lettuce seed germination. When the 2 fractions were combined in ethanol and spotted on punctured tobacco and cucumber leaves, large necrotic lesions with chlorotic halos similar to anthracnose lesions were observed. The control (ethanol only) produced a small, almost transparent lesion.

N-hexane washes of the acidic and neutral lipid fractions contained no detectable toxic activity with the lettuce seed germination assay. Thin layer chromatography was used to purify the toxic fractions. A total of 3 acidic and 1 neutral lipid toxin fractions were identified. Their mobilities in several solvent systems are shown in Table 1.

The fungus was grown again in liquid culture (4L), and the acidic and neutral lipid fractions were obtained using partition chromatography as above. The two fractions were combined (total weight=0.13 g) and suspended in 1 ml ethanol. One  $\mu$ l was used in a leaf puncture assay in the greenhouse on 7 cucumber genotypes with varying levels of resistance to race 2 *C. lagenarium*. The leaf puncture assay was also used on 16 F<sub>2</sub> cucumber plants segregating for anthracnose resistance. The 7 genotypes and 16 respective F<sub>3</sub> families were inoculated in the field with the same isolate. No relationship was found between the lesion size caused by the leaf puncture assay and the field disease rating for either the 7 genotypes or the 16 F<sub>2</sub> plants and their respective F<sub>3</sub> families.

The high concentration of lipids used in the leaf puncture assay may have precluded a proportional response to the toxin. An alternative hypothesis is that the putative toxin is only one element of the pathogen's virulence.

Table 1.  $R_f$  values of the 4 toxic fractions in 10 solvent systems on silica gel G thin layer chromatography.

Solvent system <sup>z</sup>	Toxic Fraction <sup>y</sup>			
	N1	Ala	Alb	A2
Bz:EtAc:Ac 70:30:1	0.250-0.500	0.125-0.375	0.125-0.375	0.500-0.625
Bz:MeOH 90:10	0.47	-	-	-
Bz:EtAc 30:70	0.56	-	-	-
Et2 100	0.50-0.60	0.00-0.10	0.30-0.50	0.00-0.10
EtAc 100	0.50	0.00	0.00	-
CHCl <sub>3</sub> :MeOH 90:10	0.58	-	0.00	-
Acetone 100	-	0.00-0.30	0.00	-
EtOH 100	-	-	0.10-0.30	-
EtOH:MeOH 90:10	-	-	0.70-0.80	-
MeOH 100	-	-	1.00	-

<sup>z</sup>BZ = benzene, EtAc = ethyl acetate, Ac = acetic acid, CHCl<sub>3</sub> = chloroform, Et2 = diethyl ether, MeOH = methanol, EtOH = ethanol.  
<sup>y</sup>'N' = neutral lipid toxic fraction, 'A' = acidic lipid toxic fraction.

#### Literature Cited

1. Gohbara, M., S-B. Hyeon, A. Suzuki and S. Tamura. 1976. Isolation and structure elucidation of colletopyrone from *Colletotrichum nicotianae*. Agr. Biol. Chem. 40:1453-1455.
2. Gohbara, M., Y. Kosuge, S. Yamasaki, Y. Kimura, A. Suzuki and S. Tamura. 1978. Isolation, structures, and biological activities of colletotrichins, phytotoxic substances from *Colletotrichum nicotinae*. Agr. Biol. Chem. 42:1037-1043.
3. Grove, J.F., R.N. Speake and G. Ward. 1966. Metabolic products of *Colletotrichum capsici*: isolation and characterization of acetocolletotrichin and colletodiol. J. Chem. Soc. C:230-237.



## Tolerance of Cucumber to Chloramben Herbicide

Jack E. Staub and Linda K. Crubaugh, USDA, ARS  
Department of Horticulture, University of Wisconsin, Madison, WI 53706

Lack of an efficacious chemical weed control system is a major factor which limits yield in commercial cucumber (*Cucumis sativus* L.) production in the United States. This is particularly true of once-over, mechanically-harvested acreage where uniform emergence and flowering, and plant growth at close spacings can be dramatically affected by weed competition (4).

Bensulide, DCPA, CDEC, naptalam, paraquat, trifluralin and chloramben are currently registered for use in commercial cucumber production in the United States (9). Bensulide, CDEC, and naptalam often give poor weed control (5,6) and DCPA causes severe damage when surface-applied prior to crop emergence (4). Paraquat, being a contact herbicide, is only suitable for removing weeds for seedbed preparation and does not provide control for an extended period of time (9). Moreover, since the suggested safe use of chloramben requires the addition of activated charcoal as a safening agent (8), which adds costs of time and materials, it has received limited use among growers (Personal communication, H.J. Hopen, 1988).

Given these restrictions and/or the poor performance of these herbicides, it would be useful to identify germplasm possessing herbicide resistance or tolerance. Although chloramben (3-amino-2,5-dichlorobenzoic acid) provides excellent grass and broadleaf weed control (8,9), crop tolerance and genotypic variability is low (1,3). We felt it prudent to survey the U.S. cucumber collection for chloramben tolerance. If tolerant accessions were identified, this would allow for the development of a resistant population for use in breeding programs.

The germplasm collection was surveyed by planting 25 seeds of each accession (753) in each of 20 replications arranged in a randomized complete block design at Hancock, WI (sandy loam soil) in 1987. After planting, chloramben 75DF was surface applied at 6.72 kg/ha to half of the plots. After 12 hours, 13 mm of water was applied through overhead sprinkler irrigation. Treated seedlings were compared to controls 1 and 3 weeks after emergence, and rated for chloramben injury on a 10 point scale (1=seedling death, 5=moderate to severe, and 10=no injury). All plants showed some injury. Plants with mean values of 7 to 9 (Table 1) were classified as tolerant. These plants were transplanted to the greenhouse and random-mated.

The mechanism of resistance and/or tolerance to chloramben in these plants is unclear. Several mechanisms have been proposed to explain tolerance to chloramben. Stoller (7) suggests that plants tolerant to chloramben sustain higher internal chloramben concentrations and conjugate absorbed chloramben more rapidly than susceptible species. Colby (2) hypothesized that tolerance is a function of the binding of the chloramben in the roots of more tolerant species. In this scenario, chloramben bound in the roots reduces phytotoxicity in the leaves in tolerant plants; hence, there is less translocation of chloramben.

Our objective was to develop a population tolerant to chloramben from which inbred lines with acceptable horticultural characteristics could be developed. An elite population is being developed from chloramben tolerant lines (Table 1) through recurrent half-sib family selection. After initial selection, near-isogenic tolerant and susceptible lines will be developed. Not only will these lines be of value in hybrid production, but near-isogenic lines may allow for further elucidation of tolerance mechanisms.

Table 1. Plant introductions in the U.S. cucumber germplasm collection which were classified as tolerant to chloramben herbicide (6.72 kg/ha) at Hancock, WI in 1987.

<u>PI no.</u>	<u>Origin</u>	<u>Varietal Name</u>
173892	India	Khira
482464	Zambia	-
275411	Netherlands	Lange Groene Broei
179676	India	Kakri
279464	Japan	Kara-Aonaga-Fushinari
1649502	Turkey	-
436609	Peoples Rep. China	Tsin Sanz Yen 15919
279465	Japan	Natsufushinari
277741	Netherlands	Green Spot Super

#### Literature Cited

1. Baker, R.S. and F.F. Warren. 1962. Selective herbicidal action of amiben on cucumber and squash. *Weeds* 10:219-224.
2. Colby, S.R. 1966. The mechanism of selectivity of amiben. *Weeds* 14:197-210.
3. Miller, Jr., J.C., D. Penner and L.R. Baker. 1973. Basis for variability in the cucumber for tolerance to chloramben methyl ester. *Weed Sci.* 21:207-211.
4. Monaco, T.J. and C.H. miller. 1972. Herbicide activity in close-spaced, pickling cucumbers. *Weed Sci.* 20:545-548.
5. Noll, C.J. 1977. Weed control in cucumbers in a conventional planting and in a stale seed bed. *Proc. NE Weed Sci. Soc.* 31:248-251.
6. Romanowski, R.R. and J.S. Tanaka. 1965. An evaluation of herbicides for use with cucumber (*Cumcumis sativus*) and watermelon (*Citrullis vulgaris*) in Hawaii. *Hawaii Ag. Exp. Stat. Prog. Rpt.* 144, 30 pages.
7. Stoller, E.W. 1969. The kinetics of amiben absorption and metabolism as related to species sensitivity. *Plant Phys.* 44:854-860.
8. Union Carbide Agricultural Products Company, Inc., Union Carbide 1986 Chemical Guide. Page 39.
9. Weed control manual 1986 and Herbicide Guide. Published by Ag. Consultant and Fieldman, A Meister Publication, 1986. Pages 196-97.

## Cucumber Yield Improvement Through Breeding in the Southeast U.S.A.

Todd C. Wehner

Department of Horticultural Science, North Carolina State University, Raleigh,  
NC 27695-7609

It is of interest to cucumber breeders in the U.S.A. to determine how much progress they have made in the improvement of yield. Yield is a complex trait, and is affected by sex expression, disease resistance, and cultural practices, as well as other factors. All of those have been improved over the past decades by researchers in public and private institutes.

In a survey of cucumber breeders made in 1987, the primary objectives for trait improvement listed were yield, disease resistance, fruit quality, and earliness/sex expression (2). With emphasis on many traits, progress on any one will be slow because selection for many traits simultaneously reduces the selection intensity on each trait. In my recurrent selection program, 14 populations are subjected to a 5% selection intensity (20 families kept out of 400 tested) for yield, earliness, quality, and disease resistance (mostly anthracnose, downy mildew and gummy stem blight). Actual selection intensity is approximately 40% for yield and 50% each for earliness, quality and disease resistance ( $.05 = .40 \times .50 \times .50 \times .50$ ). Thus, one would not expect much progress to be made where many traits are being selected simultaneously.

Nevertheless, progress has been made for yield, even after accounting for the contributions of improvement in cultural practices, sex expression and disease resistance. For example, the cultivars released from the public breeding programs run sequentially by Carroll Barnes, Richard Lower, and me in the Carolinas have lead to continuously improved yield even though many releases were similar in sex expression and disease resistance. The objective of this study was to estimate the improvement made for yield in pickling cucumbers grown in the southeast U.S.A.

*Methods.* Five cultivars which are most similar in type (gynoecious hybrid pickling cucumbers with resistance to the southern foliar diseases) developed in the Carolinas over the last 2 decades were grown in trials in Clinton, NC under standard cultural practices (1). The trials were run in the spring when there was no foliar disease load, and in the summer when anthracnose, downy mildew and gummy stem blight were moderate to severe. The trials were run in 1981 through 1985 using 3 replications and 6 harvests. No summer trials were run in 1982 and 1983.

Irrigation was used to supplement rainfall. Weeds, diseases and insects were controlled as needed using labelled pesticides. Weight of all fruits produced, regardless of size (most being grade 2 and 3 with a diameter of 27 to 50 mm), were summed over harvests to get total yield. Yield was regressed on release date to determine the progress made per year. Release date is not completely accurate in determining when the material was developed. 'Raleigh', for example could have been released in 1985 if it had been given top priority in the program.

**Results.** It is interesting to note that the cultivars do not keep the same rank for any one trial as the overall mean (Table 1). In general, yield increased with each subsequent release, with an average of 0.4 t/ha each year of breeding. That yield progress was made even though other traits (such as fruit color, fruit shape, and length:diameter ratio) were being improved.

Since the 5 cultivars were tested under the same cultural practices, and had similar sex expression and disease resistance, progress in yield must have been due to direct improvement of the trait. Thus, I conclude that we have not hit a yield plateau in cucumber breeding, but have been working on so many traits that progress on each one of them is slow.

Table 1. Yield (t/ha) of disease resistant, gynoecious pickling cucumber hybrids grown in field trials (spring and summer) in Clinton, NC<sup>2</sup>.

Release date	Cultivar name	1981		1982	1983	1984		1985		Mean
		Spr	Sum	Spr	Spr	Spr	Sum	Spr	Sum	
1969	Explorer	19	20	29	34	31	22	38	37	28.8
1973	Carolina	20	10	28	33	41	21	45	38	29.6
1975	Calypso	21	21	32	34	42	30	41	41	32.7
1979	Regal	24	18	40	38	41	27	48	41	34.6
1987	Raleigh	26	26	37	34	33	27	52	48	35.5

<sup>2</sup>Data are means of 3 replications and 6 harvests.

#### Literature Cited

1. Hughes, G.R., C.W. Averre and K.A. Sorensen. 1983. Growing pickling cucumbers in North Carolina. N.C. Agric. Ext. Serv. AG-315.
2. Wehner, T.C. 1988. Survey of cucumber breeding methods in the U.S.A. Cucurbit Genet. Coop. Rpt. 11:9-12.

## Source-Sink Relationships in Cucumber

Jack E. Staub, USDA, ARS

Department of Horticulture, University of Wisconsin, Madison, WI 53706

Average yield of cucumber (*Cucumis sativus* var. *sativus* L.) in the United States has increased from approximately 65 (1920) to 200 (1980) bushels per acre (1). Much of that yield improvement was the result of improved cultural practices, gynocious sex expression, and disease resistance (5,6). Knowledge of plant physiology will help in the direct improvement of yield. A fruit developing from the first pollinated flower on the cucumber plant inhibits the development of subsequent fruits. It is not known whether this inhibition is due to a substance which is translocated from the fruit, or to a substrate-limited source-sink relationship (2,4,7).

Unlike var. *sativus*, *Cucumis sativus* var. *hardwickii* (R.) Alef. possesses a sequential fruiting habit (3), and therefore has potential for increasing fruit yield in cucumber (9). Inbred lines derived from var. *sativus* x var. *hardwickii* matings have been developed in my program (10). Although the fruit quality of these lines is commercially unacceptable (11), their fruit yielding abilities are significantly higher than standard cultivars (10).

In order to gain more information concerning the fruit setting nature of var. *hardwickii*, an experiment was designed to compare the morphological and photosynthetic characteristics of a standard var. *sativus* inbred (WI 1606), a var. *hardwickii* accession (PI 215589), and a var. *sativus* x var. *hardwickii* derived inbred (WI 5551). It was thought that these comparisons would provide information concerning the role of source-sink relationships in cucumber.

Seeds of WI 1606, WI 5551, and PI 215589 were planted in 10 replications (single plant), each equidistantly spaced 2.7 m apart (center to center) in a randomized complete block design. Fruit, seed, and plant (stem + leaf) dry weight, as well as fruit and seed number per plant were recorded at maturity (100 days after sowing). Harvested tissues were dried at 60°C for 7 days. The net CO<sub>2</sub> assimilation rate of the 4th (leaf #1) from the terminal whorl was recorded 3 weeks after sowing on cloudless days using an LI 6000 portable gas analysis system (Li-Cor, Inc., Lincoln, Nebraska). Photosynthetic rates of the 4th and 6th (leaf #2) leaves were measured at 5 and 6 weeks, while rates of the 4th, 6th, 8th (leaf #3) and 10th (leaf #4) leaves were measured 7, 8, 9 and 10 weeks after sowing. The LI 6000 consists of a battery powered non-dispersive infra-red gas analyzer, a porometer, a communications device, and a dedicated datalogger. When a leaf is placed into the monitoring chamber, CO<sub>2</sub> concentration decreases as CO<sub>2</sub> assimilation occurs. Net carbon assimilation rate is calculated based on leaf area, changes in CO<sub>2</sub> concentration and air flow rate.

Stem weight per plant as well as fruit number per plant was significantly higher in PI 215589 when compared to the other inbred lines (Fig. 1). However, the seed number and weight per fruit of PI 215589 was significantly lower than for WI 1606. The means of WI 5551 for most characters were intermediate (seed weight per 500 seeds) to the parents, or closer to WI 1606 (stem and fruit weight, fruit number) than to PI 215589. There were no significant differences observed in the mean net CO<sub>2</sub> assimilation rate (AR) among leaves or between inbred lines during the growing season. Mean AR fell dramatically in all lines when flowering (weeks 7 to 8) and fruit development began, but the magnitude of this decrease was similar in all three lines. Although this decrease may be associated with lower irradiance in weeks 9 to

10 ( $1017 \pm 431$  mmols/m<sup>2</sup>/s) when compared to weeks 3 to 8 ( $1569 \pm 281$  mmols/m<sup>2</sup>/s), irradiance was greater than light saturation (300-500 mmols/m<sup>2</sup>/s) for cucumber.

A significantly higher proportion of photosynthate was translocated to the fruit in WI 1606 when compared to the other lines (Table 1). In contrast, the percent of dry weight of leaf and stem tissue was higher, in PI 215589 (9 and 38% respectively) when compared to WI 1606. While the portion of assimilates in the leaf and stem in WI 5551 was similar to that of WI 1606, contribution to fruit development was 10% lower. PI 215589 typically flowers 2 weeks later than the other lines in days to anthesis (approx. 51 days in Wisconsin). The effect of this difference in maturity date on assimilate partitioning was minimized by delaying the harvest 100 days after sowing.

Consistent differences in the direction (+ or -) of phenotypic corrections in traits between lines may indicate dissimilarities in their physiologic nature. Different significant correlations in direction between lines were observed for fruit number and weight/500 seeds, weight/500 seeds and stem weight, and seed weight/500 seeds and seed number (Table 2). Negative correlations in fruit number and weight/500 seeds and seed number were negatively correlated in PI 215589 and positively so in WI 1606.

These calculated associations along with the observed differences in carbohydrate partitioning between lines suggest that they are physiologically different. It appears that PI 215589 has the ability to set large numbers of fruits containing small but numerous seeds. On the other hand, WI 1606 does not. Although AR among inbred lines is similar, PI 215589 partitions more of its photosynthate to leaves and stems when compared to the other inbred lines examined, suggesting that sinks and/or their strengths are dissimilar. A similar finding was reported by Ramirez and Wehner (8). The fact that WI 5551 is higher yielding than WI 1606, but partitions significantly more assimilates to seeds than to fruit suggests that: i) Seeds may be a significant sink; and ii) Seed maturation may be related to the observed reductions in fruit size. One could hypothesize that selection for fewer seeds per fruit in populations having high fruit number per plant may result in derived inbreds partitioning more assimilates to the mesocarp of the fruit, thereby resulting in larger length/diameter ratios.

Table 1. Dry weight percentage of plant tissue of a *C. sativus* var. *sativus* (WI 1606), a *C. sativus* var. *hardwickii* (PI 215589) and a derived var. *sativus* x var. *hardwickii* (WI 5551) inbred line grown at Hancock, WI<sup>2</sup>.

Plant part	Proportion of plant by weight (%) <sup>Y</sup>		
	WI 1606	WI 5551	PI 215589
Fruit	50 a	40 b	14 c
Leaf	22 b	22 b	31 a
Stem	16 c	18 b	54 a
Seed	12 d	20 a	1 c

<sup>2</sup>Different letters within a row indicate that mean percent values are significantly different (5%) using LSD test.

<sup>Y</sup>WI 1606 = *C. sativus* var. *sativus* inbred; PI 215589 = *C. sativus* var. *hardwickii*; WI 5551 = var. *sativus* x var. *hardwickii* derived inbred.

Table 2. Phenotypic correlations between dry weights of tissue of a *C. sativus* var. *sativus* (WI 1606), a *C. sativus* var. *hardwickii* (PI 215589) and a derived var. *sativus* x var. *hardwickii* (WI 5551) inbred line grown at Hancock.

Parameters correlated	Inbred line or accession <sup>2</sup>		
	WI 1606	WI 5551	PI 215589
Fruit no. vs. seed wt./500 seeds	-0.56*	0.33	0.67*
Seed wt./500 seeds vs. stem. wt.	0.62*	-0.01	0.83**
Seed wt./500 seeds vs. seed no.	0.60*	0.38	-0.63*

<sup>2</sup>WI 1606=*C. sativus* var. *sativus* inbred; PI 215589=*C. sativus* var. *hardwickii*; WI 5551=var. *sativus* x var. *hardwickii* derived inbred.

\*,\*\* Indicates that correlation coefficients are significant at 5 and 0.1%, respectively.

#### Literature Cited

1. Agricultural Statistics. 1940, 1980. United States Department of Agriculture. United States Government Printing Office, Washington D.C.
2. Fuller, G.L. and C.A. Leopold. 1977. The rose of nucleic acid synthesis in cucumber fruit set. *J. Amer. Soc. Hort. Sci.* 102:384-388.
3. Horst, E.K. and R.L. Lower. 1978. *Cucumis hardwickii*: A source of germplasm for the cucumber breeder. *Cucurbit Genet. Coop. Rpt.* 1:5.
4. Nienhuis, J. and R.L. Lower. 1980. Influence of reciprocal donor scions on fruit setting characteristics of recipient scions of *Cucumis sativus* and *C. hardwickii* (R.) Alef. *Cucurbit Genet. Coop. Rpt.* 3:17-19.
5. Peterson, C.E. and D.J. DeZeeuw. 1963. The hybrid pickling cucumber, Spartan Dawn. *Mich. Agr. Expt. Stat. Quart. Bul.* 46: 267-273.
6. Peterson, C.E. 1975. Plant introductions in the improvement of vegetable cultivars. *HortScience* 10:575-579.
7. Pharr, D.M., S.C. Huber and H.N. Sox. 1984. Leaf carbohydrates status and enzymes of translocate synthesis in fruiting and vegetative plants of *Cucumis sativus* var. *hardwickii* (R.) Kitamura. *Cucurbit Genet. Coop. Rpt.* 11:25-28.
8. Ramirez, D.R. and T.C. Wehner. 1984. Growth analysis of three cucumber lines differing in plant habit and yield. *Cucurbit Genet. Coop. Rpt.* 7:17-18.
9. Smith, O.S., R.L. Lower and R.H. Moll. 1978. Estimates of heritabilities and variance components in pickling cucumber. *J. Amer. Soc. Hort. Sci.* 103:222-225.
10. Staub, J.E. 1985. Preliminary yield evaluation of inbred lines derived from *Cucumis sativus* var. *hardwickii* (R.) Kitamura. *Cucurbit Genet. Coop. Rpt.* 8:18-21.
11. Staub, J.E. and L.R. Fredrick. 1988. Evaluation of fruit quality in *Cucumis sativus* var. *hardwickii* (R.) Alef.-derived lines. *Cucurbit Genet. Coop. Rpt.* 11:25-28.

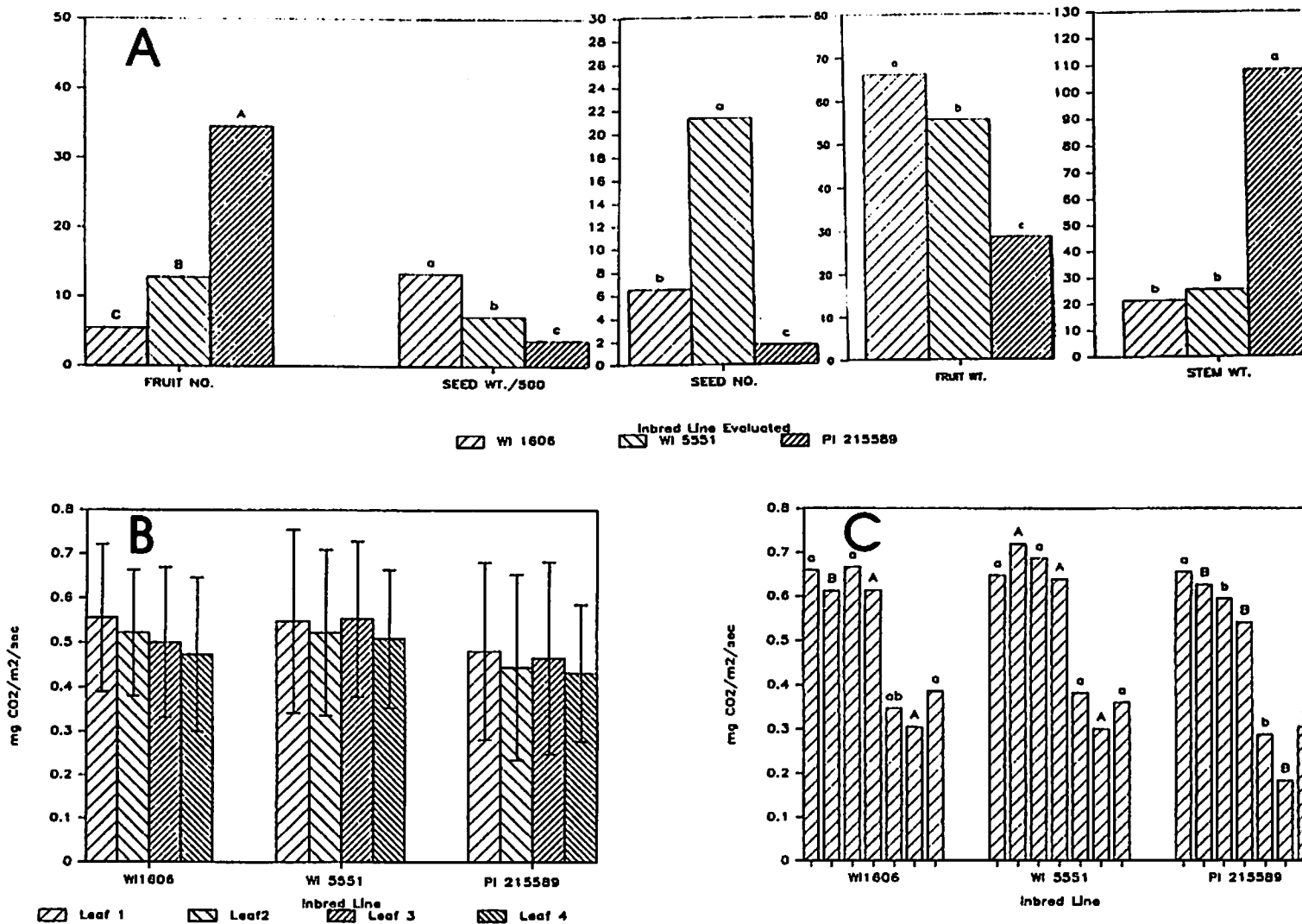


Figure 1. Mean morphological (A) and net CO<sub>2</sub> assimilation rate (B&C) comparisons between a *Cucumis sativus* var. *sativus* (WI 1606), a *C. sativus* var. *hardwickii* (PI 215589) and a derived var. *sativus* x var. *hardwickii* (WI 5551) inbred line evaluated at Hancock, WI in 1986. A=mean fruit number per plant, seed weight per 500 seeds per fruit (g), seed number per fruit, and fruit and stem weight per plant (g). B=4th (leaf 1), 6th (leaf 2), 8th (leaf 3), 10th (leaf 4) from the terminal whorl. C=mean of all leaves for weeks 3,5,6,7,8,9, and 10. Statistical comparisons made between weeks among lines examined. Different letters indicates that mean values are significantly different at P=.05 using LSD test.



## Delayed Pollination Successful for Cucumbers in North Carolina Greenhouse

Todd C. Wehner and Rufus R. Horton, Jr.

Department of Horticultural Science, North Carolina State University, Raleigh,  
NC 27695-7609

Munger reported that pistillate flowers of cucumber could be pollinated successfully up to 24 hours after they opened in the Philippines and in his New York greenhouses, but not in his New York fields (2). Lower and Edwards (1) recommended that pistillate flowers be pollinated on the morning they open, up until noon. Generally, bee activity falls off after 12 noon due to the heat in the summer of the southern U.S. cucumber production areas.

Usually, we make all of our pollinations on the morning the pistillate flowers open because it is more comfortable to work then. Also, field pollinations made in some years (where the maximum temperature was above 35°F) failed if they were made after 10 am. In July, our greenhouses reach 40°C in the afternoon, even with shading and a water-cooled ventilation system. Therefore, we doubt that delayed pollinations would be successful in the summer greenhouse. However, it is occasionally useful to pollinate pistillate flowers 12 to 24 hours after they open. We have found this to be possible, and have taken data to show the effect of the delay on seed set.

*Methods.* Plants of Gy 14A and 'Marketmore 80F' were grown in 150 mm diameter pots in the North Carolina State Univ. greenhouses at Raleigh, NC. Plants were planted in January and pollinated in February to March. Temperatures were maintained at 23 to 30°C during the day and 19 to 21°C at night. Newly-opened pistillate flowers were pollinated at 8 am, 12 noon, 4 pm and 8 am on the following day for each cultigen, setting one fruit per plant. The experiment was replicated 4 times.

*Results.* Generally, all of the pollination treatments were successful, and resulted in 46 to 242 seeds per fruit. There appeared to be a slight reduction in the number of seeds per fruit, and in the number of successful pollinations as pollination was delayed (Table 1). However, there were larger differences among replications than among pollination treatments, and the treatments were not significantly different.

For convenience and comfort, we intend to continue our practice of pollinating pistillate flowers on the morning they open (7 am to 12 noon). However, we will make delayed pollinations when necessary, since one would expect nearly as much success under our spring and fall greenhouse conditions.

### Literature Cited

1. Lower, R.L. and M.D. Edwards. 1986. Cucumber breeding. In: Breeding Vegetable Crops. AVI Publishing Co. M.J. Bassett, Ed.
2. Munger, H.M. 1988. A revision on controlled pollination of cucumber. Cucurbit Genet. Coop. Rpt. 11:8.

Table 1. Effect of pollination time on seed number and fruit set of cucumbers grown in the greenhouse in Raleigh, NC<sup>2</sup>.

<u>Time of day</u>	<u>Hours after flower opening</u>	<u>Cultigen</u>	<u>Seeds/fruit</u>	<u>No. fruits set/4</u>
8:00	0	Gy 14A	204	4
		MM 80F	126	4
12:00	4	Gy 14A	179	3
		MM 80F	202	3
16:00	8	Gy 14A	148	4
		MM 80F	68	3
8:00	24	Gy 14A	81	4
		MM 80F	183	3
LSD (5%)			NS	-
x			148	-
CV (%)			43	-

<sup>2</sup>Data are means over 4 replications of 1 fruit each of 2 cultigens, Gy 14A (gynoecious pickle inbred) and Marketmore 80F (gynoecious slicer inbred).

\* \* \* \* \*

### Seed Weight of Cucumber Cultivars

Todd C. Wehner and Rufus R. Horton, Jr.  
 Department of Horticultural Science, North Carolina State University, Raleigh,  
 NC 27695-7609

It is useful to know the weight of cucumber seeds for cultivars being grown for research and production, since many operations are done by weight even though it is number that is of interest. For example, to achieve the proper stand, Knott's Handbook for Vegetable Growers recommends planting 2 to 3 lb/A of seed (1). The handbook bases that recommendation on its published value of 1100 seeds/ounce for the typical cucumber cultivar.

We have observed differences in seed weight among cultivars, and were interested to know how our measurements compared with the published estimates. The objective of this study was to compare seed weights for cucumber cultivars commonly used for field production in the U.S.A.

*Methods.* Seeds of 9 different breeding lines and cultivars (collectively referred to as cultigens hereafter) were obtained from seeds companies and the N.C. State Univ. breeding program. The cultigens were chosen to represent pickling and slicing fruit types, northern and southern adaptation, and compact, determinate and little leaf plant types. Seeds were divided into 4

lots of 500 seeds each to provide replication for the measurement of seed weight. Seed weight was then converted into number of seeds per gram, ounce and pound for use by those who use those measures.

*Results.* There was a large range in number of seeds per ounce among the 9 cultigens and 4 samples counted (Table 1). Cultivars had between 904 and 1291 seeds per ounce in the 4 samples counted, ranging 18% below to 17% above the figure of 1100 seeds per ounce published by Lorenz and Maynard (1).

The only cultigen that did not fit the general trend for seed size was the compact (cp cp) type. In addition to small vine size, that gene results in plants with small, deformed seeds, and a low percentage of germination. There are more than twice as many seeds per ounce (approx. 2600) of the compact type compared to the other cultigens (approx. 1100).

In summary, the published number of seeds is very close to the value we measured for the cultigens here (excluding the small-seeded compact type). However, the specific cultigen being used can diverge significantly from the general value of 1100 seeds per ounce.

#### Literature Cited

1. Lorenz, O.A. and D.N. Maynard. 1980. Knott's Handbook for Vegetable Growers, 2nd edition. John Wiley & Sons, New York. p. 57.

Table 1. Seed number per gram, ounce, and pound for 9 cucumber cultigens of 5 different types<sup>2</sup>.

Cultigen	Type	Seeds/g.		Seeds/oz.		Seeds/lb.	
		Mean	Range	Mean	Range	Mean	Range
Sprint 440	Slicer	32	32-33	921	904-929	14731	14464-14872
Pioneer	Pickle	34	34-34	955	953-958	15283	15252-15324
Calypso	Pickle	35	33-36	991	947-1027	15851	15150-16434
Sumter	Pickle	36	35-36	1018	1002-1029	16291	16028-16458
Dasher II	Slicer	37	36-37	1037	1035-1042	16600	16554-16676
M 21	de de	39	37-39	1098	1050-1118	17562	16799-17886
Poinsett 76	Slicer	45	45-46	1278	1268-1291	20451	20286-20655
Little John	ll ll	46	46-47	1313	1303-1323	21005	20845-21176
Compact	cp cp	92	86-98	2611	2444-2790	41784	39102-44644
LSD (5%)		2	-	72	-	1146	-
CV (%)		4	-	4	-	4	-
x (all cultigens)		44	-	1247	-	19951	-
x (compact excluded)		38	-	1076	-	17222	-

<sup>2</sup>Data are from 4 replications of 500 seeds each. Cultigens are pickling, slicing, compact (cp), determinate (de) or little leaf (ll) types.

## Electrophoretic Examination of *Cucumis sativus* L. and *Cucumis melo* L.

V.S. Sujatha and V.S. Seshadri

Division of Vegetable Crops, Indian Agricultural Research Institute, New Delhi 110012 India

The genus *Cucumis* contains 30 species of which only two species, *C. sativus* (cucumber) and *C. melo* (muskmelon), are extensively cultivated. While *C. melo* has chromosome number of  $x=12$ , and *C. sativus* has  $x=7$ , the attempts to produce interspecific hybrids between the two have not succeeded (2,3). An isozymic analysis was designed to compare the two taxa and determine whether justification exists to classify them as a single genus. Taxa were compared using peroxidase (PRX), glutamate oxaloacetate transaminase (GOT) and esterase (EST).

**Methods.** Polyacrylamide gel electrophoresis was performed using varietal slab gels (ADCO, India) at 5°C under 40 MV in the following manner. Peroxidase (PRX) was sampled from the root and hypocotyl region of 4 to 5 week-old seedlings. Gels consisted of 7% acrylamide, and electrophoresis was carried out using a Tris-chloride gel buffer (pH 8.3). Gels were stained according to Conklin and Smith (1). Glutamate oxaloacetate transaminase was sampled from 3 to 4 day-old seedlings, and electrophoresis was performed using 9.5% gels. Gel and electrode buffers were the same as those used for peroxidase, and staining procedures were those of Shaw and Koen (6). Esterase was sampled from 3 to 4 day old seedlings and extracts electrophoresed on a 7.0% gel. Gel and electrode buffers were the same as above, and staining was performed according to Shaw and Koen (6).

**Results.** In the peroxidase system, *C. sativus* was lacking in the fastest moving PRX which was present in all the *Cucumis* species ( $x=12$ ; data not shown). The allozymes of *C. sativus* were observed at PRX2, PRX3 and PRX4, corresponding to the three loci of *C. melo*. However, allozymes of *C. sativus* were not similar in mobility to those of *C. melo* (Fig. 1).

The two taxa shared a common band at GOT4. This allozyme was common to the 13 *Cucumis* species studied and absent in the other general in the Cucurbitaceae like *Citrullus*, *Luffa*, *Momordica*, *Praecitrullus*, *Lagenaria* (data not presented). The allozyme at GOT1 present in *C. melo* was absent in *C. sativus*. The allozyme at GOT2 of *C. sativus* had identical mobility with the hybrid isozyme at GOT2 in *C. melo*. However, since the banding pattern at GOT2 in *C. melo* was identified to be a hybrid type, the allozyme at GOT2 of *C. sativus* was treated as having a different subunit constitution than that of the hybrid allozyme of *C. melo*. The allozymes at GOT3 also differed in mobility. There were no similarities between the two taxa in esterase zymograms.

Data suggest that there is little similarity between *C. melo* and *C. sativus* for the 3 enzymes studied. However, isozyme constitution at GOT4 in both species was characteristic of the genus *Cucumis*, and justifies their classification under the genus *Cucumis*. This conclusion contrasts to that of Pangalo (4), who suggested that the two *Cucumis* species should be elevated to generic status because of their wide variability, non-crossability, and chromosome number differences. Also, Ramachandran and Seshadri (5) consider *C. sativus* cytogenetically very different from *C. melo*. Our data (common band at GOT4) of *C. melo* and *C. sativus* lends support to the proposition that these widely divergent taxa remain under one genus.

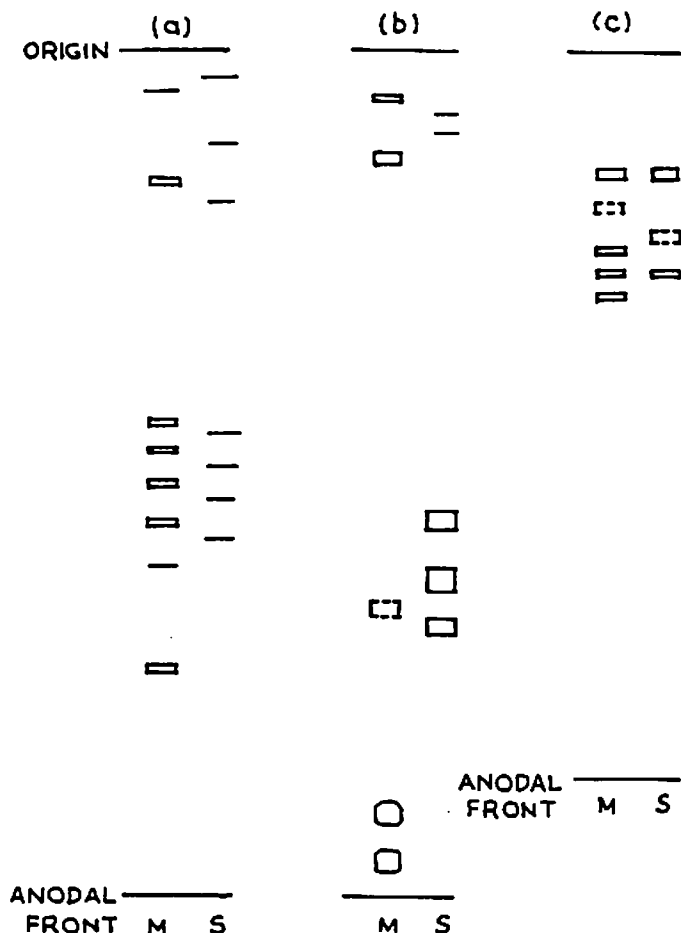


Fig. 1. Comparison of zymograms of *C. sativus* (S) and *C. melo* (M) for peroxidase (a), esterase (b), and glutamate oxaloacetate transaminase (c).

#### Literature Cited

1. Conklin, M.E. and H.H. Smith. 1971. Peroxidase isozymes. A measure of molecular variation in ten species of *Datura*. *Amer. J. Botany* 58:688-696.
2. Dane, F., D.W. Denna and T. Tsuchiya. 1980. Evolutionary studies of wild species in the genus *Cucumis*. *Zeits. Pflanzenzucht.* 85:89-109.
3. Deakin, J.R., G.W. Bohn and T.W. Whitaker. 1971. Interspecific hybridization in *Cucumis*. *Econ. Bot.* 25:105-211.
4. Pangalo, K.I. 1950. (Melons and independent genus *Melo* Adans). *Botanichesky Zhurnal* 35:571-80.
5. Ramachandran, C. and V.S. Seshadri. 1986. Cytological analysis of the genome of cucumber (*Cucumis sativus* L.) and muskmelon (*Cucumis melo* L.). *Z. Pflanzenzucht.* 96:25-38.
6. Shaw, C.R. and A.L. Koen. 1968. Starch gel zone electrophoresis. In: L. Smith (Ed.), *Chromatographic and electrophoretic techniques*. Vol. 2. John Wiley, New York.

## Improvements of *in vitro* Growth of Cucumber

J.B.M. Custers and E.C.P. Verstappen  
Institute for Horticultural Plant Breeding (IVT), P.O. Box 16, 6700 AA  
Wageningen, The Netherlands

In general, *in vitro* culture of cucumber (*Cucumis sativus* L.) meets with several problems. In regeneration studies, adventitious buds as well as somatic embryos develop poorly into plants, which show structural abnormalities and absence of apex formation (1,3). The *in vitro* culture of complete plants is hampered by vitrification, precocious flower formation, and cessation of growth (2). In order to improve this, *in vitro* growth of small shoot tips and axillary buds was studied. Attention was paid to the effect of better aeration during the continuous culture of cucumber plants.

Seeds of *C. sativus* cultivar Hokus (Rijk Zwaan, De Lier) and *C. sativus* var. *hardwickii* (IVT Gene bank number 0777) were aseptically germinated in honey jars on 40 ml Murashige-Skoog medium with 3% (w/v) sucrose and 0.6% (w/v) agar (Oxoid Bacteriological). The jars were closed with white, partially transparent plastic lids. Three seeds were incubated per jar. The cultures were grown at a 16 hour photoperiod (Philips TL 84, 1 klux in the jar) at 25°C day / 23°C night. Shoot cuttings, including the cotyledons, were excised from the seedlings 8 days after germination and subcultured on fresh media. After 2 weeks, shoot tip and nodal cuttings were collected from the plants obtained.

Three experiments were designed. In experiment 1, shoot tips of different sizes (2, 3 and 5 mm in length) were compared for their growth capacity. In experiment 2, nodal cuttings with internodes of different lengths (2, 10 and 20 mm) were examined for the ability of the axillary buds to develop into complete plants. In both experiments, the period of culture was 4 weeks, under the same conditions as described for the seedlings.

Experiment 3 was designed to study continuous *in vitro* culture of cucumber plants by successive subculturing. Each subculture was started from nodal cuttings with a 15 mm internode. Effects of growth conditions were studied. Aeration was changed using 3 methods of closing the jars: a plastic lid, one layer of vitafilm (Good Year), and 3 layers of vitafilm. Light was reduced by covering the jars with layers of cheese cloth.

**Shoot tips.** As a consequence of choosing main axes of different length from 'Hokus' plants, the size of the basal leaf of the cuttings differed considerably (Table 1). All cuttings survived incubation, but the amounts of growth and plant formation were different. The large cuttings generally developed into normal plants with 4 full-grown leaves having blade lengths up to 40 mm. In contrast, most cuttings of 2 and 3 mm in length initially showed arrest of growth. After growth had started, very compact plantlets developed with 2 to 4 small leaves with blades about 10 to 20 mm in length. Upon subculture, these plants did not regain normal growth, but instead formed numerous flower buds in the axils.

**Nodal cuttings.** As consequence of the varying length of the internodes attached, the distance from axil to medium was different (Table 2). Normal plants developed from the long cuttings of 10 and 20 mm length. The short

cuttings, however, formed compact plants with small leaves. In general, the features of these plants were similar to those grown from shoot tips.

Table 1. Capacity of plant formation *in vitro* of *Cucumis sativus* cv. Hokus shoot tip cuttings of different sizes. The plants obtained after 4 weeks are classified by length<sup>Z</sup>.

Cutting size (lengths in mm)		Classes of plant length (%)		
Main axis <sup>Y</sup>	Blade of basal leaf	5-10 mm	10-50 mm	50-75 mm
2	0	90	5	5
3	3-7	80	10	10
5	10-16	0	14	86

<sup>Z</sup>Each treatment comprised 21 shoot tips.

<sup>Y</sup>Length measured from apex to base.

Table 2. Capacity of plant formation *in vitro* of *Cucumis sativus* cv. Hokus nodal cuttings with internodes of different lengths. The plants obtained after 4 weeks are classified by length<sup>Z</sup>.

Internode length (mm)	Distance from axil to medium (mm)	Classes of plant length %		
		5-10 mm	10-50 mm	50-75 mm
2	0	90	10	0
10	5-7	0	10	90
20	15-17	0	5	95

<sup>Z</sup>Each treatment comprised 21 shoot tips.

*Continuous in vitro culture.* In the initial culture, the nodal cuttings yielded plants that grew well, but after 2 and 3 subcultures, plants developed which showed several irregularities such as abundant flower formation, vitrification and stunted growth. The leaf color became light green. These problems were more obvious in 'Hokus' than in the *C. sativus* var. *hardwickii* accession. Sealing the culture jars with vitafilm instead of using the plastic lids considerably improved the condition of the plants. One layer of the film proved to be better than 3 layers. In that treatment, plants were produced having vital, dark green leaves and without flower bud formation, but plant extension growth as well as leaf size were reduced. Moreover, the culture medium desiccated rapidly. These problems could be overcome by covering the jars sealed with one layer vitafilm with one layer of cheese cloth, which reduced the light to approximately 1 klux, and by application of 5 ml sterilized water on top of the solid medium. Under these conditions continuous culture of cucumber plants was successful.

From the results in this study, we concluded that cucumber cultures that grow well can be obtained by starting from relatively large cuttings (shoot tip or

nodal). Cultures started from small cuttings proved to be less successful. As can be deduced from the experiment with the nodal cuttings, the distance from the culture medium rather than the size of the cuttings appeared to be important. Apparently, close contact of the apex or axillary bud with the culture medium prevents their normal development into plants, possibly because of a disturbance in functioning of the endogenous hormones. This might also be an explanation for the poor development into plants of adventitious buds and somatic embryos of cucumber under normal tissue culture conditions. The continuous culture of cucumber plants is improved considerably under special conditions, viz. culturing in jars sealed with a thin vitafilm instead of closing them with an air-tight lid. This suggests that the culture needs aeration. Cucumber plants in culture apparently produce certain harmful gases, such as ethylene, which can diffuse through the thin vitafilm.

#### Literature Cited

1. Kim, S.G., J.R. Chang, H.C. Cha and K.W. Lee. 1988. Callus growth and plant regeneration in diverse cultivars of cucumber (*Cucumis sativus* L.). *Plant Cell, Tissue Organ Cult.* 12:67-74.
2. Rute, T.N., R.G. Butenko, and K.A. Maurinya. 1978. Influence of cultivation conditions on morphogenesis of the apical meristems of cucumber plants in cultures *in vitro*. *Soviet Plant Physiol.* 25:432-438.
3. Ziv, M. and G. Gadasi. 1986. Enhanced embryogenesis and plant regeneration from cucumber (*Cucumis sativus* L.) callus by activated charcoal in solid/liquid double-layer cultures. *Plant Sci.* 47:115-122.

\* \* \* \* \*

#### Haploid Gynogenesis in *Cucumis sativus* Induced by Irradiated Pollen

A. Sauton  
Royal Sluis France, Research and Development Station, BP 1431 30017 Nimes,  
France

A very efficient method of doubled haploid production is now commonly used in muskmelon (*Cucumis melo* L.) breeding programs (2). This method consists of the induction of gynogenesis *in situ* with gamma-ray irradiated pollen, then followed by rescue of haploid embryos by *in vitro* culture.

My first attempts to apply the same method in cucumber (minicucumber type) were promising and produced viable gynogenetic haploid plants (1). This study was undertaken in order to develop the method for cucumber.

The gynogenetic induction and development process is similar in muskmelon and cucumber. In the two cases, when an irradiation from 300 to 1000 Gy was applied, the pollination with such irradiated pollen induced normal development of fruit and seed coats. In one fruit, only a small number of



seeds were not empty. Three weeks after pollination with irradiated pollen, these seeds contained either a single embryo, which was haploid, or an undifferentiated structure that was probably a pseudo-endosperm or an aborted embryo. Embryo and endosperm were never observed together in the same seed. Some haploid embryos had reached the cotyledon stage, while other embryos were less differentiated (globular, heart shaped, or torpedo stage).

In cucumber, a great variation in the rate of gynogenetic induction was recorded among fruits. This heterogeneity was observed regardless of genotype studied (minicucumber type with different levels of parthenocarpy). The mean rate of viable plants was about 3 per 1000 seeds if all the developed seeds produced in fruits after pollination with irradiated pollen were taken into account. However, after pollination with normal pollen in the minicucumber type under our culture conditions, only 30 to 60% of seeds were full. Therefore, for each genotype, the real rate of viable gynogenetic plants might be calculated according to the mean number of ovules susceptible to be fertilized. This rate in the minicucumber type was near 1%.

Cucumber haploid plants were propagated *in vitro* by successive microrootings. Spontaneous diploidization was frequent in root meristems especially when plants had undergone several cycles of microrooting. These plants grew rapidly and normally in soil and produced staminate and pistillate flowers which were generally smaller than diploid ones. Furthermore, their petals were not joined together at the corolla base. The plants remained haploid and produced pollen grains typical of haploid plants. Chromosome doubling was obtained by colchicine treatment of haploid cuttings *in vitro*. Doubled haploid plants produced normal and fertile pollen and normal seeds.

Further studies are in progress to i) increase the production of viable haploid plants, ii) apply the soft X-ray radiography technique to detect haploid embryos in immature seeds as it has been shown in melon (3), and iii) perform the technique of chromosome doubling.

#### Literature Cited

1. Andre, I. 1988. *In vitro* haploid plants derived from pollination by irradiated pollen on cucumber. Proceedings of the Eucarpia meeting on Cucurbit Genetics and Breeding, Avignon - Montfavet, France. 31 May, 1988, 06/01-02, 143-144.
2. Sauton, A. 1988. Doubled haploid production in melon (*Cucumis melo* L). Proceedings of the Eucarpia meeting on cucurbit genetics and breeding, Avignon - Montfavet, France. 31 May, 1988, 06/01-02, 119-128.
3. Sauton, A., C. Olivier and A. Chavagnat. 1988. Use of soft X-ray technique to detect haploid embryos in immature seeds of melon. ISHS 4th International Symposium on Seed Research in Horticulture. Angers, France. 5-9 Sept., 1988, Acta Hort. (in press).

## Preliminary Data on Haploid Cucumber (*Cucumis sativus* L.) Induction

Katarzyne Niemirowicz-Szczytt and Robert Dumas de Vaultx

Department of Genetics and Horticulture Plant Breeding, University of Agriculture, ul. Nowoursynowska 166, 02-766, Warszawa, Poland (1st author); INRA, Station d'Amelioration des Plantes Maraicheres, 84140 Montfavet-Avignon, France (2nd author)

Pollination of muskmelon (*Cucumis melo* L.) with irradiated pollen resulted in the production of haploid embryos which developed into haploid plants *in vitro* (2). The same method was used to induce haploid cucumber embryos (3). In the latter case, pollination with irradiated pollen (400 to 600 Grays, 60 Co) followed by ovule culture gave 0.3 percent viable plants. These plants were haploid ( $x=7$ ) when first meristems were evaluated and exhibited mixoploid chromosome numbers (with some  $3x$  and  $4x$  cells) later. No details of varieties, media or plant numbers were published. The objective of this study was to determine whether a haploid cucumber F1 cultivar ( $2n=2x=14$ ) could be obtained using this method.

**Methods.** Pistillate flowers of the cultivar Polan F1 were pollinated with pollen which had been subjected to one of two levels of irradiation (900 or 300 Grays, 60 Co). All flowers pollinated with normal pollen produced fruits with on average 400 seeds each. After irradiation of pollen, fewer fruits developed with 250 seeds per fruit. All control seeds contained normal embryos, while only 13 embryos were produced after irradiation of pollen with 300 Grays (Table 1). Eighteen to 20 days after pollination, these embryos (heart to cotyledonary stage) were excised from seeds and cultured on E20 medium (2). Embryos were smaller than those of the control, with abnormalities in cotyledons (with respect to size, position and color) and in proper embryo development.

From these 13 embryos, 8 plants were obtained. These plants were transplanted onto a P medium (1) which promoted further development. The chromosome number of four of these plants was estimated in root and stem meristems using the Feulgen method. After four weeks in culture these four plants were micropropagated and their chromosome number was estimated a second time (Table 2).

**Results.** It was found that, after micropropagation of plant n°3 and plant n°4, a number of cells in new root meristems had undergone spontaneous chromosome doubling. The four remaining plants exhibited teratological changes and were difficult to micropropagate.

### Literature Cited

1. Masson J., M. Lecerf, P. Rouselle, P. Perennec and G. Pelletier. 1987. Plant regeneration from protoplast of diploid potato derived from crosses of *Solanum tuberosum* with wild *Solanum* species. *Plant Sci.* 53:167-176.
2. Sauton A. and R. Dumas de Vaultx. 1987. Obtention de plantes haploides chez le melon *Cucumis melo* L. par gynogenese induite par du pollen irradie. *Agronomie* 7, 2:141-148.
3. Truong-Andre, I. 1988. *In vitro* haploid plants derived from pollinisation by irradiated pollen on cucumber. *Proc. Eucarpia Meeting on Cucurbitaceae.* 88:143-144.

Table 1. Number of fruits and embryos obtained after pollination of 'Polan' F1 with irradiated pollen.

<u>Grays</u>	<u>Pollinated flowers</u>	<u>Number of fruits</u>	<u>Embryos</u>
900	10	5	0
300	10	6	13
Control	5	5	All seeds with embryos

Table 2. Number of chromosomes before and after micropropagation in mitotic divisions and numbers of plants in clones.

<u>Plant number</u>	<u>Chromosome number</u>		<u>Number of plants in clones</u>
	<u>Before prop.</u>	<u>After prop.</u>	
1	7	7	13
2	7	7	11
3	7	7 and 14	7
4	7 and 8	7 and 14	11



Fig. 1. Chromosomes in root meristem of haploid  $n=x=7$  cucumber plant.

## Isolation and Culture of *Cucumis metuliferus* Protoplasts

William H. McCarthy, Todd C. Wehner and Margaret E. Daub  
Department of Horticultural Science, Box 7609, North Carolina State  
University, Raleigh, NC 27695-7609 (1st and 2nd authors) and Department of  
Plant Pathology, Box 7616 (3rd author)

Research supported in part by a grant from Pickle Packers International. The authors wish to thank Mr. D.F. Moxely for technical assistance.

In the southeastern United States, approximately 12% of the potential cucumber yield is lost to root knot nematodes (*Meloidogyne* spp.). Screening of the *Cucumis sativus* germplasm revealed no resistant accessions (4). Within *Cucumis*, the species *C. metuliferus* has shown medium- to high-level resistance to root knot nematode (3). Traditional sexual hybridization techniques have been unsuccessful in producing hybrids between *C. sativus* and *C. metuliferus* (1). Protoplast fusion is one possible method of overcoming the barriers which exist between these two species. Before fusion work can take place, techniques for protoplast isolation and culture of *C. metuliferus* need to be established. The objective of this study was to develop a procedure for protoplast isolation and culture of *C. metuliferus* protoplasts.

**Methods.** *Cucumis metuliferus* PI 482454 seeds were sterilized using the industrial disinfectant LD (Alcide Corporation, Norwalk, Conn. USA 06851) for 30 minutes at the suggested rate of 1:1:10 for base, activator, and double glass-distilled water, respectively. Seeds were rinsed 5 times with sterilized water, and placed onto C1 medium (Table 1) and incubated in the dark at 30°C. After 84 hours, seedlings were placed in a growth room held at 22°C and 16 hours of light (8,000 lux). Twenty four hours before protoplast isolation, seedlings were transferred back to 30°C in darkness.

An enzyme solution was prepared consisting of 0.7 mM KH<sub>2</sub>PO<sub>4</sub>, 7 mM CaCl<sub>2</sub>·2H<sub>2</sub>O, 0.5 M mannitol, 3 mM MES [2-(N-morpholino)ethanesulfonic acid], 2% cellulysin (Cal. BioChem.), and 0.5% macerace (Cal. BioChem.). This solution was then mixed at a 1:1 ratio with C2 medium (Table 1) as described by Durand et al. (2), modified by adding an additional 230 mg/l CaCl<sub>2</sub>·2H<sub>2</sub>O (5). Ten ml of enzyme-C2 solution were added to 0.5 grams of cotyledons (5 to 7 days old), which were then vacuum infiltrated at 9.33 kPa for 20 seconds. The infiltrated tissue was put into sterile 50 ml flasks on a gyrator run at 60 rpm at 25°C in the dark. After 6 hours of digestion, the protoplasts were separated by gently swirling the 50 ml flasks. Protoplasts were isolated from cell walls and other debris by filtering through sterilized miracloth (Cal. BioChem.).

Protoplasts were washed 3 times with C2 medium by centrifuging at 100 g for 3 minutes. Viability was determined using a fluorescein diacetate stain (7). Protoplasts were cultured in 5 ml of C2 medium at a density of 1 X 10<sup>5</sup> protoplast/ml, in 10 X 60 mm petri plates, and incubated in the dark at 25°C. Five days after protoplast isolation, half of the plates were moved to a 30°C chamber in the dark. Seven days after protoplast release, 1 ml of C3 (Table 1) medium was added to each plate. Fourteen and 21 days after isolation, 1 ml of C4 (Table 1) medium was added to each plate. Protoplast culture plates were briefly swirled daily to increase aeration.

Estimates of plating efficiency (percentage of protoplast which had undergone cell division) were made 8 to 10 days after isolation. Plating efficiency was estimated by visual observation of 5 samples per plate, at 320X magnification. Plating efficiency was calculated by counting the number of cells with clearly defined (1 or more) cell divisions. Using the sample results, total number of divided cells per plate was calculated. This number was then compared to the total number of protoplasts in the plate ( $5 \times 10^5$ ) to produce an estimate of plating efficiency. Approximately 3 weeks after isolation, the number of microcalli per plate (clumps of 8 to 64 cells which appeared to have originated from 1 cell) were estimated. The number of microcalli per plate was estimated by counting the number of microcalli in 5 samples per plate (100X magnification), and calculating an approximate number per plate from the random visual counting. Experiment 1 was a randomized complete block with 4 replications.

In experiment 2, protoplasts were isolated and cultured using the methods described above. After 3 weeks, microcalli suspensions were pipetted onto C5 medium (Table 1) containing different amounts of 2,4-dichlorophenoxyacetic acid (2,4-D), indoleacetic acid (IAA), kinetin (kin), and benzylaminopurine (BA) (Table 2). The callus cultures were maintained at 22°C in the dark for 3 weeks before being rated for percentage of the petri plate covered with callus. Callus color was rated 1 to 9 (1-3=white, 4-6=yellow, 7-9=brown). For both experiments, protoplast viability and number of protoplasts isolated per gram of tissue were determined. Experiment 2 was a randomized complete block with 4 replications.

*Results.* Protoplast viability (as determined by fluorescein diacetate staining) was consistently between 80 and 100%, and the number of viable protoplasts isolated per gram of tissue was  $8.2 \pm 2.5 \times 10^6$ . In both experiments, protoplasts rapidly regenerated cell walls and underwent cell division. Cell wall regeneration was determined by observed changes in protoplast shape, and actual cell division. In experiment 1, protoplasts cultured at 25°C had a plating efficiency (PE) of 4%. Protoplasts cultured at 30°C had a PE of 7%. Analysis indicated there was a significant difference between the 2 temperatures for plating efficiency. After 3 weeks of culture at 25°C, each plate had a average of 3970 microcalli, while culture of protoplasts at 30°C produced an average of 5025 microcalli per plate.

In experiment 2, medium A3 (Table 2) was best for producing a large amount of yellow, friable callus. The color ratings showed no significant differences among media, but protoplasts cultured at 30°C were significantly whiter. Callus color appeared to indicate potential for continued proliferation because callus with ratings above 5 usually had little or no continued growth, even when transferred to fresh media. Although no plant regeneration occurred from any of the 4 media, medium A3 provided the means for producing large amounts of callus which could subsequently be transferred to a embryo inducing medium.

From these two experiments, successful isolation of a large number of viable protoplasts, and regeneration of cell walls of *C. metuliferus* protoplasts was achieved. A rapid method of producing protoplast-derived callus, suitable for possible plant regeneration was also found. In future experiments, we will attempt to increase the plating efficiency of isolated *C. metuliferus* protoplasts, and regenerate plants from culture.

Table 1. Components used for culture media for *C. metuliferus* protoplasts<sup>Z</sup>.

Component	Medium				
	C1	C2	C3	C4	C5
Mannitol	-	0.3 M	0.15 M	-	-
2,4-D	-	0.5 mg/l	0.5 mg/l	0.5 mg/l	-
Kinetin	-	1.0 mg/l	1.0 mg/l	1.0 mg/l	-
Agar(W/v)	0.8%	-	-	-	0.8%
Salts and vitamins	1/2 MS <sup>Y</sup>	Mod. DPD <sup>X</sup>	Mod. DPD	Mod. DPD	Mod. DPD
Sucrose (g/l)	15.0	17.1	17.1	17.1	17.1

<sup>Z</sup>All media were adjusted to a pH of 5.8.

<sup>Y</sup>Murashige and Skoog salts (6).

<sup>X</sup>Durand, Potrykus and Donn medium (2) modified by Jia et al. (5).

Table 2. Results of callus production from *C. metuliferus* protoplasts<sup>Z</sup>.

Code no.	Media Components <sup>Y</sup>	Protoplast culture temperature			
		25°C		30°C	
		% plate covered	Color rating	% plate covered	Color rating
A1	0.01 mg 2,4-D 1.0 mg BA	3.0	6.1	5.0	5.0
A2	0.20 mg IAA 0.5 mg BA	0.0	-	3.0	5.5
A3	0.25 mg 2,4-D 0.5 mg Kin	10.0*	5.3	8.0	4.4
A4	0.50 mg 2,4-D 1.0 mg Kin	2.0	5.3	5.0	3.7*

<sup>Z</sup>Data are means of 4 replications.

<sup>Y</sup>Base medium was C5 (Table 1).

\*Significant at 5% level.

#### Literature Cited

1. Deakin, J.R., G.W. Bohn and T.W. Whitaker. 1971. Interspecific hybridization in *Cucumis*. Econ. Bot. 25:195-211.

2. Durand, J., I. Potrykus and G. Donn. 1973. Plantes issues de protoplastes de *Petunia*. Z. Pflanzenphysiol. 69:26-34.
3. Fassuliotis, G. 1970. Species of *Cucumis* resistant to the root-knot nematode, *Meloidogyne incognita acrita*. J. Nematol. 2:174-178.
4. Fassuliotis, G. and G.J. Rau. 1963. Evaluation of *Cucumis* spp. for resistance to the cotton root-knot nematode, *Meloidogyne incognita acrita*. Plant Dis. Repr. 47:809
5. Jia, Shi-rong, You-ying Fu and Yun Lin. 1986. Embryogenesis and plant regeneration from cotyledon protoplast culture of cucumber (*Cucumis sativus* L.). J. Plant Physiol. 124:393-398.
6. Murashige, T. and F. Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol. Plant. 15:473-497.
7. Widholm, J.M. 1972. The use of fluroscein diacetate and phenosafranine for determining viability of cultured plant cells. Stain. Tech. 47:189-194.

\* \* \* \* \*

#### Isolation and Culture of Protoplasts of *Cucumis sativus* and *Cucumis metuliferus* and Methods for Their Fusion

F.A. Tang and Z.K. Punja  
Campbell Institute for Research and Technology, Campbell Soup Company, Route 1, Box 1314, Davis, CA 95616

The introduction of disease resistance into pickling cucumber (*Cucumis sativus* L.) is an essential component of all cultivar development programs. Efforts continue to identify new sources of resistance to major disease problems, such as root-knot nematodes (*Meloidogyne incognita*) and to viruses, such as zucchini yellow mosaic (ZYMV) and watermelon mosaic (WMV). The wild African horned cucumber (*Cucumis metuliferus*) PI 292190 has been shown to carry resistance to *M. incognita* and to ZYMV and WMV-1 (7,15,16) but not to WMV-2 (15). Efforts to introgress this germplasm by conventional sexual crosses have not yielded any success due to severe incompatibility barriers (3,10). Somatic hybridization by protoplast fusion has been one approach that investigators have shown to be successful in transferring traits of interest from distantly related species to cultivated species in *Brassica* (14), *Daucus* (5), *Lycopersicon* (13), *Nicotiana* (4), and *Solanum* (1,2,6,17). In this report, we describe results from studies aimed at establishing a procedure for the isolation and fusion of mesophyll protoplasts of two species, *C. sativus* and *C. metuliferus*. The ultimate goal is to identify somatic hybrids which may bring in traits of interest from *C. metuliferus* into a *C. sativus* background.

*Plant materials.* Seeds of *C. sativus* Gy 14 and *C. metuliferus* PI 292190 were dipped in 70% ethanol for 20 sec, followed by a 20 min soak in a 20% solution of commercial bleach (Chlorox, 5.25% sodium hypochlorite) to sterilize them, followed by 3 rinses in sterile, distilled water. The seed coats were excised under sterile conditions and the embryos transferred to Magenta boxes containing 50 ml of hormone-free Murashige and Skoog (12) basal medium (MS) with full strength macroelements and microelements, myo-inositol (100 mg/l), thiamine HCL (0.8 mg/l), 3% sucrose, and 0.65% Phytoagar. The pH of the medium was adjusted to 5.8 with 1 N KOH prior to autoclaving at 15 psi for 16 min. Boxes were incubated in a walk-in growth chamber set at a 18/24°C night/day temperature regime with 16 hr/day photoperiod provided by cool-white fluorescent lamps (intensity of 160 mEM<sup>-2</sup> sec<sup>-1</sup>). These *in vitro* cultures were used to provide plant materials for protoplast isolation. The first to third leaf from 15 to 21 day-old seedlings were used as the source of mesophyll protoplasts.

*Isolation and purification of protoplasts.* True leaves (1 g) were cut into 1-2 mm wide x 10 mm long strips with a scalpel under sterile conditions and placed in 20 ml of the enzyme solution in a 100 x 25 mm petri dish. The optimal concentration of pectinase (Sigma) and cellulysin (Calbiochem) required for both Gy 14 and for *C. metuliferus* was 0.5% and 1.0%, respectively. These resulted in yields of 5 to 6 x 10<sup>6</sup>/g tissue. Enzyme solutions were prepared in modified MS medium containing half-strength major salts, full complement of minor salts and vitamins, 2% sucrose and 0.25M mannitol. The enzyme solution was sterilized by filtration using a syringe (B-D disposable) and Nalgene disposable filter unit (0.22 µm pore size). Tissues were incubated overnight (15 to 16 h) in the dark at 24 ± 2°C on a reciprocating shaker set at 60 rpm. The resulting suspension was passed through multilayers of sieve cloth (pore sizes from 50 to 300 µm) to separate protoplasts from undigested plant debris. Two rinses in basal medium containing mannitol and centrifugation at 1200 rpm were conducted to remove the enzyme solution and purify the protoplasts. Protoplasts were concentrated as a dark green band at the meniscus of the Babcock bottles following purification. The pellet was removed with a Pasteur pipette and resuspended in basal medium and protoplasts were diluted to the desired density (2.5 to 3.0 x 10<sup>4</sup>/ml) for fusion.

*Protoplast fusion.* One-half ml of the protoplast suspension of each species was mixed in a 60 x 15 mm petri dish and 1 ml of the following fusion treatments were tested: PEG M.W. 8,000 (8) at a concentration of 15% (in final volume), with or without 1% DMSO, for 20 min; high pH/Ca for 15 to 20 min (solution comprised of mannitol, 80 g/l; CaCl<sub>2</sub>·2H<sub>2</sub>O, 7.35 g/l; glycine, 3.75 g/l; pH 10.0) (9). Following the treatments, the protoplast suspension was washed 2 to 3 times with basal medium to remove the fusigenic agents, and protoplasts were concentrated to a density of 2.5 to 3.0 x 10<sup>4</sup>/ml.

*Protoplast culture.* Protoplasts of *C. sativus* at a density of 2.5 to 3.0 x 10<sup>4</sup>/ml or at 0.5 to 0.6 x 10<sup>4</sup>/ml, *C. metuliferus* protoplasts alone, and a mixture of the two species, were plated without any fusion treatment, and following the treatments described above, in MS medium with half strength major salts, full complement of minor salts and vitamins, 2% sucrose and 0.25 M mannitol. Hormonal requirements were provided by 2,4-D/BA at 5.0/5.0 mM or NAA/BA at 5.0/2.5 mM. The suspension (2 ml) was added to soft agarose (0.4%) in 35 x 10 mm petri dishes. All dishes were incubated in the dark at 24 to 26°C in a growth chamber for the first 7 days and then transferred to a 16 h



photoperiod provided by cool-white fluorescent lamps, intensity of  $100 \text{ mEM}^{-2} \text{ sec}^{-1}$ . The days to first division, second-third division, and formation of minicalli were assessed for each species and fusion treatment. An additional treatment was imposed on these platings, namely that of a nurse culture (11). This was achieved by placing droplets of the protoplast suspension (with or without fusion treatments) in the center of the petri dish and placing along the periphery of the dish a 1.0 to 1.5 cm zone of mesophyll protoplasts of *C. sativus* at a density of  $2.5$  to  $3.0 \times 10^4/\text{ml}$ , avoiding contact with the protoplasts under experimentation by providing a cell free circular zone about 1.5 cm wide.

**Results.** The protoplast isolation procedure described gave high yields of good quality protoplasts of both species. Without imposing any fusion treatment, protoplasts of *C. sativus* formed minicalli within 13 days when plated at a density of  $2.5$  to  $3.0 \times 10^4/\text{ml}$  (Table 1). At a lower density of  $0.5$  to  $0.6 \times 10^4/\text{ml}$ , a nurse culture system was essential to promote sustained divisions. With *C. metuliferus*, only first cell divisions were observed and there was no development of minicalli. When a mixture of these two species was plated out, division and regeneration of *C. sativus* was inhibited by the presence of *C. metuliferus* protoplasts (possibly due to a dilution of the plating density), but this was overcome by the presence of the *C. sativus* nurse culture system (Table 1). When fusion treatments were imposed, their effects were determined on control protoplasts of *C. sativus* as well as in mixtures. Both PEG and high pH/Ca delayed the onset of divisions and development of minicalli in *C. sativus*, and this was partially overcome by the presence of the nurse culture (Table 1). Fusion frequencies were estimated to be around 5 to 6% for PEG and 2 to 5% for high pH/Ca. The presence of 1% DMSO in PEG was detrimental, since it caused cell enlargement and rupturing of the protoplast membrane. In mixtures of the two species with PEG or high pH/Ca as the fusigenic agent, (Fig. 1) cell divisions of fused and unfused cells were observed (Fig. 2) and minicalli developed (Fig. 3). These have been subcultured onto callus proliferation medium containing full strength MS salts containing the same hormonal combinations, with 3% sucrose and 0.65% Phytoagar.

**Discussion.** Sustained division of mesophyll protoplasts to produce callus, which eventually gave rise to plantlets (unpublished) was accomplished for *C. sativus* but not in *C. metuliferus*. The lack of regeneration of *C. metuliferus* is advantageous in fusion studies, since only *C. sativus*-*C. sativus* or *C. sativus*-*C. metuliferus* fusions would be selected. Since low plating density affected the extent of protoplast divisions, which occurs because fusion followed by washings dilutes the initial plating density, a nurse culture system was employed in this study. Nutrients or compounds released by the adjacent growing cells enhanced division of mixed cells. Although protoplasts were used to provide the nursing effect, suspension culture cells can also be substituted (unpublished). The nurse culture system also minimized the extent of delay of cell divisions due to the fusion treatments.

PEG 8000 yielded higher fusion frequencies than high pH/Ca in this study. The callus developing from fusion mixtures would be of the *C. sativus* genotype and potentially *C. sativus*-*C. metuliferus* hybrids. Because high plating densities are required for growth, individual isolation of potential hybrid cells cannot be accomplished. However, hybrid callus or plants regenerated from them should be distinguishable from *C. sativus* by morphological differences, chromosome numbers and isozyme banding patterns. The results described here

are the first step toward accessing the desired traits of disease resistance from *C. metuliferus*.

Table 1. Response of protoplasts of *Cucumis sativus* and *C. metuliferus*, alone or in mixture, to a nurse culture and fusion treatments.

Species	Days required to obtain					
	Nurse culture	Cell wall formation	First division	Second-third division	Mini callus	
<b>No Fusion Treatment</b>						
<i>C. sativus</i> <sup>Z</sup>	-	1-2	4-5	6-7	13	
	+	1-2	4-5	6-7	13	
<i>C. sativus</i> <sup>Y</sup>	-	3-4	10-20	>20	-	
	+	2-3	5-6	9-10	20	
<i>C. metuliferus</i> <sup>Z</sup>	-	5-6	8-10	-	-	
	+	5-6	8-10	-	-	
Mixture	-	3-4	10-20	>20	-	
	+	2-3	7-10	14	28	
<b>With Fusion Treatment</b>						
<i>C. sativus</i>	PEG	-	2-3	5-7	10-14	22-28
		+	2-3	5-6	9-12	20
	High pH/Ca	-	2-3	5-7	10-14	22-28
		+	2-3	5-6	9-12	20
Mixture	PEG	+	3-4	7-8	12-16	28
	High pH/Ca	+	3-4	7-8	12-16	28

<sup>Z</sup>Plating density of 2.5 to 3.0 x 10<sup>4</sup>/ml

<sup>Y</sup>Plating density of 0.5 to 0.6 x 10<sup>4</sup>/ml

#### Literature cited

1. Austin, S., M.A. Baer and J.P. Helgeson. 1985. Transfer of resistance to potato leaf roll virus from *Solanum brevidens* into *Solanum tuberosum* by somatic fusion. *Plant Science* 39:75-82.
2. Austin, S., M.K. Ehlenfeldt, M.A. Baer and J.P. Helgeson. 1986. Somatic hybrids produced by protoplast fusion between *S. tuberosum* and *S. brevidens*: phenotypic variation under field conditions. *Theor. Appl. Genet.* 71:682-690.
3. Deakin, J.R., G.W. Bohn and T.W. Whitaker. 1971. Interspecific hybridization in *Cucumis*. *Econ. Bot.* 25:195-211.
4. Douglas, G.C., L.R. Wetter, C. Nakamura, W.A. Keller and G. Setterfield. 1981. Somatic hybridization between *Nicotiana rustica* and *N. tabacum*.

III. Biochemical, morphological, and cytological analysis of somatic hybrids. *Can. J. Bot.* 59:228-237.

5. Dudits, D., G. Hadlaczky, E. Levi, O. Fejer, Z. Haydu and G. Lazar. 1977. Somatic hybridisation of *Daucus carota* and *D. capillifolius* by protoplast fusion. *Theor. Appl. Genet.* 51:127-132.
6. Gibson, R.W., M.G.K. Jones and N. Fish. 1988. Resistance to potato leaf roll virus and potato virus Y in somatic hybrids between dihaploid *Solanum tuberosum* and *S. brevidens*. *Theor. Appl. Genet.* 76:113-117.
7. Granberry, D.M. and J.D. Norton. 1980. Response of progeny from interspecific cross of *Cucumis melo* x *C. metuliferus* to *Meloidogyne incognita acrita*. *J. Ameri. Soc. Hort. Sci.* 105:180-183.
8. Kao, K.N. and M.R. Michayluk. 1974. A method for high frequency intergeneric fusion of plant protoplasts. *Planta* 115:335-367.
9. Keller, W.A. and G. Melchers. 1973. The effect of high pH and calcium on tobacco leaf protoplast fusion. *Z. Naturforsch.* 28c:737-741.
10. Kho, Y.O., A.P.M. Den Nijs and J. Franken. 1980. Interspecific hybridization in *Cucumis* L. II. The crossability of species, an investigation of in vivo pollen tube growth and seed set. *Euphytica* 29:661-672.
11. Kyojuka, J., Y. Hayashi and K. Shimamoto. 1987. High frequency plant regeneration from rice protoplasts by novel nurse culture methods. *Mol. Gen. Genet.* 206:408-413.
12. Murashige, T. and F. Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue cultures. *Physiol. Plant.* 15:473-497.
13. O'Connell, M.A. and M.R. Hanson. 1987. Regeneration of somatic hybrid plants formed between *Lycopersicon esculentum* and *L. pennelli*. *Theor. Appl. Genet.* 75:83-89.
14. Primard, C., F. Vedel, C. Mathieu, G. Pelletier and A.M. Chevre. 1988. Interspecific somatic hybridization between *Brassica napus* and *Brassica hirta* (*Sinapis alba* L.). *Theor. Appl. Genet.* 75:546-552.
15. Provvidenti, R. and R.W. Robinson. 1974. Resistance to squash mosaic virus and watermelon mosaic virus 1 in *Cucumis metuliferus*. *Plant Dis. Repr.* 58:735-738.
16. Punja, Z.K., F.A. Tang and L.H. Watkins. 1988. Identification of resistance to root knot nematodes and virus diseases in *Cucumis metuliferus* and approaches to hybridization with *Cucumis sativus* by protoplast fusion. *Phytopathology* 78 (Abstr.).
17. Shepard, J.F., D. Bidney, T. Barsby and R. Kemble. 1983. Genetic transfer in plants through interspecific protoplast fusion. *Science* 219:683-688.

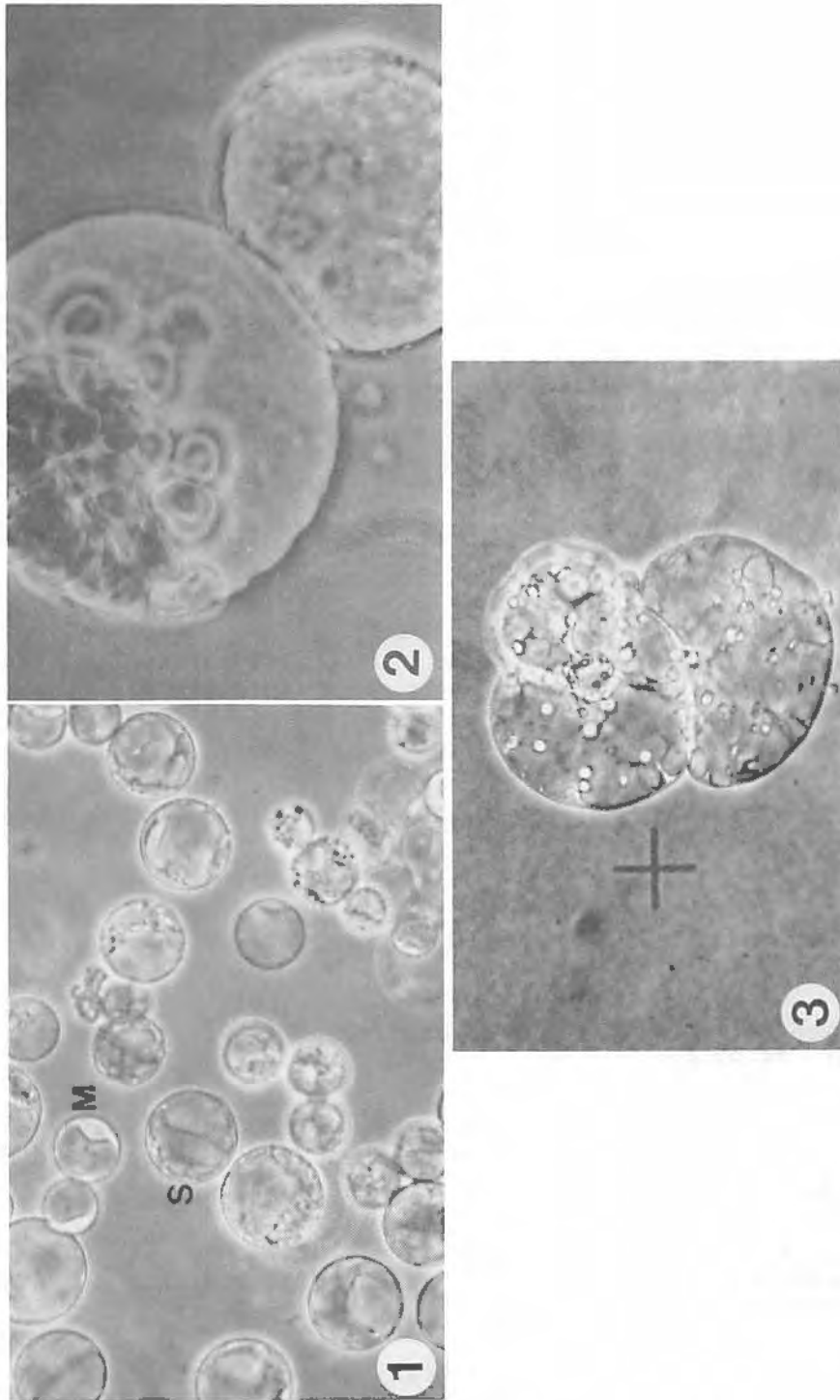


Fig. 1. Mixture of protoplasts of *Cucumis sativus* (S) and *C. metuliferus* (M).

Fig. 2. Close-up of fusion of protoplasts of the two species.

Fig. 3. Cell division of fused cells.

## Transformation of Cucumber with *Agrobacterium rhizogenes*

F. van der Mark, J.H.W. Bergervoet and J.B.M. Custers  
Institute for Horticultural Plant Breeding (IVT), P.O. Box 16, 6700 AA  
Wageningen, The Netherlands.

*Agrobacterium rhizogenes* induces hairy root disease in many dicotyledonous plants. The root inducing ability is conferred to plant cells by bacterial genes (T-DNA) which are transferred from the root inducing (Ri) plasmid of the bacterium to the plant genome. The Ri plasmid of the often used agropine type strains of *A. rhizogenes* consists of two distinct transformation elements, designated TL- and TR-DNA. TL-DNA contains genes relevant for hairy root induction, whereas TR-DNA contains genes involved in agropine and mannopine synthesis, as well as genes involved in the production of auxin. However, recent reports indicate that TR-DNA alone can cause production of hairy roots (1). Transformation of cucumber (*Cucumis sativus* L.) with *A. rhizogenes* has been reported only once (4). An agropine type strain was used. The results showed that the frequency of Ri T-DNA transfer into cucumber was rather low and that mostly only a small part of TL- or TR-DNA was integrated in the plant genome. This contrasts with *A. rhizogenes* transformation of other plant species, as most Ri-plants analyzed so far contain both TL- and TR-DNA, whereas sometimes the integration of TL-DNA alone is found (1). In this paper, we present preliminary results of *A. rhizogenes* transformation of cucumber inbreds Gy 3 and 'Straight Eight'.

**Methods.** Hypocotyl explants were inoculated on the basal wound with agropine type *A. rhizogenes* strain LBA-9402 and inserted upside down in a Murashige-Skoog solid medium supplemented with 3% (w/v) sucrose. Developing roots were excised from the hypocotyl explants and root cultures were made on the same medium for examining autonomous growth and expression of hairy root phenotype, i.e. excessive formation of lateral roots and partial nongeotropism. After 3 weeks of culture, growing roots were divided in 1 cm explants which were rechecked on a medium without hormones for another 3 weeks. Subsequently, root clones with the hairy root phenotype were tested for agropine and mannopine production. Opine positive clones were subcultured on media with hormones for induction of plant regeneration. Two embryo-inducing media were used; (M1) MS with 5 $\mu$ M 2,4-D + 5 $\mu$ M NAA + 2 $\mu$ M BA (4), and (M2) MS with 4 $\mu$ M 2,4-D + 4 $\mu$ M BA.

**Results.** The 2 inbred lines reacted rather similarly. After 6 weeks of culture, 75% of the inoculated hypocotyl explants showed root formation from the treated wound surface. No rooting was ever observed from the control explants. A total of 174 roots was excised from the hypocotyl explants, and 58% showed rapid growth on a medium without hormones. Large clones could be obtained from these roots, which clearly expressed the hairy root symptoms. The test on opine synthesis was carried out for only 25 fast growing root clones. In 20% of these clones opiines could be detected. Upon subculture on hormone containing media, these roots formed a grey, slowly-growing callus on M1, whereas on M2 a more vital callus was formed from which regular protuberances of an embryogenic, yellow callus developed. We transferred the yellow callus into a liquid medium of the same hormone composition as M2. Several somatic embryos appeared in this medium, but until now it was impossible to regenerate plants.

In the root cultures, evident differences were found between the roots derived from the *A. rhizogenes* infected cucumber hypocotyl sections. Approximately 40% of the roots did not show the hairy root phenotype. These roots probably originated as an indirect result of the process of transformation. Approximately 60% of the roots exhibited autonomous growth, accompanied by expression of the hairy root phenotype. This suggests that only these roots contained genes of the Ri T-DNA responsible for hairy root formation, i.e. TL-DNA, TR-DNA or both. Since only a low percentage of the fast growing roots actually produced opines, the integration of TR-DNA seems to be less common than that of TL-DNA. In agreement with the results obtained by Trulson et al. (4), it is concluded that the integration of T-DNA via *A. rhizogenes* transformation in cucumber is a rather complicated event resulting in roots with different parts of the T-DNA. A careful analysis of the integrated DNA by Southern hybridization is needed to evaluate this phenomenon.

#### Literature Cited

1. Birot, A., D. Bouchez, F. Casse-Delbart, M. Durand-Tardief, L. Jouanin, V. Pautot, C. Robaglia, D. Tepfer, M. Tepfer, J. Tourneur, and F. Vilaine. 1987. Studies and uses of Ri plasmids of *Agrobacterium rhizogenes*. *Plant Physiol. Biochem.* 25:323-335.
2. Custers, J.B.M., J.E.M. van Deelen, and J.H.W. Bergervoet. 1988. Development of callus and somatic embryos from zygotic embryos of cucumber (*Cucumis sativus* L.). *Cucurbit Genet. Coop. Rpt.* 11:1-2.
3. Malepszy, S and A. Nadolska-Orczyk. 1983. *In vitro* culture of *Cucumis sativus*. I. Regeneration of plantlets from callus formed by leaf explants. Z. *Pflanzenphysiol.* 111:273-276.
4. Trulson, A.J., R.B. Simpson and E.A. Shahin. 1986. Transformation of cucumber (*Cucumis sativus* L.) plants with *Agrobacterium rhizogenes*. *Theor. Appl. Genet.* 73:11-15.

Tolerance Reaction of Muskmelon to Inoculation with Fusarium oxysporum f. sp. melonis Races 0 and 1.

D.Gabillard and M.Jacquet.

Institut de Recherches Vilmorin, Lédénon, 30210 Remoulins, France.

Intermediate resistances have already been described with Fusarium oxysporum f.sp. melonis race 2.

This study deals with a case of tolerance to races 0 and 1 found in a line "Vilmorin 109".

The line "Vilmorin 109" was crossed with a very susceptible (to race 0 and 1) netted line "Vilmorin 110". None of both lines had gene (Fom-1) nor (Fom-2). Both can be considered homozygous (inbreeding for 9 generations).

Two types of inoculation were tested :

A) Plantlet were removed from seedling pots at the cotyledon stage ; roots were pruned to about 20 mm and dipped for 1 mn in Fusarium suspension ( $10^5$  conidia/ml). Then they were transplanted into growing trays and placed in a growth chamber (day/night, 24/18°C, 14/10 hours).

B) 5 ml of the same suspension were poured at the basis of each plantlet at the cotyledon stage and placed in the same growth chamber.

Susceptible and resistant controls were respectively cv. Charentais T and cv. Vedrantaïs for race 0 and cv. Vedrantaïs (Fom-1) and "Vilmorin 108" (Fom-2) for race 1.

Virulence of both races was studied on the two parental lines and on the hybrid for one month. Two Fusarium oxysporum isolates of each race were also studied but they were not statistically different for their pathogenicity. The symptom scale is : (1) no symptom, (3) symptom of physiological disorders, (5) beginning of yellowing, (7) entire plantlet yellowing, (9) plantlet death (fig. 1a,b,c,d).

In every four experiments, "Vilmorin 109" appeared statistically different from the susceptible and the resistant controls (see table 1). On the other hand the symptoms became visible faster on "Vilmorin 110" than on the two controls. The level of the F1 ("Vilmorin 109" x "Vilmorin 110") was between the level of the two parents indicating a partially dominant gene action. This intermediate level, obvious with race 0, was impossible to detect with the race 1 and method A (fig.1c) but could be seen with method B (fig.1d) . This agreed with the work of Latin and Snell (1) and emphasized that different results could be obtained with different inoculation methods.

In the case of emergence of a new race of Fusarium or the spreading out of the race 1,2, these "minor" genes, beside the 2 genes (Fom-1) and (Fom-2), will perhaps play a prominent part in muskmelon breeding programmes.

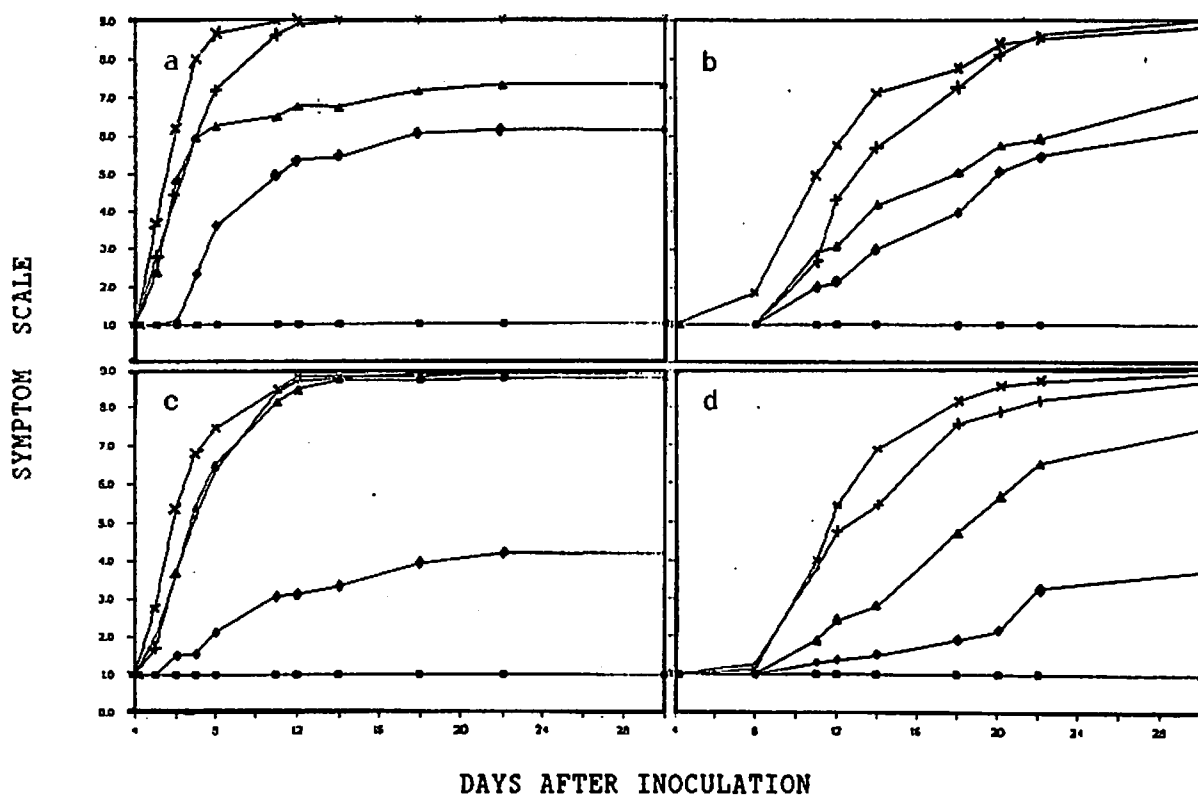


fig.1 Virulence of *Fusarium oxysporum* f.sp. *melonis* on five cultivars ; (a) race 0 inoculation method A, (b) race 0 inoculation method B, (c) race 1 inoculation method A, (d) race 1 inoculation method B. ■ : resistant control, + : susceptible control, ◆ : "Vilmorin 109", x : "Vilmorin 110", ▲ : F1 ("Vilmorin 109" x "Vilmorin 110").

Table 1. Newmann-Keuls test on symptom scale (P = 0,05)

cultivars	DAYS AFTER INOCULATION											
	6	8	14	11	14	22	6	8	14	11	14	22
	fig.1a			fig.1b			fig.1c			fig.1d		
"Vilmorin 110"	A	A	A	A	A	A	A	A	A	A	A	A
Susc.Control	B	B	A	B	AB	A	AB	A	A	A	B	A
F1 (109 x 110)	B	B	B	B	BC	B	AB	A	A	B	C	B
"Vilmorin 109"	C	C	C	B	C	B	BC	B	B	B	D	C
Resis.Control	C	D	D	B	D	C	D	B	C	B	D	D

#### LITERATURE CITED

1. Latin, R.X. and S.J.Snell.1986. Comparison of methods for inoculation with *Fusarium oxysporum* f.sp.*melonis*. *Plant Disease* 70 :297-300
2. Zink, F.W., W.D. Gubler, G.R. Grogan.1983. Reaction of muskmelon germ plasm to inoculation with *Fusarium oxysporum* f.sp. *melonis* race 2. *Plant Disease* 67 : 1251-1255



Resistance to *Sphaeroteca fuliginea* (Schlecht. ex Fr.) Poll. in Spanish Muskmelon Cultivars

M.L. Gómez-Guillamón and J.A. Torés

Estación Experimental "La Mayora", Algarrobo-Costa, 29750 Málaga, Spain

In 1987 and 1988 several cultivars of Spanish type melons were inoculated with *Sphaeroteca fuliginea* race 1 to determine possible sources of resistance to this pathogen. The cultivars chosen were those who in previous years were free of disease symptoms under natural conditions of infection.

Two methods of artificial inoculation were employed; both used a dry inoculum. In one, a small mass of spores was placed on the leaf surface with a scalpel (M. Pitrat, personal communication). This method allowed a visual check of the efficiency of inoculation success. In the other, the spores were applied by dusting the leaves (1). The inoculum was a strain of *S. fuliginea* race 1 isolated in the Estación Experimental "La Mayora" (Málaga, Spain) (3).

Table 1. Response of different Spanish melon cultivars against *S. fuliginea* race 1

Cultivars	Artificial inoculation	Natural inoculation	Observations
AN-C-36	R	+	Piel do Sapo type
C-C-3	S	+	Type no ascribable
AN-C-57	R	0	Yellow type
AN-C-39	S	+++	
MU-C-44	S	+++	
AN-C-7	S	+++	
PI 124112 B	R	0	Resistant races 1, 2 and 3
PMR 6	R	0	Resistant races 1 and 2
AN-C-68	R	0	Yellow type
PMR 45	R	0	Resistant race 1
E-C-14	S	+++	
AN-C-08	S	+++	
AN-C-42	R	0	Type no ascribable
J-22112-C	S	+++	

R resistant; S sensitive

+++ the symptoms appeared from the start of cultivation period.

+ mild symptoms appear at the end of the cultivation period.

0 no symptoms were observed.

The same cultivars were grown under a polyethylene greenhouse on a sandy soil with drip irrigation in a field with a previous history of powdery mildew. No fungicide applications against the fungus was carried out and the plants were left to be infected naturally. The sensitive genotypes acted as a source of inoculum throughout the cultivation period, and melon genotypes with known resistance to the three races of *S. fuliginea* were used as testers (2).

Crosses have been initiated between the resistant cultivars AN-C-42, AN-C-68 and AN-C-57, and the muskmelon varieties of commercial importance of the Yellow and Piel do Sapo types to study the genetic of this resistance and ways of introducing it.

#### Literature Cited

1. Adeniji, A.A. and D.P. Coyne. 1983. Genetics and nature of resistance to powdery mildew in crosses of Butternut with Calabaza Squash and 'Seminole Pumpkin'. J. Amer. Sci. Hort. Sci. 108:360-368
2. McCreight, J.D., M. Pitrat, C.E. Thomas, A.N. Kishaba and G.W. Bohn. 1987. Powdery mildew resistance genes in muskmelon. J. Amer. Soc. Hort. Sci. 112:156-160
3. Torés, J. A. 1987. *Sphaeroteca fuliginea* (Schlect. ex Fr.) Poll., causal agent of cucurbit powdery mildew in southern Spain. 7th Congress of the Mediterranean Phytopathological Union. September 1987, Granada, Spain.

\* \* \* \* \*

#### Transmission of the Causal Agent of Muskmelon Yellowing Disease

C. Soria and M.L. Gómez-Guillamón  
Estación Experimental "La Mayora", Algarrobo-Costa, (Málaga), España

Since 1982, a yellowing disease has seriously affected muskmelon (*Cucumis melo* L.) crops cultivated under polyethylene greenhouses on the southeast coast of Spain. It now seriously affects the profitability of muskmelon growing in this area because it considerably decreases the numbers of fruits per plant and the average fruit weights.

The symptomology of the affected plants is of two types: one starts with small yellow spots on the leaves; the other shows up as an intense yellow stain at the base of the leaf stalk. In each case, the disease spreads until the whole of the leaf, except the veins, is yellowed (1). In both cases, the symptoms start on the old leaves and progress to the younger ones.

The observation that there is a close relationship between the presence of greenhouse white-fly *Trialeurodes vaporariorum* and the appearance of the disease and the symptoms described suggests that muskmelon yellowing disease may be the same as that previously described in Japan (5), Holland (4), France (3) and Bulgaria (2). In each of these works, the cucumber yellows virus (CuYV) is ascribed as the causal agent of the yellowing in spite of the fact that no virus particle was isolated.

To determine the optimum conditions for carrying out controlled infections in experiments in order to select genotypes which might be used to introduce resistance to this yellowing disease into commercial varieties usually

cultivated in this area, the three following possible types of disease transmission were studied: a) transmission by *Trialeurodes vaporariorum*, b) mechanical inoculation and c) seed transmission.

The experiments were carried out at temperatures between 25°C (max) and 11°C (min), with a relative humidity of 70% and a 16:8 hr light:dark cycle. The vegetable material employed was *Cucumis melo* var. Piel do Sapo.

The conclusions arrived at from the results were that the greenhouse white-fly *Trialeurodes vaporariorum* acts as the vector of the causal agent of this yellowing disease. Under the conditions in which the experiments were carried out, at least 40 days were required to confirm transmission. The symptoms observed in the infected plants were identical to those described above. The disease was not transmitted by mechanical inoculation of the infected extract.

No case of seed transmitted disease was observed in the 100 plantings obtained from seeds of diseased muskmelon plants which were previously inoculated using *T. vaporariorum* as vector.

#### Literature Cited

1. Cuartero, J., J. Esteva, and F. Nuez. 1985. Sintomatología y desarrollo del amarilleamiento del melón en cultivos bajo invernadero. IV Congreso Nacional de Fitopatología. Pamplona (España).
2. Hristova, D.P., and V.T. Natskova. 1986. Interrelation between *Trialeurodes vaporariorum* W. and the virus causing infectious chlorosis in cucumber. Comptes Rendus de l'Academie Bulgare de Sciences 39:105-108.
3. Lot, H., B. Delecolle, and H. Lecoq. 1982. A whitefly transmitted virus causing muskmelon yellows in France. Acta Horticulturae 127:175-182.
4. Van Dorst, H.J.M., N. Huijberts, and L. Bos. 1980. A whitefly-transmitted disease of glasshouse vegetables, a novelty for Europe. Neth. J. Pl. Path. 86:311-313.
5. Yamashita, S., Y. Doy, K. Yora, and M. Yoshino. 1979. Cucumber Yellows Virus: its transmission by the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), and the yellowing disease of cucumber and muskmelon caused by the virus. Ann Phytopathol. Soc. Japan 45:484-496.

Search for Sources of Resistance to Yellowing Disease in *Cucumis* spp.

C. Soria and M.L. Gómez-Guillamón  
Estación Experimental "La Mayora", Algarrobo-Costa, (Málaga), Spain

J. Esteva and F. Nuez  
Universidad Politécnica de Valencia, Spain

The unpromising results obtained from earlier experiments seeking sources of resistance to muskmelon yellowing disease in a large collection of different muskmelon (*Cucumis melo* L.) cultivars under conditions of natural infection led to this present search for wild species with resistance to this disease.

In addition to three wild species -- *Cucumis zeyheri*, *C. anguria* var. *longipes*, and *C. myriocarpus* (A) and (B) -- shown the year before to have satisfactory resistance to yellowing disease (2), this present work studied six new wild species of the genus *Cucumis*. The two sensitive cultivars Piel de Sapo and Bola de Oro were used as controls.

Previous work in this laboratory (3) demonstrated that the greenhouse whitefly *Trialeurodes vaporariorum* is the vector of transmission of the causal agent of yellowing disease; consequently, in this work the populations of whitefly on each species were estimated. The 12 species (Table 1) were cultivated in the same polyethylene greenhouse in sandy soil with drip irrigation.

Table 1. Incidence of yellowing disease and presence of whitefly *Trialeurodes vaporariorum*.

Species	Yellowing symptoms	Whitefly population
<i>Cucumis myriocarpus</i> (A)	1/10	+
<i>Cucumis myriocarpus</i> (B)	10/10	+++
<i>C. zeyheri</i>	10/10	+++
<i>C. anguria</i> var. <i>longipes</i>	1/10	++
<i>C. anguria</i> var. <i>anguria</i>	0/10	+
<i>C. africanus</i>	0/10	+++
<i>C. meeusii</i>	0/4	++
<i>C. dipsaceus</i>	0/10	+++
<i>C. figarei</i>	0/10	+
<i>C. melo</i> var. <i>agrestis</i>	3/10	++
Piel de Sapo (*)	10/10	+++
Bola de Oro (*)	10/10	+++

(A) Resistant line. (B) Sensitive line. (\*) Controls (*C. melo* cultivars).  
n/n = Plants with symptoms / Plants observed.

*Cucumis zeyheri* exhibited resistance the year before (2), but was found to be sensitive in this present work. The appearance of symptoms of yellowing in some generally resistant accessions suggests the need for controlled artificial inoculations using *T. vaporariorum* as the vector.

*C. melo* var. *agrestis* showed good resistance. Because this accession belongs to *C. melo*, it is the most interesting one to introduce the yellowing resistance into cultivated muskmelons.

In the experiments with *Cucumis africanus* and *C. dipsaceus* no symptoms were observed although the populations of whitefly were similar to those of the controls. It can be supposed that these accessions are resistant to the disease transmission by *T. vaporariorum*, but it is necessary to prove this behavior using controlled infections before making such an assertion.

A study has been initiated of the genetics of the resistance to yellowing found in *C. myriocarpus*. Likewise, there is on-going a program seeking to transfer the genes for disease resistance discovered in some wild species to commercial cultivars. This bridge was designed to exploit the known interspecies compatibilities of the *Cucumis* genus described in (1).

#### Literature Cited

1. Esquinas-Alcazar, J.T., and P.J. Gulick. 1983. Genetic resources of Cucurbitaceae. AGPGR: IBPGR/83/48:20.
2. Esteva, J., F. Nuez, and J. Cuartero. 1988. Resistance to yellowing disease in wild relatives of muskmelon. Cucurbit Genetics Cooperative 11:52-53.
3. Soria, C., and M.L. Gómez-Guillamón. 1988. Transmission of a muskmelon yellowing disease by *Trialeurodes vaporariorum* Westwood. Eucarpia. Cucurbitaceae 88. Avignon-Montfavét. (France).

## Resistance to Yellowing Disease in Muskmelon

J. Esteve and F. Nuez

Departamento de Biotecnología. Universidad Politécnica. Camino de Vera nº 14  
46020 Valencia, Spain

M. L. Gómez-Guillamón

Estacion Experimental La Mayora. 49750 Algarrobo-Costa, Málaga, Spain

Cultivation of greenhouse muskmelon on the south east coast of Spain is being seriously affected by a yellowing disease (3). The disease is transmitted by greenhouse whitefly (Trialeurodes vaporariorum Westwood) (5). The causal agent has not been detected yet, but other whitefly transmitted diseases of cucurbits that cause similar symptoms are virus diseases (1, 2, 4, 6). All the muskmelon hybrids and cultivars grown in the area have showed high levels of susceptibility. Therefore in 1985 we initiated an programme to search sources of resistance.

We have evaluated 189 accessions of Spanish landraces from 1985 to 1988. The accessions were distributed through 5 tests. These were carried out during the 1985, 1986 and 1987 seasons in Algarrobo-Costa (Málaga) and during the 1987 and 1988 seasons in El Egido (Almería). The incidence of the yellowing disease in both localities is very high. The tests was made under natural infection conditions.

Only one accession, which belongs to 'Tendral' type and which was evaluated during 1988 in El Egido, behaved as resistant. The observed resistance have to be confirmed under controled inoculation conditions. The remaining accessions were notably affected. The 'Piel de Sapo' and 'Tendral' types landraces have a tendency to show susceptibly levels which are slightly lower than 'Amarillo' and 'Rochet' types.

In the season of 1986 we evaluated other muskmelon genotypes of non-Spanish origin. These were 'Nagata Kim Makuwa', 'Ginsen Makuwa', 'Muchianskaja', 'Miel Blanc', 'Freeman's Cucumber', 'Kafer Hakin', PI 161375, PI 157084 and PI 157080. All of them were susceptible to yellowing disease but 'Nagata Kim Makuwa', PI 161375 and PI 157084 showed levels of symptomatology lower than the Spanish landraces. The behaviour of these three genotypes during the seasons of 1987 and 1988 was heterogeneous since some plants which belong to them displayed a high susceptibility whereas others were slightly affected (Table).

Also from among the plants which belong to progenies derived from the crosses between highly susceptible parents ('Galia' and 'Piel de Sapo') and 'Nagata Kim Makuwa' or PI 161375 there were always some of them slightly affected whereas the remaining ones were seriously affected.

It is important to state that all the plants of the highly susceptibility accessions (188 Spanish lanraces and 6 non-Spanish genotypes) showed severe symptoms.

In the season of 1987 we started to test wild cucurbits species since we thought that the only possible thing to do was to resort to these species as

Table. Incidence of yellowing disease in the genotypes which were slightly affected during the 1986 season.

Genotype	Locality and season of test	Incidence of yellowing disease <sup>z</sup>
Nagata Kim Makuwa	Algarrobo 1987	14/09
	El Egido 1987	3/18
	Algarrobo 1988	5/10
PI 161375	Algarrobo 1987	18/07
	El Egido 1987	16/04
	Algarrobo 1988	2/11
PI 157084	Algarrobo 1987	15/00
	El Egido 1987	15/00
	Algarrobo 1988	6/04

<sup>z</sup> a/b: slightly affected plants/seriously affected plants

sources of resistance to yellowing disease. But during the 1988 season, in Algarrobo, the majority of plants of a accession of Cucumis melo var. agrestis showed resistance under natural severe infection conditions. Only 3 of the 13 plants displayed slight symptoms of yellowing disease. If the behaviour of this accession and the previously mentioned landrace were confirmed, the present prospect of muskmelon breeding for resistance to yellowing disease could be substantially changed.

#### Literature Cited

1. Dorst, H.J.M. van, N. Huijberts, and L. Bos. 1983. Yellows of glasshouse vegetables, transmitted by Trialeurodes vaporariorum. Neth. J. Path. 89:171-184.
2. Duffus, J.E. 1965. Beet pseudo-yellows virus, transmitted by the greenhouse whitefly (Trialeurodes vaporariorum). Phytopathology 55:450-453.
3. Esteva, J., F. Nuez, and J. Cuartero. 1988. Resistance to yellowing disease in wild relatives of muskmelon. Cucurbit Genet. Coop. Rpt. 11:52-53.
4. Lot, H., B. Delecolle, and H. Lecoq. 1982. A whitefly transmitted virus causing muskmelon yellows in France. Acta Horticulturae 127:175-182.
5. Soria, C., Gómez-Guillamón, M.L. 1988. Transmission of a muskmelon yellowing disease by Trialeurodes vaporariorum Weestwood. Proceeding of the EUCARPIA Meeting on Cucurbit Genetic and Breeding. (Avignon-Montfavet, France May 31-June 1-2. 1988): 209-213.
6. Yamashita, S., Y. Doi, K. Yora and M. Yoshino. 1979. Cucumber yellows virus: Its transmission by the greenhouse whitefly, Trialeurodes vaporariorum (Westwood), and the yellow diseases of cucumber and muskmelon caused by the virus. Annals Phytopatho. Soci. Japan 45:484-496.

## A Screening Procedure for ZYMV Resistance in Muskmelons

A. J. Raffo\*

Department of Plant Pathology, University of California, Riverside, CA 92521

I. A. Khan

Department of Horticulture, University of Agriculture, Faisalabad, Pakistan

L. F. Lippert, M. O. Hall, and G. E. Jones

Department of Botany and Plant Sciences, University of California,  
Riverside, CA 92521, USA

Breeding for disease resistance is often restricted due to the lack of reliable and efficient screening procedures. Resistant individuals may be identified by symptomatology, bioassay, and/or serology; however, in some situations, these methods are of limited applicability. Zucchini yellow mosaic virus (ZYMV), a recently reported virus in the potyvirus group (4), has caused appreciable economic losses in many cucurbit species. The economic impact of this virus has been especially significant on various types of melons growing in the irrigated semi-arid Imperial Valley of California. Melon line PI 414723 has been identified as a source of dominant, single gene resistance to this virus (7). Our group has been utilizing this material in a breeding program designed to transfer ZYMV resistance into the western shipping-type muskmelon. We have previously reported a procedure to vegetatively propagate the breeding progenies, as well as a two-step evaluation of this material (3). In this report, we describe a procedure based on the use of cDNA probes to screen for ZYMV resistance in our laboratory. Similar procedures have been developed for the identification of other viruses and viroids and have been found to be highly sensitive and efficient (1, 6, 8).

cDNA copies of several regions of the ZYMV genome were developed by AJR according to standard procedures of cDNA cloning (5). The cDNA clones were tested for their specific homology to the ZYMV genomic RNA and not to several closely related potyviruses by hybridization (DNA/RNA) before using them as diagnostic probes. Out of approximately two hundred clones tested, several dozen had a high degree of homology and selectivity for our ZYMV isolate. The sensitivity was found to be in the picogram range of viral RNA.

For screening purposes, the breeding progenies were vegetatively propagated (3). The plants were mechanically inoculated with ZYMV freshly extracted by grinding leaves of a source squash plant ("Early Prolific" Zucchini) in a 10 mM Potassium Phosphate buffer, pH 7.0 with 1% (w/v) celite as an abrasive. It has been observed that the virus infects most efficaciously under greenhouse conditions if the plants are infected at the 2-3 new leaf stage after being repropagated. The systemic mosaic symptoms appear within 2-3 weeks post-inoculation.

Leaves of these plants are harvested (1-5 gm of tissue) and ground in liquid nitrogen. The frozen powdered tissue is soaked in 12 ml of a 1 x SET solution [1% SDS (sodium dodecyl sulfate), 1 mM EDTA, 25 mM TRIS-HCL pH 7.5], and 0.5 ml of 10 mg/ml Protease K for approximately 2 hr at 37°C. The extract is centrifuged at 10,000 g for 15 min and the pellet discarded. The supernatant is treated with 0.5 ml of 10 M ammonium acetate and 25 ml of 95% ethanol and the nucleic acids allowed to precipitate at -20°C. The pellet is collected by centrifugation, as described above, air dried, and redissolved in 1 x SET and reprecipitated. This is repeated 2-3 times until its spectroscopic analysis showed it to be fairly pure nucleic acid (260/280 ratio greater



than 1.7). Finally, the pale green pellet is resuspended in 0.5 ml of 1 x SET and the nucleic acid content measured by spectroscopy. All samples are first adjusted for the same amount of nucleic acid, then denatured with 7.5 % formaldehyde at 65°C for 10-15 min, brought to 10 x SSC (1.5 M Sodium Chloride and 150 mM Sodium Citrate pH 7.0) and finally spotted under vacuum onto nitrocellulose paper in a 96-well manifold (Bethesda Research Laboratories). The nitrocellulose paper is baked at 80°C for 90 min to fix the nucleic acids onto this paper. The unbound portion of the nitrocellulose paper is blocked by prehybridization at 65°C overnight with 100 µg/ml denatured salmon sperm DNA and 5 x Denhardt's solution (1% polyvinylpyrrolidone, 1% ficoll, and 1% Bovine Serum Albumin) in 0.5% SDS and 6 x SSC. Hybridization to the nick-translated ( $P^{32}$  labelled according to 5) cDNA probe of ZYMV is carried out in the same solution, this time with probe at 65°C, now for approximately 2 days. Unhybridized probe is stringently washed off the paper prior to autoradiography; first 2 times in 2 x SSC and 0.1% SDS at 65°C for at least 30 min each then 2 additional times in 0.1 x SSC and 0.1% SDS at 65°C, for similar times.

The data presented in Fig. 1 is a representative example. Lanes 1-12 are as follows: 1-3 are uninfected healthy controls; 4, 5, and 6 are inoculated  $F_2$  plants without symptoms; 7 is a "Top-Mark" plant with symptoms; 8-11 are field samples showing some type of mosaic symptoms and lane 12 is a squash plant infected with ZYMV as a positive control. The presence of spots at lanes 4, 6, 7, and 12 and absence at 1-3 show that this probe is capable of hybridizing to ZYMV. The absence at lane 5 reflects resistance in this  $F_2$  segregate, while ZYMV detection in lanes 4 and 6 may suggest tolerance in these  $F_2$  segregates. The lack of detection at lanes 8-11 indicates that this probe does not hybridize to false positives. These field samples had mosaic symptoms apparently from an infection by another virus and not from ZYMV. Samples from other field plants, not connected with this study, but infected with ZYMV have tested positive with this probe (AJR, personal communication).

The relative intensities of the dots shown in Figure 1 were quantified using a LKB Ultrosan XL laser densitometer. These values are presented in Table 1 as the area of the dot's peak adjusted for 1 µg of total nucleic acid applied. These figures reflect the conclusions discussed above while allowing for a comparison of the relative titer of virus in each sample. The virus levels in the symptomless  $F_2$  plants seen in lanes 4 and 6 are approximately 30% of the levels found in the susceptible plant presented in lane 7.

The resistance to ZYMV has been considered as a Mendelian character. The data presented by Pitrat (7), based on symptomatology, can be explained by a single dominant gene (*Zym*) and is similar to Tobacco Mosaic Virus resistance found in *Nicotiana glutinosa* (conferred by the "N gene") (2). While preliminary, our data suggest a more complex genetics. The finding of tolerance, as well as the ability to easily sort infected  $F_2$  plants in the greenhouse, on the basis of severity of symptoms, into several classes is similar to Ryegrass Mosaic Virus resistance in rye grass (9). This resistance is considered polygenic.

The authors again wish to stress the preliminary nature of our data, however, we also wish to stress the power of the molecular probe. Not only can the cDNA probe be used to detect and quantitate a specific viral presence, and thus be useful in a breeding program such as ours, but the molecular probe can be used to help elucidate the genetics of resistance as well as to identify a possible source of viral potential in an otherwise healthy population.

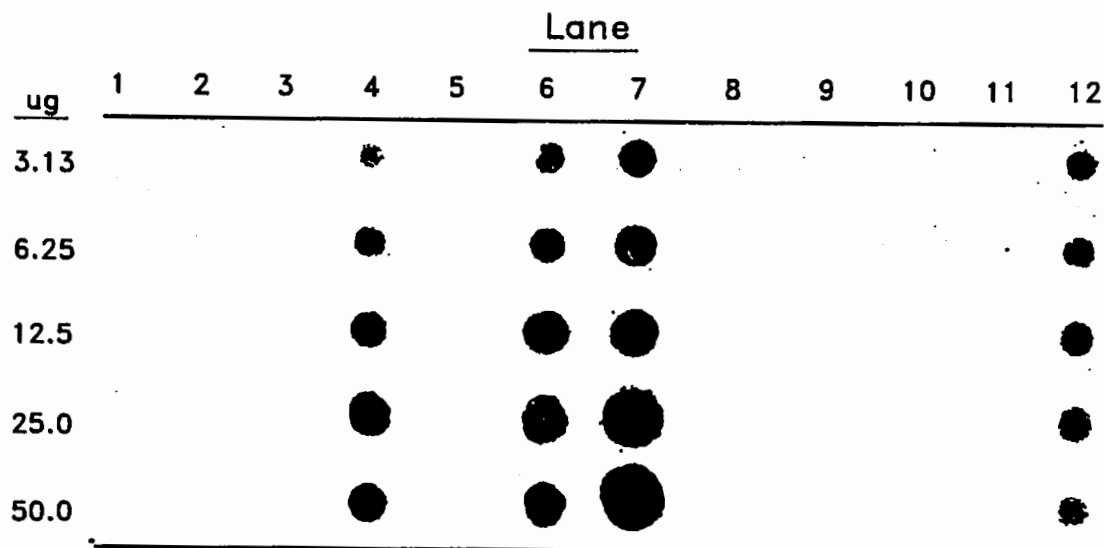


Figure 1. Dot blot analysis of plant extracts hybridized to a radiolabelled cDNA probe to ZYMV isolated from the Imperial Valley of California. Please see text for lane designations. Ug refers to the amount of total nucleic acids applied to each dot in that row.

Table 1. Relative quantitation of ZYMV levels from dot blot analysis presented in Figure 1

Lane <sup>z</sup>	rel. amount <sup>y</sup>	Lane <sup>z</sup>	rel. amount <sup>y</sup>
1	0.000	7	0.774 ± 0.084
2	0.000	8	0.000
3	0.000	9	0.000
4	0.249 ± 0.019	10	0.000
5	0.000	11	0.000
6	0.215 ± 0.006	12	0.110 ± 0.015

z—please see text for lane designations

y—relative amounts are in Absorbance X peak width (mm)  
adjusted for one microgram of total nucleic acid

### Literature Cited

1. Candresse, T., G. Macquaire, M. Monsion, and J. Dunez (1988) Detection of chrysanthemum stunt viroid (CSV) using nick-translated probes in a dot-blot hybridization assay. *J. Virological Methods* 20:185-193.
2. Holmes, F. O. (1938) Inheritance of resistance to tobacco mosaic disease in tobacco. *Phytopathology* 28:553-561.
3. Khan, I. A., L. F. Lippert, M. O. Hall, and G. E. Jones (1988) A simple procedure and the genetic potential for rooting of stem cuttings in muskmelon cucurbit. *Genet. Coop. Rept.* 11:43-46.
4. Lisa, V., G. Boccardo, G. D'agostino, G. Dellavalle, and M. d'Aquilio (1981) Characterization of a potyvirus that causes zucchini yellow mosaic. *Phytopathology* 71:667-672.
5. Maniatis, T., E. F. Fritsch, and J. Sambrook (1982) "Molecular cloning; a Laboratory Manual." Cold Springs Harbor Laboratory.
6. Maule, A. J., R. Hull, and J. Donson (1983) The application of spot hybridization to the detection of DNA and RNA viruses in plant tissues. *J. Virological Methods* 6:215-224.
7. Pitrat, M. and H. Lecoq (1984) Inheritance of zucchini yellow mosaic virus resistance in *Cucumis melo* L. *Euphytica* 33:57-61.
8. Salager, L. F., R. A. Owens, D. R. Smith, and T. O. Diener. (1983) Detection of potato spindle tuber viroid by nucleic acid spot hybridization: evaluation with tuber sprouts and true potato seed. *Amer. Potato J.* 60:587-597.
9. Wilkins, P. W. (1974) Tolerance to ryegrass mosaic virus and its inheritance. *Ann. Appl. Biol.* 78:187-192.

## Low Temperature Germination in Muskmelon is Dominant

Haim Nerson, ARO, Neve Ya'ar Experiment Station, Israel, and Jack E. Staub, USDA-ARS, Department of Horticulture, Univ. Wisconsin, Madison, WI 53706

Muskmelon seed (*Cucumis melo* L.), like most domestic cucurbits, requires 17<sup>o</sup>-18<sup>o</sup>C for germination (threshold temperature). At lower temperatures the membrane transfer from the 'dry' to the 'wet' phase is very slow, resulting in destructive leakage of solutes (H. Nerson, unpublished data). The existence of germplasm with low-temperature germination potential in muskmelon has previously been reported (1,2). This report provides preliminary information regarding the inheritance of low-temperature germination in this species.

The birdsnest inbred line P202, which possesses an ability to germinate at 15<sup>o</sup>C (2), was crossed with Noy-Yizreel (NY), an indeterminate cultivar which does not germinate at this temperature. The F<sub>1</sub>'s were produced in a greenhouse (Winter 1985) and the F<sub>2</sub>'s in a field nursery (Spring 1985) at Neve Ya'ar Experiment Station (northern Israel). Seeds were kept at 10<sup>o</sup>±2<sup>o</sup>C and 45-55% RH for three years before evaluation of germinability. Four replicates of 25 seeds each were germinated in 9 cm petri dishes on Whatman No. 2 blotting paper moistened with 4 ml deionized water under optimal (28<sup>o</sup>C) and low (15<sup>o</sup>C) temperatures in the dark. In a greenhouse 10, 15 and 50 replicates (10 seeds each) of parents, and reciprocal F<sub>1</sub> and F<sub>2</sub> progeny, respectively, were sown in 3 liter pots containing a soil:sand:peat (2:1:1) medium for an emergence test. The maximum day and minimum night temperatures ranged between 25<sup>o</sup>-32<sup>o</sup>C and 18<sup>o</sup>-21<sup>o</sup>C, respectively. Germination (radicle length > 3mm) and emergence (cotyledon above soil) were recorded daily during a 3 week period to determine final percent and rate (mean days germination - MDG, and mean days emergence - MDE).

The preliminary results (Table 1) demonstrate the low-temperature germination in P202 is dominant. It could be hypothesized that more than one dominant gene (perhaps 2) are involved in the expression of this character. This hypothesis is currently being tested using BC<sub>1</sub> families. Germination rates in reciprocal F<sub>1</sub> progeny indicates that there is a significant maternal effect. Progeny of P<sub>2</sub> x P<sub>1</sub> matings having NY maternal tissues are slower to germinate than their reciprocals. This effect was essentially eliminated in F<sub>2</sub> progeny germination. The maternal effect in the F<sub>1</sub> was probably limited to radicle initiation, since there was no significant difference in emergence rate (MDE) at the suboptimal temperature tested.

### Literature Cited

1. Hutton, M.G. and J.B. Loy. 1987. Association between cold germinability and seedling cold tolerance in muskmelon. HortScience 22:1131 (Abstr.)
2. Nerson, H., D.J. Cantliffe, H.S. Paris and Z. Karchi. 1982. Low-temperature germination of birdsnest type muskmelons. HortScience 17:639-640.

Table 1. Germination, and emergence percentage and rate of P202 (P<sub>1</sub>) and NY (P<sub>2</sub>) muskmelon and their F<sub>1</sub> and F<sub>2</sub> progeny.

	Percent Germination		Mean days to Germinate		Emergence Percentage MDE <sup>1</sup>	
	28°C	15°C	28°C	15°C		
P <sub>1</sub> (P202)	100±0	98±2	1.18±0.08	7.06±0.10	91±5	7.32±0.72
P <sub>2</sub> (NY)	91±2	2±2	2.86±0.34	----	85±8	9.96±1.14
F <sub>1</sub> (P <sub>1</sub> ×P <sub>2</sub> )	94±2	87±8	1.21±0.08	8.34±0.26	85±10	6.71±0.91
F <sub>1</sub> (P <sub>2</sub> ×P <sub>1</sub> )	75±15	82±9	2.67±0.70	13.48±0.58	85±8	7.90±1.19
F <sub>2</sub> (P <sub>1</sub> ×P <sub>2</sub> )	97±2	87±5	1.09±0.06	9.65±0.59	94±3	6.90±0.75
F <sub>2</sub> (P <sub>2</sub> ×P <sub>1</sub> )	98±2	89±3	1.02±0.03	8.48±0.50	96±1	7.01±0.86

ZMDE = Mean days emergence.

\* \* \* \* \*

#### Ethylene Production by Germinating Seeds of Different Sexual Genotypes of Muskmelon (*Cucumis melo* L.)

J. Alvarez

Unidad de Horticultura, Servicio de Investigación Agraria, Apartado 727, 50080 Zaragoza

The use of gynoecious genotypes has been proposed as a method for muskmelon hybrid seed production. The identification of gynoecious plants is necessary for the introduction of this character into agronomically interesting lines; in order to save time and space this identification should be done as early as possible.

It is known that cucumbers and muskmelon gynoecious lines produce more ethylene than monoecious genotypes (1,3). Ethylene production from cotyledonary disks of cucumber changes with different sexual expressions (5). Germinating seeds of gynoecious cucumbers produce more ethylene than monoecious, andromonoecious or hermaphroditic lines (4). In this study, we tried to assess whether it was possible to identify different muskmelon sexual genotypes by measuring the ethylene produced by germinating seeds.

The plant material used in this experiments was made up by the following cultivars or lines: 'Piel de Sapo' and 'Invernizo', both andromonoecious local cultivars, line 8502, a monoecious local line, and the gynoecious line 'WI 998'.

Ten seeds of each of the above muskmelon lines or cultivars were placed on moistened filter paper and introduced into 12.5 ml glass flasks sealed with a rubber serum cap and maintained at 30<sup>0</sup>±0.5<sup>0</sup>C. Five replications were performed on each line or cultivar and the number of germinated seeds were

counted 3 days later. One ml of the internal gas was taken from each flask with a chromatographic syringe and the ethylene contents of that gas determined by gas chromatography.

During germination, seeds of the gynoecious 'WI 998' produced more ethylene than the other sexual genotypes, among which no significant differences were found (Table 1).

Table 1. Mean ethylene production (nl) by germinated seeds of four sexual muskmelon genotypes.

Genotype	Total C <sub>2</sub> H <sub>4</sub> production (nl)	C <sub>2</sub> H <sub>4</sub> production/germinated seed
Piel de Sapo	1.2	0.14 a <sup>Z</sup>
Invernizo	0.8	0.10 a
8502	0.9	0.11 a
WI 998	1.9	0.21 b

<sup>Z</sup>Means followed by different letters are significantly different (Newman-Keuls' test,  $p \leq 0.05$ ).

Thus, it seems possible to identify the gynoecious line 'WI 998' by measuring the ethylene produced by germinating seeds. This agrees with Rudich et al. (4), who found that germinating seeds of gynoecious cucumber produced much more ethylene than seeds from androecious, monoecious and hermaphroditic plants. It will be necessary in the future to assess whether this higher ethylene production in germinating seeds of 'WI 998' will be kept when the gynoecious trait is introduced into other genetic backgrounds.

#### Literature Cited

1. Byers, R.E., L.R. Baker, H.M. Sell, R.C. Herner and D.R. Dilley. 1972. Ethylene: a natural regulator of sex expression of *Cucumis melo* L. Proc. Nat. Acad. Sci. USA 69:717-720.
2. Peterson, C.E., K.W. Owens and P.R. Rowe. 1983. Wisconsin 998 muskmelon germplasm. HortScience 18:116.
3. Rudich, J., A.H. Halevy and N. Kedar. 1972. Ethylene evolution from cucumber plants as related to sex expression. Plant Physiol. 49:998-999.
4. Rudich, J., L.R. Baker and H.M. Sell. 1978. Ethylene evolution during germination of different sex phenotypes of cucumber. Sci. Hortic. 9:7-14.
5. Takahashi, H. and H. Suge. 1972. Sex expression and ethylene production in cucumber plants as affected by 1-aminocyclopropane-1-carboxylic acid. J. Jap. Soc. Hort. Sci. 51:51-55.

Flesh Calcium Content of Group Inodorus and Group Reticulatus Muskmelon  
(Cucumis melo L.) Fruits.

Timothy J Ng and Vermal Carr  
Univ. Maryland, Dept. Horticulture, College Park, MD 20742-5611

Honeydew and casaba (group Inodorus) muskmelons tend to have extended storage lives when compared to netted (group Reticulatus) muskmelons (5). Decline in storage is usually manifested by flesh softening and breakdown, and by shriveling and discoloration of the rind. Genetic differences in storage life may be attributable in part to differences in the timing and magnitude of the ethylene climacteric in the different types of muskmelons (2,4).

Calcium may also be involved in regulating ripening in muskmelons. Higher calcium concentrations can retard ripening and senescence activities in many climacteric fruit tissues (1). The slower decline in flesh firmness of ripening fruits with higher calcium concentrations has been attributed to the ability of calcium to combine with pectin to form calcium pectate in cell walls (3). The current study was initiated to determine whether differences in flesh calcium concentrations existed among different types of muskmelons, and whether these differences might be related to fruit longevity in storage.

Two casaba, two honeydew and two netted cultigens of muskmelon were grown under identical conditions in Salisbury, Md. Six ripe fruits of each cultigen were harvested on the same day. Ripeness was determined on netted types by abscission of the fruit from the vine, while ripeness of honeydew and casaba melons was determined by fruit softening at the blossom end. Fruits were transported back to College Park, Md., and three fruits of each cultigen were sampled immediately for percent dry weight and flesh calcium content. The remaining three fruits were stored for 7 days at 10°C and 95% RH, then sampled. For calcium determinations, ashed tissue samples were dissolved in boiling 5N HCl, filtered, and subjected to atomic absorption and emission spectrophotometry.

Flesh dry weight and calcium concentrations for the six cultigens are presented in Table 1. The analyses of variance for the effects of muskmelon type and storage on dry weight and calcium content are presented in Table 2. Percent dry weight was similar among the different fruit types but increased during storage, probably as a result of fruit dehydration. Calcium, on both a fresh and dry weight basis, was significantly affected by muskmelon type. However, the casaba cultigens, which have the longest storage life, had the lowest calcium concentrations. In particular, the casaba 'MaryGold', which can be stored for over two months in a marketable state (personal observation), had the lowest calcium concentration among all lines. Honeydews, which are intermediate in storage ability between casaba and netted types, had the highest calcium concentrations.

Although this study was preliminary in nature, it seems unlikely that major differences in the rate of fruit ripening and senescence among group Inodorus and group Reticulatus muskmelons can be simply explained on the basis of flesh calcium content.

Table 1. Flesh dry weight and calcium content in honeydew, casaba and netted muskmelons at harvest or stored for 7 days at 10°C.

Muskmelon type	Line	Dry Weight (% fw)		Flesh Calcium Content			
		Fresh	Stored	(ug Ca/g fw)		(ug Ca/g dw)	
				Fresh	Stored	Fresh	Stored
Casaba	MD8562	0.14	0.14	1.07	0.91	7.82	6.78
	MaryGold	0.13	0.14	0.85	0.91	6.55	6.44
Honeydew	MD85100	0.13	0.15	1.46	1.26	11.54	8.50
	MD8599	0.13	0.14	1.40	0.88	10.90	6.70
Netted	MD8540	0.12	0.13	1.05	1.02	8.55	8.17
	MD266	0.14	0.15	1.15	1.02	8.52	6.73

Table 2. ANOVA for effect of muskmelon type on dry weight and calcium.

Dependent variable	Muskmelon type	Storage
Flesh dry weight	NS	*
Calcium (fw basis)	*	NS
Calcium (dw basis)	*	*

NS,\* indicate not significant, and significant at the 5% level.

#### Literature Cited

1. Ferguson, I.B. 1984.  $Ca^{2+}$  in plant senescence and fruit ripening. *Plant Cell Env.* 7:477-489.
2. Kendall, S.A. and T.J Ng. 1988. Genetic variation of ethylene production in harvested muskmelon fruits. *HortScience* 23:759-761.
3. Legge, R.L., J.E. Thompson, J.E. Baker and M. Liederman. 1982. The effect of calcium on the fluidity and phase properties of microsomal membranes isolated from post-climacteric Golden Delicious apples. *Plant & Cell Physiol.* 23:161-169.
4. Pratt, H.K., J.D. Goeschl, and F.W. Martin. 1977. Fruit growth and development, ripening, and the role of ethylene in the 'Honey Dew' muskmelon. *J. Amer. Soc. Hort. Sci.* 102:203-210.
5. Ryall, A.L. and W.J. Lipton. 1972. *Handling, Transportation, and Storage of Fruits and Vegetables. Vol. 1: Vegetables and Melons.* AVI Publishing Co., Inc., Westport, CT.



Direct and indirect regeneration of Cucumis melo L. from cotyledon culture.

W.A. Mackay, T.J Ng. Department of Horticulture, University of Maryland, College Park, MD 20742 USA.

F.A. Hammerschlag. Plant Molecular Biology Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD 20705 USA.

Successful in vitro selection requires the regeneration of plants from unorganized tissue. We have previously reported the regeneration of three cultivars of muskmelon ('Hales Best', 'Iroquois' and 'Perlita') using a modification of the protocol described by Moreno et al. (3). However, regeneration efficiency was low for 'Perlita' and 'Iroquois'. Regeneration with other growth regulator combinations has been reported (1, 4). To improve low regeneration efficiency alternate growth regulator combinations were tested.

Surface disinfection and removal of cotyledons was accomplished as previously described (2). Cotyledons were plated on 25 ml of medium contained in 15x90 mm petri dishes. The basal medium consisted of Murashige and Skoog salts and vitamins, 3% sucrose, 0.8% Phytoagar supplemented with 0.0, 0.5, 1.0, 2.5, or 5.0 mg l<sup>-1</sup> benzyladenine (BA) and 0.0, 0.1, 0.25, 0.5, or 1.0 mg l<sup>-1</sup> naphthaleneacetic acid (NAA) in factorial combination. Rooting medium consisted of basal medium supplemented with 0.001 mg l<sup>-1</sup> NAA dispensed into 55x70 mm jars (42.5 ml). The pH was adjusted to 5.7-5.8 with NaOH and HCL prior to autoclaving for 20 minutes at 121° C, 124 kPa.

Primary callus initiated on basal medium supplemented with either 0.5, 1.0, or 2.5 mg l<sup>-1</sup> BA was subcultured on basal medium supplemented with either the same level of BA or the next two higher levels of BA. Cultures from treatments producing less friable or morphogenic callus were then subcultured in the same manner for each new level of BA.

Cotyledon cultures were grown for 28 days either in the dark or under 16 hr photoperiods from cool white fluorescent lamps (~50 uEm<sup>-2</sup>s<sup>-1</sup>) at 25° C. Subcultured callus was transferred every 28 days. Cultures with shoots were transferred to basal medium with 0.1 mg l<sup>-1</sup> BA for shoot elongation. Shoots were excised from cotyledons or callus clumps and rooted under 16 hr photoperiods from cool white fluorescent lamps (50 uEm<sup>-2</sup>s<sup>-1</sup>). Rooted shoots were transferred to sterile 1:1 Jiffy mix:soil contained in Plant Cons (Flow Laboratories, McLean, VA 22102). When shoots and roots began active growth, plants were transferred to 6" plastic azalea pots and acclimated in a greenhouse mist chamber for seven days before placement under in vivo conditions.

The effect of the absence or presence of light was similar to that previously reported on medium supplemented with kinetin and

indoleacetic acid (IAA). Cotyledons cultured in the light formed green or white callus while those cultured in the dark formed friable white callus. However, unlike the kinetin-IAA medium there was direct regeneration of shoots from cotyledons on basal medium supplemented with 0.5, 1.0, 2.5 mg l<sup>-1</sup> BA combined with 0.0, 0.1, or 0.25 mg l<sup>-1</sup> NAA, and 5.0 mg l<sup>-1</sup> BA combined with 0.0 mg l<sup>-1</sup> NAA (Fig. 1). In general shoot number decreased as NAA concentration increased. Media lacking BA formed progressively more roots with numerous root hairs as the NAA concentration increased. This pattern of root growth was the same for cotyledons grown both in the dark or the light.

All three cultivars developed shoots from subcultured callus when transferred as follows: 0.5--0.5--0.5 or 0.5--0.5--1.0 mg l<sup>-1</sup> BA. Other successful treatment combinations were as follows: 'Hales Best' 2.5--2.5--2.5--2.5 mg l<sup>-1</sup> BA, 'Iroquois' 2.5--2.5--2.5 mg l<sup>-1</sup> BA, and 'Perlita' 1.0--1.0--1.0 mg l<sup>-1</sup> BA. In general when callus was transferred to higher levels of BA friable nonmorphogenic callus overgrew the shiny green morphogenic callus previously formed.

We previously reported that 'Hales Best' had the highest morphogenetic potential on basal medium supplemented with kinetin and IAA (2). On basal medium supplemented with BA and NAA, 'Perlita' had the highest morphogenetic potential, followed by 'Hales Best' and 'Iroquois'. Optimum BA and NAA levels varied with cultivar. For indirect regeneration 'Perlita' also had the highest morphogenic response followed by 'Hales Best' and 'Iroquois'.

#### Literature Cited

1. Halder, T. and V.N. Gadgil. 1982. Shoot bud differentiation in long-term callus cultures of Momordica & Cucumis. Ind. J. Exp. Biol. 20:780-782.
2. Mackay, W.A., T.J Ng and F. Hammerschlag. 1988. Plant regeneration from callus of Cucumis melo L. Cucurbit Genetics Coop. 11:33-34.
3. Moreno, V., M. Garcia-Sogo, I. Granell, B. Garcia-Sogo, and L. A. Roig. 1985. Plant regeneration from calli of melon (Cucumis melo L., cv. 'Amarillo Oro'). Plant Cell Tissue Organ Culture. 5:139-146.
4. Smith, S., K. Dunbar, R. Niedz, and H. Murakishi. 1988. Factors influencing shoot regeneration from cotyledonary explants of Cucumis melo. In Vitro 24:57A.

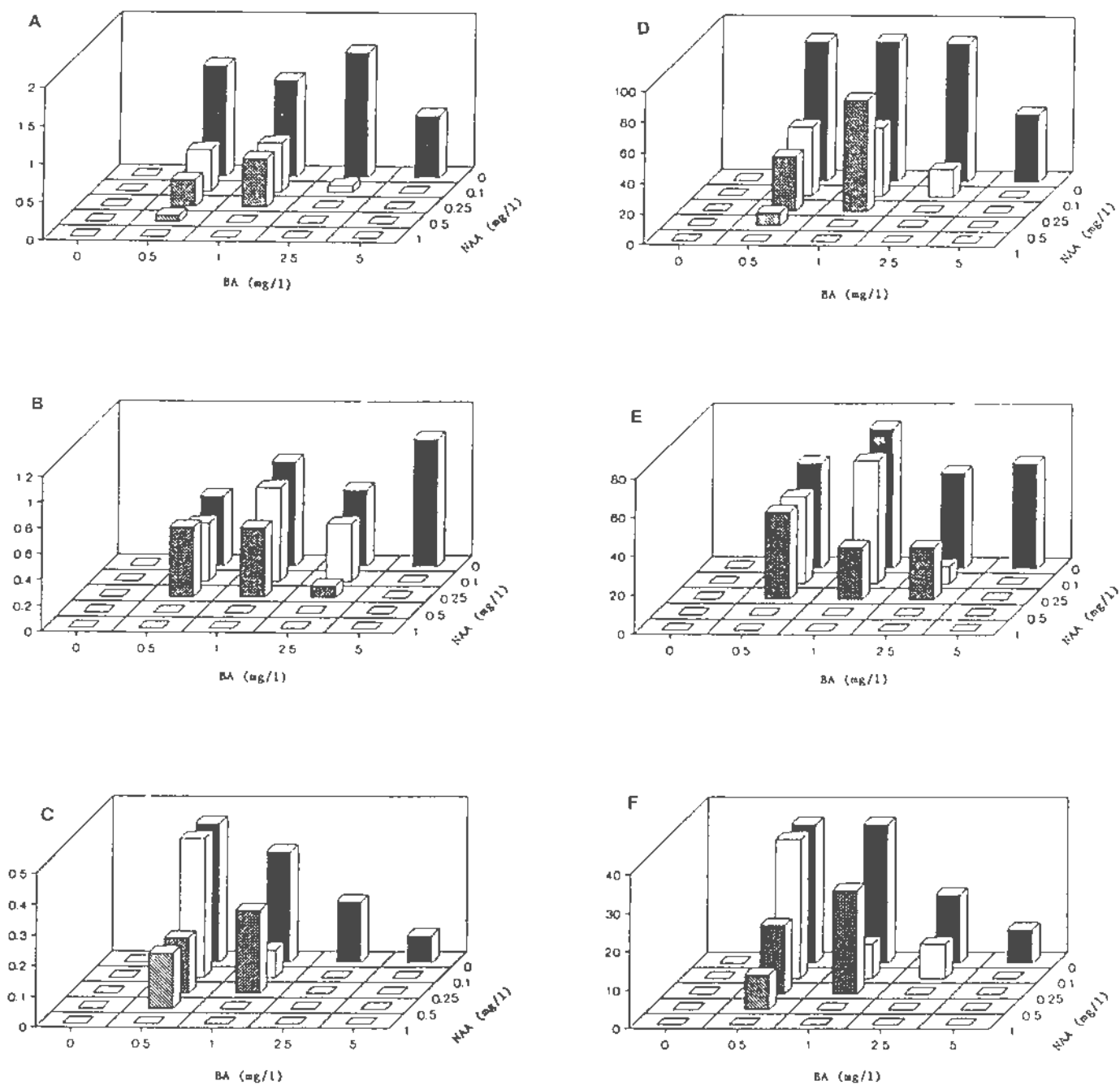


Fig. 1. A-C) Average rating of eleven light-grown cotyledons. Rating scale 0=No shoots 0-1=1-10 shoots 1-2=11-20 shoots. A) 'Perlita' B) 'Hales Best' C) 'Iroquois'. D-F) Percentage of eleven light-grown cotyledons forming shoots. D) 'Perlita' E) 'Hales Best' F) 'Iroquois'.

## A Second Look at the Glabrous Male-Sterile (gms) Character in Watermelon

B. B. Rhodes, B. A. Murdock and J. W. Adelberg  
Clemson University Edisto Research and Education Center  
Blackville, SC 29817

Watts (5) recovered the gms character from irradiated seed in 1957 and reported on the variant in 1962. Although the variant behaved as a single recessive gene, there were two notable exceptions. One glabrous plant grown in the greenhouse produced enough pollen to set 35 seed in a fruit on a homozygous normal plant. Watts was not able to recover subsequent progeny from this cross. He also noted that a single selfed heterozygote produced a 1:1 ratio of hairy:glabrous instead of a 3:1 ratio as expected. The class with fewer individuals than expected was the homozygous normal class.

Production of gmsgms gametes in a tetraploid line carrying the gms character is reduced (1,3). However, the variant segregated faithfully in the tetrasomic condition (4). Ray and Sherman (2) suggested that chromosome desynapsis was the cause of male sterility in the gms phenotype.

We now have four lines derived from a single glabrous, male-fertile variant of the gms material. Three of the lines exhibit some male fertility. Female-fertility was related to male-fertility in these lines. Male flowers with viable pollen occur two or more weeks after the appearance of the first female flower.

The gms variant is more than a well-behaved Mendelian recessive. Glabrousness is recessive to hairiness, but sterility and glabrousness are not pleiotropic effects of the same gene. Male-sterility and female-sterility are related, suggesting that the meiotic process is flawed (2). The extremely late development of male fertility in new recombinants may provide a far superior system for hybrid seed production than previously envisioned.

### Literature Cited

1. Love, S. L., B. B. Rhodes and P. E. Nugent. 1986. Controlled pollination transfer of a nuclear male-sterile gene from a diploid to a tetraploid watermelon line. *Euphytica* 35:633-638.
2. Ray, D. T. and J. D. Sherman. 1988. Desynaptic chromosome behavior of the gms mutant in watermelon. *J. of Heredity* (in press).
3. Rhodes, B. B. and L. C. Blue. 1986. Segregation of glabrous male-sterile in an autotetraploid line of Citrullus lanatus. *Cucurbit Genetics Coop.* 9:84-86.
4. Rhodes, B. B. and R. T. Nagata. 1988. Evidence for a tetrasomic line in watermelon. *Cucurbit Genetics Coop.* 11:57-59.
5. Watts, V. M. 1962. A marked male-sterile mutant in watermelon. *Proc. Amer. Soc. Hort. Sci.* 81:498-505.

## Inheritance of Orange Flesh Color in Watermelon.

Warren R. Henderson

Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609.

A variety of flesh colors are present in watermelon: red, orange, yellow, and white. Porter (3) reported yellow flesh from 'Golden Honey' was recessive,  $y$  to red flesh,  $Y$ . Poole (2) showed that yellow flesh which he termed golden yellow and also from 'Golden Honey' as well as from 'Yellow Flesh Ice Cream', was controlled by a single recessive gene,  $y$ . Poole also demonstrated that Canary yellow from 'Honey Cream' was controlled by a single dominant gene,  $C$ , to pink flesh,  $c$  from 'Dove.' Shimotsuma (5) found that two pairs of genes with epistasis controlled white, yellow and red flesh color derived from: a) a cultivated form of *Citrullus lanatus*. 2) a bitter, wild type of *C. lanatus*; and 3) a non-bitter wild *C. lanatus*. White flesh was controlled by a single dominant gene,  $Wf$ , to yellow and red flesh; thus  $Wf = B =$  and  $Wf = bb$  both gave white flesh; yellow flesh was dominant to red flesh and was expressed only when  $wf\ wf$  was present, thus yellow =  $wf\ wf\ B =$  and red flesh was the double homozygous recessive,  $wf\ wf\ bb$ . An  $F_2$  phenotypic segregation ratio would thus be 12 white: 3 yellow: 1 red.

In the present investigation the inheritance of orange flesh derived from 'Tendersweet Orange Flesh' ('Tendersweet O.F.') was studied in crosses with red flesh from 'Dixielee' and 'Sweet Princess', and yellow flesh from 'Golden Honey'. Following the flesh color symbols referred to earlier and those given by Robinson et. al. (4) and by Henderson et. al. (1)  $y$  will be used in this study to designate yellow flesh from 'Golden Honey' and  $Y$  red flesh color.

The  $F_1$  of 'Dixielee' x 'Tendersweet' O.F.' was red indicating dominance of red flesh to orange flesh. The  $F_2$  and BC data support a single gene hypothesis whereby orange flesh was recessive to red flesh (Table 1). Chi-square values are all non-significant indicating a good fit to the single recessive gene hypothesis for orange flesh to red flesh. Also an orange fleshed  $F_2$  selection produced all orange  $F_3$  progeny. A red flesh  $F_2$  selection segregated 3:1 for red to orange flesh as would be expected in 2/3 of the red selections.

A test for heterogeneity for Chi-square goodness of fit (Table 2) showed that each family segregated in a similar direction and was similar to the pooled value in both the  $F_2$  and backcross generations. Thus, reliability can be placed in the pooled data e.g. a deficiency in a character of one family was not cancelled by a surplus in another family.

In the test for allelism (Table 3) orange flesh was dominant to yellow flesh in the cross 'Tendersweet O.F.' x 'Golden Honey'. Further, red flesh was dominant to yellow flesh in the cross Golden Midget (red flesh) x 'Golden Honey' (yellow flesh). It is tempting to hypothesize a multiple allelic system as is shown in Table 1 and 2 whereby  $yy =$  yellow flesh,  $y^o y^o$  or  $y^o y =$  orange flesh and  $Y =$  red flesh. However, a dihybrid system with epistasis has not been ruled out and awaits the  $F_2$  and back cross data.

Tentatively the symbol  $y^o$  is given to orange flesh which is recessive to red flesh ( $Y$ ) but dominant to yellow flesh ( $y$ ).

Table 1. Segregation and Chi-square goodness of fit test for watermelon flesh color in the cross 'Tendersweet Orange Flesh' (orange) x 'Dixielee' (red).

Genera- tion	Parents	Hypo- thesized parental geno- type(s) <sup>z</sup>	Flesh color Off Spring (no. plants)		Expected ratio	Chi- square	Proba- bility
			Red	Orange			
P1	Dixielee	yy	8	0	1:0		
P2	Tendersweet O.F. <sup>y</sup>	y <sup>o</sup> y <sup>o</sup>	3	0	1:0		
F1	Dixielee x Tendersweet O.F.	Yy <sup>o</sup>	12	0	1:0		
F2	Dixielee x Tendersweet O.F.F1 <sup>⊗</sup>	Yy <sup>o</sup> ⊗	21	11	3:1	1.50	.50-.75
BC1	F1 x Dixielee	Yy <sup>o</sup> xYY	46	0	1:0	0	1.00
BC2	F1 x Tendersweet O.F.	Yy <sup>o</sup> +y <sup>o</sup> y <sup>o</sup>	47	65	1:1	2.89	.05-.10
F3	F2 - red selection <sup>⊗</sup>	Y- <sup>⊗</sup>	11	3	1:0 or 3:1	0.10	.75-.90
F3	F2 - orange selection <sup>⊗</sup>	y <sup>o</sup> y <sup>o</sup> ⊗	0	10	0:1	0	1.00

<sup>z</sup> Tentative flesh color genotypes

Y- = red - dominant to orange and yellow

y<sup>o</sup>y<sup>o</sup> or y<sup>o</sup>y = orange - recessive to red, dominate to yellow

yy = yellow - recessive to both red and orange

<sup>y</sup> Tendersweet O.F.<sup>1</sup>. = 'Tendersweet Orange Flesh'

Table 2. Heterogeneity test for Chi-square goodness of fit test for F<sub>2</sub> and backcross generations for watermelon flesh color in the cross, 'Dixielee' X 'Tendersweet Orange Flesh'.

Generation	df	Chi-square	Probability
<b>F<sub>2</sub></b>			
Sum of two chi-squares	2	1.66	.25-.50
Pooled	1	1.50	.10-.25
Heterogeneity	1	0.16	.50-.75
<b>Backcross (F<sub>1</sub> x Tendersweet)</b>			
Sum of four chi-squares	4	6.73	.10-.25
Pooled	1	2.89	.05-.10
Heterogeneity	3	3.84	.25-.50

Table 3. Allelism tests for watermelon flesh color<sup>z</sup>.

Cross	Family	Flesh Color (no. of plants)		
		Red	Orange	Yellow
		<u>Y-</u>	<u>y<sup>0</sup>y<sup>0</sup> or y<sup>0</sup>y</u>	<u>yy</u>
Tendersweet O.F. x Golden Honey y <sup>0</sup> y <sup>0</sup> YY	1 2	0 0	17 4	0 0
	Total	0	21	0
Tendersweet O.F. x Golden Midget y <sup>0</sup> y <sup>0</sup> YY	1 2	16 13	0 0	0 0
	Total	29	0	0
Golden Honey x Golden Midget yy                              YY	1	12	0	0
Tendersweet O.P. x Sweet Princess y <sup>0</sup> y <sup>0</sup> YY	1	19	0	0
Golden Honey x Sweet Princess yy                              YY	1	9	0	0
Golden Midget x Sweet Princess YY                              YY	1	14	0	0

<sup>z</sup> Yellow derived from 'Golden Honey', orange from 'Tendersweet Orange Flesh' and red flesh color from 'Golden Midget' and 'Sweet Princess'.

<sup>y</sup> Tendersweet O.F. = 'Tendersweet Orange Flesh'

<sup>x</sup> Tentative gene symbols:

Y = red

y<sup>0</sup> = orange (recessive to Y dominant to y)

y = yellow (recessive to Y and y<sup>0</sup>)



### Literature Cited

1. Henderson, W. R., M. Pitrat, R. W. Robinson, T. C. Wehner and T. W. Whitaker. 1987. Gene list for watermelon, Cucurbit Genetics Cooperative, 10: 106-110.
2. Poole, C. F. 1944. Genetics of cultivated cucurbits, J. Heredity, 35: 122-128.
3. Porter, D. R. 1937. Inheritance of certain fruit and seed characters in watermelons, Hilgardia, 10: 489-509.
4. Robinson, R. W., H. W. Munger, T. W. Whitaker and G. W. Bohn. 1976. Genes of the cucurbitaceae, HortScience, 11: 554-568.
5. Shimotsuma, M. 1963. Cytogenetical studies in the genus Citrullus VI. Inheritance of several characters in watermelons, Jap. J. Breeding, 13: 235-240.

Influence of Handling and Nitrogen Nutrition on Flowering and Growth of Watermelon Transplants in the Greenhouse.

R. N. McArdle

Biological and Chemical Sciences, Central Research Division, General Foods USA, 555 S. Broadway, Tarrytown, NY 10591

Efficient, early production of female flowers in watermelon Citrullus lanatus (Thunb.) Matsum. and Nakai is of keen interest to those making controlled crosses or otherwise attempting to produce fruit in a greenhouse setting. I noted on numerous occasions that seedlings started in peat pellets and transplanted at a very late stage were early and precocious flowerers. Manipulation of this stress response might prove useful to those requiring greenhouse-grown watermelon fruit, since earlier female formation could lead to more rapid fruit set and moreover, better control of the vining habit.

Seeds of 'Charleston Gray #5' (CG) and 'Bush Charleston Gray' (BCG) were sown in Jiffy -7 peat pellets held in plastic flats. The flats were watered to runoff daily until the pellets were removed for transplanting to 1-gallon pots (2:1 vermiculite:peat) at either the two-true-leaf stage (early) or 3 weeks afterwards (late); these constituted the 2 levels of the handling treatment. The third treatment was fertilization level, altered by adding 100 ml of 0, 200 or 400 ppm N three times a week as reagent-grade ammonium nitrate in double-distilled water. A completely randomized design of a complete 2x2x3 factorial, replicated 3 times, was used. Flower counts were made at 3 weeks following the delayed transplanting date (approx. 6 weeks from seeding) and again at 6 weeks, at which time the plants were also harvested for dry weight determination. Flower counts at 6 weeks excluded the first 8 nodes on each plant.

Results are presented in Table 1. The two cultivars clearly differed for flowering and growth. CG plants were, as expected, larger and had more flowers, but BCG seemed to produce earlier female flowers (significantly lower node). Average dry plant weight of the two cultivars was similar (although significantly different), but differences in the number of male flowers produced per plant indicate a different flowering response for the two types. Nonetheless, femaleness was not significantly different for these two cultivars. These results seem to suggest that the bush type produces fewer flowers than the vining type, but in the same male-female proportion, and on a shorter, stockier plant.

Time of transplanting had the most dramatic effect of any factor. Late planting significantly reduced growth and flower development of the plants. However, these same seedlings produced the earliest female flowers by a wide margin (fifth node as opposed to ninth). Transplant timing also seemed to reduce the numbers of flowers produced and femaleness (% female flowers) at the earlier measurement date. It seems likely that differences in the number of flowers produced was a direct result of plant development differences, as plant dry weight was severely lowered by delayed transplanting. Femaleness was not significantly different for the two timings at the later measurement date.

Increasing N resulted in small but statistically significant increases in male

flowers at six weeks and female flowers at three weeks. Here again the flowering response may be attributable to plant growth, since plant dry weight was highly influenced by N level. Earliness of female development was increased significantly by increased N level, although not substantially. N level promoted femaleness at the three-week measurement, but not at the later date. Although significant nitrogen x time interactions were found for two variables, the data (not shown) merely tended to show a much stronger influence of nitrogen in the late planted seedlings, no doubt an outcome of their poor initial nutritive condition.

Response of earliness to N level was opposite to that indicated by the timing data, and suggests that delayed transplanting causes more than simple nitrogen stress. Certain environmental influences, such as daylength, temperature and application of growth regulators have well-documented influences on watermelon sex expression (2,3,4). A field study (1) on watermelon showed little difference in date of first female anthesis under N rates of 0-150 lb/A. Higher N rate did increase the number of females/plant, but percent females was not recorded. Sex expression in Cucumis is known to be influenced by environmental factors, but a recent report (5) showed no effect of increased fertilization on sex expression and earliness of gynecious cucumber lines. It seems possible that differences between the handling regimes is attributable to more than nutrient stress. Moisture, which was undoubtedly less stable in the delayed transplants, may be involved.

The results suggest that female flowering can be accelerated by late transplanting, but probably at the expense of general plant vigor. Application of N appeared to alter flowering mainly by altering growth response, but the promotion of female earliness by increasing N contradicts earliness induced by late transplanting, a condition one might expect to be related to nutrition. Nutritional differences due to other (unmonitored) consequences of ammonium nitrate application (pH, etc.) are also plausible.

The previously mentioned field study (1) showed fruit set in watermelon to be reduced by low N application rates. A priority of further work will be to test whether stressed watermelon plants can set and produce fruit with appropriate late nutrition.

Table 1. Main treatment and interaction effects for cultivar, transplant timing and nitrogen regime on flowering and growth of watermelon transplants.

Main effect	# Males 3 wk	# Males 6 wk	# Fe males 3 wk	#Fe males 6 wk	Node bearing first female	% Female 3 wk	% Female 6 wk	Plant dry weight (g)
<u>Culti var (Cv)</u>								
Ch Gray	12.4	16.9	1.3	1.6	9.5	7.4	12.1	8.8
Bush CG	9.3	7.2	1.7	1.4	6.4	13.2	16.4	8.2
Signif. <sup>2</sup>	ns	**	ns	ns	**	ns	ns	*
<u>Trans planting</u>								
Early	17.2	14.4	2.7	2.3	9.3	14.5	11.6	12.6
Late	4.6	9.8	0.3	0.8	5.0	6.1	17.2	4.5
Signif.	**	**	**	**	**	*	ns	**
<u>N level ppm</u>								
0	8.0	9.6	1.1	1.3	8.6	9.1	14.8	7.0
200	12.3	13.1	1.4	1.5	8.2	7.7	12.9	7.6
400	12.4	13.6	1.9	1.9	6.6	14.3	15.3	10.9
Signif. linear quadr.	ns ns	* ns	** ns	ns ns	* ns	ns *	ns ns	** **
<u>Inter actions</u>								
CV x time	ns	ns	ns	**	ns	ns	ns	*
N X time	*	ns	ns	ns	ns	**	ns	ns
N X cv	ns	ns	ns	ns	ns	ns	ns	ns
N X cv X time	ns	ns	ns	ns	ns	ns	ns	ns

<sup>2</sup>Separation by F-test, ns=not significant at 5% level, \*=significant at the 5% level, \*\*=significant at the 1% level. Analysis performed on transformed data as needed to account for lack of homogeneity of treatment variance.

## Literature Cited

1. Brantley, B.B. and G.F. Warren. 1960. Effect of nitrogen on flowering, fruiting and quality in watermelon. Proc. Amer. Soc. Hort. Sci. 75:644-649.
2. Buttrose, M.S. and M. Sedgley. 1978. Some effects of light intensity, daylength and temperature on growth of fruiting and non-fruiting watermelon (*Citrullus lanatus*). Ann. Bot. 42:339-344.
3. Christopher, D.A. and J.B. Loy. 1983. Influence of foliar-applied growth regulators on sex expression in watermelon. J. Amer. Soc. Hort. Sci. 107:401-404.
4. Rudich, J. and A. Peles. 1976. Sex expression in watermelon as affected by photoperiod and temperature. Sci. Hortic. 5:339-344.
5. Staub, J.E. and L. Crubaugh. 1987. Imposed environmental stresses and their relationship to sex expression in cucumber (*Cucumis sativus* L.). Cucurbit Genet. Coop. Report 10:13-17.

\* \* \* \* \*

Studies of Watermelon Germplasm Resources and Breeding. III. Correlation between Parents and their F<sub>1</sub> Hybrids, Phenotypic Correlation among Characters and Path Analysis

Zhang Xingping and Wang Ming  
Department of Horticulture, Northwestern University, Yangling, Shaanxi,  
712102, China

### ABSTRACT

Twenty-one (21) watermelon lines and their 18 F<sub>1</sub> hybrids were tested for correlation analysis between parents and their F<sub>1</sub> hybrids, phenotypic correlation and path coefficient analysis. The results indicated that significantly positive correlation existed between midparents and F<sub>1</sub> hybrids for fruit yield per plant, fruit numbers per plant, fruit weight, soluble solids content, resistance, and extremely significant correlation was found between high parents and F<sub>1</sub> hybrids for resistance. There has been a significant correlation between fruit weight and fruit yield per plant, shoot thickness and fruit weight, resistance and fruit weight, and resistance and soluble solids content. The results obtained from path coefficient analysis suggested that fruit weight has an obviously direct effect on fruit yield per plant and indirect effects on shoot thickness and fruit yield per plant mainly via fruit weight, apart from the direct effect by itself.

**Key words:** watermelon; germplasm resources; heterosis correlation; path analysis

Abstract reprinted from Acta Univ. Setpentriionsli Occident Agric. 15(1):82-87. 1987. (With 3 tables, 13 references)

Cucurbita moschata Half-sib Families Collected in Puerto Rico and the Dominican Republic

L. Wessel-Beaver and M. W. Carbonell  
Department of Agronomy and Soils, College of Agricultural Sciences,  
University of Puerto Rico, Mayaguez, PR 00708

Half sib families from seed of 38 fruits originating from the Dominican Republic and 12 fruits from Puerto Rico were evaluated in replicated field trials in Puerto Rico from 1986 to 1988. In the Dominican Republic fruits were collected from farmer's field with the cooperation of the Centro Sur de Desarrollo Agropecuario (CESDA), San Cristobal, Dominican Republic. An attempt was made to collect a variety of fruit types with good pulp color (yellow-orange) and thickness. In Puerto Rico fruits were collected both from farmer's fields and markets. Fruits collected were meant to represent the types distinct in shape or skin color from the traditional Puerto Rican cultivar 'Borinquen'. 'Borinquen' from six different seed sources as well as some Puerto Rico Agricultural Experiment Station breeding lines (selected from 'Borinquen') were also included in the trials. Certain families in the first and second trials were re-evaluated in the second and third trials. Some Dominican families were eliminated due to poor germination or seedling vigor. Twenty-one to twenty three entries were evaluated in each of three trials in a randomized complete block design with three or four replicates. Three (trials 2 and 3) or four (trial 1) plants per plot were spaced 20 ft apart within rows and 25 ft apart between rows. Tropical genotypes of C. mochata are extremely large and sprawling plants with vines that easily reach 50 ft in length. To contain their growth, plants were wound around their identifying stake until female flowers appeared. Nevertheless, it was often difficult to distinguish between plants within a plot or even between plots at harvest.

From this very limited sample of genotypes we found nearly every shape and color fruit imaginable. Pear, oblong, ovate, oblanceolate, obovate, oval, cuneate, elliptic, gourd-shaped, globe, round, and flat fruits were observed among these families. Within families four or five different shapes were not uncommon. Puerto Rican consumers give little importance to fruit shape when purchasing pumpkin although round, globe, or flat shapes are preferred (1).

Skin colors ranged from nearly black to dark green to mottled green and white ("pinta" in Spanish) to mottled pale orange and white. However, not a single fruit of thousands evaluated had the buff color of 'Butternut'. In Puerto Rico skin color is somewhat important to consumers (the "pinta" color is preferred) but not nearly as important as pulp thickness and pulp color (1).

These families were very variable in terms of fruit size, yield per plant, number of fruit per plant, pulp color and pulp thickness. Mean family fruit size ranged from 2.4 kg to 6.4 kg. Some individual fruit weighed more than 10 kg. Average family yield per plant ranged from 3.8 kg to 47.1 kg. Mean number of fruit per plant varied from 1 to 9. Average family pulp thickness varied from 2.2 cm to 4.8 cm. Flesh color ranged from light yellow to dark orange.

Chi-square tests of independence in a sample of 842 fruits from all families

indicated that there was an association between fruit shape and pulp color ( $\chi^2 = 77.4$ , degrees of freedom = 35,  $P \leq 0.005$ ), between fruit shape and skin color ( $\chi^2 = 146.4$ , degrees of freedom = 28,  $P \leq 0.005$ ), and between pulp color and skin color ( $\chi^2 = 45.9$ , degrees of freedom = 24,  $P \leq 0.005$ ). Flat fruits were more often associated with dark green skin color than were other fruit shapes. Dark skinned fruits generally had good pulp color compared to other skin types.

Over all trials, number of fruits per plant was highly correlated with yield ( $r=0.81$ ). Fruit size and pulp thickness were only intermediately correlated with yield ( $r=0.42$  and  $0.43$ , respectively). Increased fruit size was not associated with number of fruit per plant ( $r=-0.06$ ). No correlation was found between pulp color and pulp thickness ( $r=0.03$ ).

#### Literature Cited

1. Carbonell, M. E., L. Wessel-Beaver, F. Varela, and B. Luciano. 1989. Pumpkin preferences: A survey among Puerto Rican consumers. J. Agric. Univ. of P.R. (In Press).

## Inheritance of Mottled Leaf in Cucurbita moschata

A. Ribeiro and C.P. da Costa

Department of Genetics, ESALQ/USP, CP 83, CEP13400, Piracicaba, SP, Brazil

The mottled leaf trait in the genus Cucurbita has been described as silver gray areas in axils of leaf veins controlled by a single dominant gene, M, in C. maxima, C. moschata and C. pepo (1,2,3). Modifier genes have been reported as extending and/or intensifying the character expression, and at least five phenotypes were described (2,5). According to Shifriss (6) cell position and environment also contribute to variation in mottling.

Shifriss (4,5,6,7) reported an association between mottled leaf trait and an escape mechanism against aphid-transmitted virus diseases. Mottled leaf plants either repelled aphids similarly to aluminium mulch or slowed speed of virus multiplication.

In the cv. Pira-Moita (C. moschata), we observed a great range of expression for the trait, from non-mottled to highly mottled plants. Contrasting lines were isolated after three selfing cycles, and six generations (P1, P2, F1, F2, BC1 and BC2) were compared from the cross, highly mottled leaf (P1) x non-mottled leaf (P2). Plants were evaluated for degree of mottling at first leaf stage, and data analyzed by chi-square (Table 1).

**Table 1.** Inheritance of mottled-leaf character in different generations from the cross between two lines, highly mottled leaf (P1) and non-mottled leaf (P2), derived from cv. Pira-Moita (Cucurbita moschata).

Gener.	Number of plants		Tested ratio	X <sup>2</sup>	P
	Mottled leaf	Non-mottled leaf			
P1	all	-	1:0		
P2	-	all	0:1		
F1	all	-	1:0		
F2	627	214	3:1	0.09	0.75-0.90
BC1	819	2	1:0		
BC2	549	581	1:1	0.91	0.25-0.50



All of the F1 plants showed intermediate phenotypes, moderately mottled leaves, indicating partial dominance. The chi-square test indicated good fit to a 3:1 ratio for F2 generation and to a 1:1 ratio for BC2 generation, corroborating earlier published studies. A single, partially dominant gene confers mottled leaf, but there are modifier genes affecting the character as indicated by the continuous variation in mottled expression in F2.

Besides the possible partial protection of Cucurbita plants against aphid-transmitted virus diseases, the trait may be useful as a seedling genetic marker.

### Literature Cited

1. Coyne, D.P. 1970. Inheritance of mottled-leaf in Cucurbita moschata Poir. HortScience 5:226-227.
2. Scarchuk, J. 1954. Fruit and leaf characters in summer squash. J. Hered. 45:295-297.
3. Scott, D.H. and E. Riner. 1946. A mottled-leaf character in winter squash. J. Hered. 37:27-28.
4. Shifriss, O. 1981. Do Cucurbita plants with silvery leaves escape virus infection? Origin and characteristics of NJ 260. Cucurbita Genetics Coop. Rpt. 4:42:43.
5. Shifriss, O. 1982. On the silvery-leaf trait in Cucurbita pepo. Cucurbit Genetics Coop. Rpt. 5:48-50.
6. Shifriss, O. 1982. Reflected light spectra from silvery and non-silvery leaves of Cucurbita pepo. Cucurbit Genetics Coop. Rpt. 6:89-90.
7. Shifriss, O. 1984. Further notes on the silvery-leaf trait in Cucurbita. Cucurbit Genetics Coop. Rpt. 7:81-83.

List, Description, and Interactions of the Genes Affecting Fruit Color in Cucurbita pepo

Harry S. Paris

Department of Vegetable Crops, Agricultural Research Organization,  
Newe Ya'ar Experiment Station, P.O. Haifa, Israel.

Cucurbita pepo L. contains a fascinating array of fruit colors. A few genes affecting fruit exterior color have been identified, and their preferred symbols and names were recently summarized (2) as B (Bicolor fruit), D (Dark green stem), l (light fruit color), l-2 (light pigmentation on fruit-2), St (Striped fruit), W (White fruit), and Y (Yellow fruit color). However, this list is not complete, nor does it contain a full description of the effects and interactions of these genes. Some new data would also indicate that modification of the list is also necessary. The goal here is to present a revised list of genes affecting fruit exterior color in C. pepo, including a description of the effect(s) and interactions of each, and to review some of the literature, especially with respect to its synonymies and anomalies.

Revised gene list:

<u>Preferred</u> <u>gene symbol</u>	<u>(Synonym)</u>	<u>Name</u>
<u>B</u>		<u>Bicolor</u> fruit (13)
<u>D</u>	(R)	<u>Dark</u> peduncle, stem, and fruit (3,7)
<u>Ep-1</u>		<u>Extender of precocious</u> yellow coloration-1 (15)
<u>Ep-2</u>		<u>Extender of precocious</u> yellow coloration-2 (15)
<u>l-1, l-1<sup>St</sup></u>	(c, St)	<u>light</u> fruit coloration-1 (7,13)
<u>l-2</u>		<u>light</u> fruit coloration-2 (7)
<u>W</u>		<u>White</u> fruit coloration (16)
<u>Y</u>		<u>Yellow</u> fruit coloration (16)

Description of effects and interactions:

B Preanthesis ovaries yellow or bicolor, yellow and green. Incompletely dominant to alternative allele represented as b in literature prior to 1981 and as B+ in literature since 1981. A third allele, represented as B<sup>w</sup> (weak B) probably exists (13,14) but proof with an allelism test has not been presented. When homozygous or when heterozygous in the presence of at least two Ep alleles (15), B is epistatic to Y (11). Interacts in complementary fashion with L-2 to condition orange fruit flesh color (5), with L-1 and L-2 to condition intense yellow color of young (summer squash) fruit (7), and with W to produce cream (instead of white) mature fruit color (13). Pleiotropic, affecting foliar as well as fruit characteristics, with differing degrees of expression of the various effects occurring in different genetic backgrounds (14).

D Plant stems dark; fruits and their peduncles dark from two weeks past anthesis; thus pleiotropic, affecting foliage and fruit. Alternative allele d for light stems, peduncles, and fruits (3,7). The D allele is epistatic to both l-1 and l-2 when either or both l genes are in homozygous recessive state (7). In half-mature fruit D also is epistatic to l-1<sup>St</sup>. Originally (3) D was

considered to condition dark stems only, and reported to be tightly linked to a fruit-color gene, R (Reversal, or non-persistent color, or r for recessive white, refs. 2, 3); The R symbol was subsequently (8) adopted based on the contention that D and R are linked but separate loci. However, results of later studies (5,7, and H.S. Paris unpublished data) cast serious doubt on the case for separate linked loci. Due to the lack of firm evidence, R should presently be considered synonymous with D. Other genes affecting stem color probably exist.

Ep-1, Ep-2 Extend the precocious yellow coloration conditioned by B (15). Incompletely dominant to alternative alleles ep-1 and ep-2 and additive in action: two doses of any combination of Ep alleles result in completely yellow fruit when B is heterozygous and in extension to the adjacent peduncle, calyx, and/or corolla when B is homozygous. No known effect in genotype b/b (B+/B+).

l-1, l-1<sup>St</sup>, l-2 Young fruits lightly colored when either l is homozygous recessive. Complementary action of L-1 and L-2 results in fruit which are intensively colored throughout development (7). The gene designations c (3) and l (13) have been shown to be synonymous (8). Other results (H.S. Paris, unpublished) show that the originally designated l is in fact l-1 and not l-2. Allele l-1<sup>St</sup> results in striped fruit and is recessive to L-1 and dominant to l-1. Complementary action of l-1<sup>St</sup> and L-2 results in striped young (summer squash) and mature fruits. The symbol St was originally suggested for the gene conditioning striping of 'Caserta' (10). Striping was considered by Shifriss (13) to be conditioned by an allele of l (l-1) but he did not present evidence in support of this contention, and therefore the symbol St was accepted (9). In the progeny (approximately 100) plants of the three-way cross, l-1/l-1 L-1/L-2 x (L-1/L-1 l-2/l-2 x 'Caserta', L-2/L-2), only intense-colored and striped, and no light-colored individuals were obtained, showing that the striping of 'Caserta' is conditioned by an allele of l-1, or is very tightly linked to l-1 (6). Therefore the symbol l-1<sup>St</sup> is now to be preferred. However, other genes conditioning striping undoubtedly occur at separate loci.

W and Y W was originally (16) reported to be epistatic to Y. W is probably epistatic to some fruit color genes (8,13) but not to Y (2).

In summary, eight genetic loci having an effect on fruit exterior color have been identified. Four of these loci affect fruit hue exclusively, whereas the other four affect intensity as well as hue (7). There are at least several other genetic loci which affect fruit exterior color, and these await identification.

In many articles on cucurbit genetics, "+" (wild-type, normal) notation has been used, as proposed by Robinson et al. (9). Such use may be appropriate when the mutant allele would have a clear deleterious effect on wild forms, such as the effect of B on young, developing fruit (1). However, in most cases, genetic studies have been conducted in crosses among cultivars rather than among wild and cultivated forms. In these crosses, the defining of "normal" is difficult, and given the lack of knowledge of the genetics of the wild form, the assignment of the wild-type symbol is usually guesswork. This can and has resulted in the assignment of the "+" to the mutant form of a gene. For example, the use of the symbol l+ instead of L in the latest gene list (2) is premature at best and a mistake at worst: Wild C. pepo has

alternating broad, intense-colored and narrow, light-colored stripes. Conceivably, l-1<sup>Sc</sup> or some other, as yet unidentified, allele and not L-1 might be the wild-type. Another example has occurred with regard to the locus responsible for the presence or absence of lignification of the fruit rind (phenylalanine ammonia lyase activity or inactivity, ref. 12). all C. pepo gourds have hard, lignified rinds. Mains (4) found that the hard rind of gourds was conditioned by a single dominant gene, and soft (not lignified) rind by its recessive allele. Robinson et al. (9) assigned the symbol Hr to this gene. Perhaps inevitably, the symbol Hr+ was subsequently (14) used to designate the recessive allele for soft rind! Therefore, in crosses among cultivars, it would seem to be more prudent to use upper and lower case symbols for alternative alleles of the various identified loci, at least until such time as the wild-type alleles have been clearly identified.

#### Literature Cited

1. Bazzaz, F.A., R.W. Carlson, and J.L. Harper. 1979. Contribution to reproductive effort by photosynthesis of flowers and fruit. *Nature* 279:545-555.
  2. Gene List Committee, Cucurbit Genetics Cooperative. 1988. Gene list for Cucurbita spp. *Cucurbit Genet. Coop. Rep.* 11: 96-103.
  3. Globerson, D. 1969. The inheritance of white fruit and stem color in summer squash. *Euphytica* 18: 249-255.
  4. Mains, E.B. 1950. Inheritance in Cucurbita pepo. *Papers Mich. Acad. Arts & Lett.* 36: 27-30.
  5. Paris, H.S. 1988. Complementary genes for orange fruit flesh color in Cucurbita pepo. *HortScience* 23: 601-602.
  6. Paris, H.S. and Y. Burger. Complementary genes for fruit striping in summer squash. Submitted for publication.
  7. Paris, H.S. and H. Nerson. 1986. Genes for intense fruit pigmentation of squash. *J. Hered.* 77: 403-409.
  8. Paris, H.S., H. Nerson, Z. Karchi, and Y. Burger. 1985. Inheritance of light pigmentation in squash. *J. Hered.* 76: 305-306.
  9. Robinson, R.W., H.M. Munger, T.W. Whitaker, and G.W. Bohn. 1976. Genes of the Cucurbitaceae. *HortScience* 11: 554-568.
  10. Scarchuk, J. 1954. Fruit and leaf characters in summer squash. *J. Hered.* 45: 295-297.
  11. Schaffer, A.A., C.D. Boyer, and T. Gianfagna. 1984. Genetic control of plastid carotenoids and transformation in the skin of Cucurbita pepo L. fruit. *Theor. Appl. Genet.* 68: 493-501.
  12. Schaffer, A.A., C.D. Boyer, and H.S. Paris. 1986. Inheritance of rind lignification and warts in Cucurbita pepo L. and a role for phenylalanine ammonia lyase in their control. *Z. Pflanzenzucht* 96: 147-153.
  13. Shifriss, O. 1955. Genetics and origin of the bicolor gourds. *J. Hered.* 46: 213-222.
  14. Shifriss, O. 1981. Origin, expression, and significance of gene B in Cucurbita pepo L. *J. Amer. Soc. Hort. Sci.* 106: 220-232.
  15. Shifriss, O. and H.S. Paris. 1981. Identification of modifier genes affecting the extent of precocious fruit pigmentation in cucurbita pepo L. *J. Amer. Soc. Hort. Sci.* 106: 653-660.
  16. Sinnott, E.W. and G.B. Durham. 1922. Inheritance in the summer squash. *J. Hered.* 13: 177-186.
- Contribution No. 2544-E, 1988 series, from the Agri. Research Organization, Bet Dagan, Israel.

## Relationship between the B Genes of Two Cucurbita Species, II

Oved Shifriss

21 Walter Avenue, Highland Park, NJ 08904

Raymond B. Volin and Tom V. Williams

Northrup King Co., 10290 Greenway Rd., Naples, FL 33962

The primary effect of a B gene is precocious depletion of chlorophyll in young fruits prior to anthesis (1). Genes conditioning this effect exist in both C. pepo and C. maxima. It is practically impossible to study the relationship between the B of C. pepo and the B of C. maxima by breeding experiments. This is because the two species are isolated by strong genetic barriers. The barriers were circumvented by transferring the B genes of these species to C. moschata. As a result, two different B lines of C. moschata were established: NJ-B and IL-B. NJ-B carries the B of C. pepo and IL-B carries the B of C. maxima. A preliminary study of inheritance involving NJ-B x IL-B was conducted at Rutgers University, New Brunswick, NJ, and the results raised some unexpected issues (2).

First, individual F<sub>1</sub> plants differed in their capacity to manifest a "midrib pattern" of chlorophyll depletion in leaf blades (Fig. 1, ref. 2). Neither NJ-B nor IL-B exhibits this pattern. Second, apart from a small proportion of albino (lethal) seedlings, most F<sub>2</sub> segregates were difficult to classify, casting some doubt on the validity of the data. The F<sub>2</sub> plants were grown without supplementary light during winter months in a greenhouse that was not well insulated from outside temperature fluctuations.

The difficulties experienced in classification were largely due to the fact that precocious depletion of chlorophyll in this F<sub>2</sub> can affect several or all aerial organs of a plant. Moreover, a particular organ may or may not be affected depending on the stage in plant development at which it is differentiated. The effect is also subject to variations in the environment. Under such circumstances each F<sub>2</sub> plant must be observed over a long period of time in order to critically assess its complex phenotype, a laborious task.

Nevertheless, the preliminary results suggested that the analysis of this cross might shed some light not only on the relationship between the two B genes but also on the genetic control of chlorophyll during plant development. And this thought gave the impetus to the present investigation.

Breeding materials. Two clones were available from the previous study. Clone NOMP was obtained from an F<sub>1</sub> plant (5356-1) that did not exhibit the midrib pattern, and clone MP was obtained from an F<sub>1</sub> plant (5356-14) that exhibited this pattern. The two clones were propagated vegetatively and grown to maturity for five years. During this period they behaved in a consistent manner: NOMP did not exhibit the pattern and MP exhibited it in winter but not in summer. For the present study, new F<sub>1</sub> seed was obtained from NJ-B x IL-B. But the BC<sub>1</sub> and F<sub>2</sub> seed was obtained through the use of NOMP and MP clones.

Environment. The seed of the parental inbreds, the new F<sub>1</sub>, the BC<sub>1</sub> and F<sub>2</sub> was sown in a greenhouse in Naples, Florida, on 12 September 1988, and the seedlings were transplanted to the field on 22 September. The greenhouse temperature exceeded 30C during germination and early seedling growth. Cultural

practices were similar to those commonly used by commercial growers in the area. Field observations of individual plants continued until the end of November.

Results and interpretation (consult Table 1). The first significant observation was the absence of albino (lethal) seedlings in any one of the breeding materials.

In the BC<sub>1</sub> (test 4), the proportion of plants with precociously pigmented fruits and precociously pigmented stems (phenotypic classes 4 + 5) to plants with precociously pigmented fruits and green stems (class 3) to plants with precociously pigmented bicolor fruits and green stems (class 2) does not disagree with a 2:1:1 ratio (97:46:49, the expected ratio being 96:48:48, P=0.90-0.95). In the F<sub>2</sub> (test 7), the proportion of plants with precociously pigmented fruits and precociously pigmented stems (classes 4 + 5 + 6) to plants with precociously pigmented fruits and green stems (class 3) to plants with precociously pigmented bicolor fruits and green stems (class 2) to plants with green fruits and green stems (class 1) does not disagree with a ratio of 12:1:2:1 (258:17:42:19, the expected ratio being 252:21:42:21, P = 0.75-0.90).

The new results are compatible with the hypothesis that the two B genes are non-linked; that there exists a third gene; that the third gene is closely linked to the B of IL-B; that this linked gene activates the expression of B in stems; and that the bicolor fruited plants carried a single dose of B, donated exclusively by NJ-B, and three doses of B<sup>+</sup>. This suggests that the effect of a single B of IL-B is stronger than that of a single B of NJ-B in extending precocious chlorophyll depletion over the entire fruit.

If the above hypothesis is basically correct, let B<sub>1</sub> represent the B of C. pepo, B<sub>2</sub> the B of C. maxima and Ac-B the activator of B. Then, the partial genotype of NJ-B is  $\frac{\underline{B}_1 \cdot \underline{Ac-B}^+}{\underline{B}_1 \cdot \underline{Ac-B}}, \frac{\underline{B}_2 \cdot \underline{Ac-B}^+}{\underline{B}_2 \cdot \underline{Ac-B}}, \underline{Ac-B}^+$ . And the partial genotype of IL-B is  $\frac{\underline{B}_1 \cdot \underline{Ac-B}^+}{\underline{B}_1 \cdot \underline{Ac-B}}, \frac{\underline{B}_2 \cdot \underline{Ac-B}}{\underline{B}_2 \cdot \underline{Ac-B}}$ .

The effect of chlorophyll depletion on whole plants was more extensive and more severe in progenies obtained from the MP clone than in progenies obtained from the NOMP clone. This was particularly striking in the F<sub>2</sub>. The difference between the two BC<sub>1</sub> progenies (test 3 vs test 2) was hardly perceptible to the observer in the field, and might not be biologically significant. On the other hand, the data in Table 1 do not reflect adequately the true magnitude of the difference between the two F<sub>2</sub> progenies (test 6 vs test 5). The reason for this is that class 6 consisted of a wide spectrum of phenotypes. At one end of the spectrum were essentially class 5 plants that exhibited the midrib pattern late in the season. At the other end of the spectrum were highly variegated, almost completely yellow, plants that were essentially semi-lethal. In test 5, the 6 plants of class 6 were initially recorded as class 5 individuals, but at the end of November their new leaves exhibited the midrib pattern and therefore these plants were reclassified under class 6. In test 6, at least 35 of the 55 class 6 plants were recorded as variegated, and 8 of the 35 were almost completely yellow or essentially semi-lethal. Genotypes of such individuals might appear as albino (lethal) seedlings under conditions of low temperature and low light intensity.

Variegated plants similar to those of class 6 were observed in *C. maxima* about 10 years ago (Shifriss, unpublished). These variegated plants were F<sub>2</sub> segregates of crosses between PI-165558, a B/B cultivar from India, and several North American cultivars, B/B and B+/B+. The stem of PI-165558 is precociously pigmented (indicating the presence of B<sub>2</sub>.Ac-B), whereas the stems of most North American B/B cultivars are green (indicating the presence of B<sub>2</sub>.Ac-B+). Since PI-165558 was the donor of B to IL-B (2), it must have actually donated B<sub>2</sub>.Ac-B. Perhaps the gene pool of *Cucurbita* carries some elements that extend the effect of B<sub>2</sub>.Ac-B over the entire plant.

Finally, two of the nine unclassified plants (test 7) were tentatively described as having precociously pigmented stems, green ovaries and green leaves. If the function of the linked gene, presently designated by symbol Ac-B, is not related to the effect of B, then this linked gene should be designated by a different symbol, e.g., Cds, for chlorophyll depletion in stems.

#### Literatures Cited

1. Shifriss, O. 1981. Origin, expression and significance of gene B in *Cucurbita pepo*. L. J. Amer. Soc. Hort. Sci. 106:220-232.
2. Shifriss, O. 1986. Relationship between the B genes of two *Cucurbita* Species. Cucurbit Genetics Coop. Rpt 9:97-99.

Table 1. Inheritance of precocious depletion of chlorophyll in a cross between two special lines of *C. moschata*. 1988 field data, Naples, Florida.

		Phenotypic Classes <sup>z</sup>						Number of plants classified	% of plants in class	Number of unclassified plants
Test	Breeding materials	1	2	3	4	5	6			
		GF	PDC-BiF	PDC-UF	PDC-UF	PDC-UF	PDC-UF			
		GS	GS	GS	PDC-S	PDC-S	PDC-S			
		GP	GP	GP	GP	PDC-P	PDC-P			
		GB	GB	GB	GB	GB	PDC-B			
-	P <sub>1</sub> , NJ-B	0	0	12	0	0	0	12	0	0
-	P <sub>2</sub> , IL-B	0	0	0	0	12	0	12	0	0
1 <sup>y</sup>	F <sub>1</sub> , P <sub>1</sub> x P <sub>2</sub>	0	0	0	0	18	0	18	0	0
2 <sup>x</sup>	BC <sub>1</sub> , F <sub>1</sub> x P <sub>1</sub>	0	28	23	48	1	0	102	0	0
3 <sup>w</sup>	BC <sub>1</sub> , F <sub>1</sub> x P <sub>1</sub>	0	20	23	38	9	0	90		
4	Total for BC <sub>1</sub>	0	48	46	87	10	0	192	0	0
5 <sup>x</sup>	F <sub>2</sub>	1	16	9	54	36	6	122	4.9	3
6 <sup>w</sup>	F <sub>2</sub>	18	26	8	54	53	55	214	25.7	6
7	Total for F <sub>2</sub>	19	42	17	108	89	61	336	16.2	9

<sup>z</sup>Key to phenotypic symbols: B = leaf blade; Bi = bicolor; F = fruit; G = green; P = petiole; PDC = precocious depletion of chlorophyll; U = uniformly pigmented, referring specifically to fruit. PDC may be associated with either white, tan, yellow or golden pigmentation.

<sup>y</sup>The F<sub>1</sub> hybrids of reciprocal crosses were indistinguishable phenotypically. None of the 18 plants exhibited the "midrib pattern" (see text). The petioles of the F<sub>1</sub> plants were less intensely pigmented and more variable than the petioles of P<sub>2</sub>.

<sup>x</sup>This test was made through the use of an old F<sub>1</sub> clone (NOMP) that did not exhibit the "midrib pattern".

<sup>w</sup>This test was made through the use of an old F<sub>1</sub> clone (MP) that manifested the "midrib pattern".



Relationship between Gene B and Gene Ses-B in Cucurbita pepo L.

Oved Shifriss

21 Walter Avenue, Highland Park, NJ 08904

Gene B conditions precocious depletion of chlorophyll. And the loss of chlorophyll is often associated with precocious yellow pigmentation. The primary target of B is the fruit (2). But B can also affect other potentially photosynthetic organs, depending on the genetic background and the environment. The "genetic background" is represented by specific nuclear elements. For example, under some environmental conditions, the presence of gene Ses-B+ allows the expression of B in leaf blades early in plant development. In contrast, gene Ses-B selectively suppresses the expression of B in leaf blades under a wide range of environmental conditions (3).

The influence of the environment is illustrated in the following. When seed of 'Jersey Golden Acorn' (JGA), B/B Ses-B+/Ses-B+, is sown in May in New Brunswick, NJ, the first true leaves are often completely yellow. Similarly, the first true leaves are often completely yellow when seed is sown late in November under greenhouse conditions in New Brunswick. But when the seed is sown in September in Naples, Florida, the first true leaves are completely green. It is assumed that relatively low temperatures or low light intensities trigger the effect of Ses-B+. However, the precise temperature and light conditions necessary to elicit the Ses-B+ effect have not been determined. Moreover, the role of other non-genetic factors cannot yet be excluded.

There are marked variations in sensitivity of B/B lines to environmentally-induced leaf yellowing, a fact that alludes to a more complex genetic basis for this trait. But even a single B/B line, such as JGA, can manifest leaf yellowing in different ways. Examples: (a) Incomplete penetrance and variable expressivity, based on the phenotype of the first true leaf. (b) 100% penetrance and high expressivity, based on the first true leaf, followed by 1 to 3 partially yellow leaves, and then a switch to completely green leaves. (c) The first 3-6 leaves are yellow or partially yellow, followed by a distinct variegated phase in which chlorophyll depletion is largely confined to leaf veins, and then a switch to completely green leaves. (d) A prolonged phase of 10 to 30 yellow or partially yellow leaves followed by a switch to green.

Nevertheless, there is little doubt that in some crosses the inheritance of sensitivity is monogenic. It is speculated that Ses-B+ and Ses-B are special regulators of B. In order to study the physical relationship between B and these regulators by breeding experiments two requirements must be met. First, the parental lines must carry alternative alleles. If JGA is to be used as a B/B parent that carries Ses-B+, it is necessary to find a B+/B+ parent that carries Ses-B/Ses-B. Second, one must find an environment in which JGA predictably manifests 100% penetrance and high expressivity of leaf yellowing. Otherwise, it would be extremely difficult, if not impossible, to critically classify segregating generations.

'Sweet Dumpling' (SD), a B+/B+ cultivar, was found to carry a strong Ses-B (Shifriss 1982, unpublished). This finding fulfilled the first of the above

Table 1. Limited data on the inheritance of precocious yellow pigmentation.

Breeding materials	Number of seedlings that exhibited different grades of yellowing in the first true leaf						Total	$\chi^2$ (13:3) <sup>z</sup>	P
	1	2	3	4	1-4	5			
P <sub>1</sub> , JGA	0	0	0	0	0	10	10	-	-
P <sub>2</sub> , SD	10	0	0	0	10	0	10	-	-
F <sub>2</sub>	90	2	36	36	164	34	198	0.32	0.50-0.75

<sup>z</sup>

Testing 164:34.

Table 2. Classification of the 90 plants (grade 1, Table 1) based on fruit color at later stages of development.

Number of plants that produced				Total	$\chi^2$ (4:2:1)	P
green fruits	bicolor fruits	yellow fruits				
53	23	14		90	0.44	0.75-0.90

Table 3. Classification of the entire F<sub>2</sub> based on data in Tables 1 and 2.

Number of seedlings of			Total	$\chi^2$ (9:3:4)	P
grades 1 to 4 that at later stages produced bicolor or yellow fruits	grade 5 that at later stages produced bicolor or yellow fruits	grade 1 that at later stages produced green fruits exclusively			
111 <sup>z</sup>	34	53	198	0.51	0.75-0.90

<sup>z</sup>

This number was obtained by subtracting 87 (34 + 53) from 198.

two requirements. As a result, seed was produced of  $F_1$ ,  $BC_1$  and  $F_2$ , using JGA and SD as parents. At the same time, attempts were made (through the use of growth chambers as well as greenhouse and field facilities) to find an environment that elicits the full effect of Ses-B+. These attempts were largely unsuccessful. In four experiments, JGA manifested incomplete penetrance and variable expressivity of leaf yellowing.

But there was one limited test in which JGA manifested 100% penetrance and high expressivity of leaf yellowing. This test included the parents and the  $F_2$ . The  $F_1$  and the  $BC_1$  seedlings were lost by accident. The seed was sown in November of 1983 and the plants were grown for five months under uncontrolled greenhouse conditions at Rutgers University in New Brunswick. In a subsequent sowing, the parents and the  $F_1$  were grown during the summer of 1984, and their fruits are illustrated in Figure 1.

The data are presented in Tables 1, 2 and 3. The key for grades of yellowing in the first true leaves (Table 1) is as follows: 1 = completely green or green with 1 to 2 tiny yellow spots; 5 = yellowing extends over 3/4 of the leaf surface, and 2 to 4 = intermediate grades between 1 and 5. Yellowing appears to reflect a diffused phenomenon rather than an extension of spotting. It is well established that B+/B+ plants can exhibit yellow spotting under some environmental conditions (1).

The data in Tables 1, 2 and 3 suggest that B and Ses-B are non-linked.

#### Literature Cited

1. Shifriss, O. 1965. The unpredictable gourds. *Amer. Hort. Mag.* 44:184-201.
2. Shifriss, O. 1981. Origin, expression and significance of gene B in Cucurbita pepo L. *J. Amer. Soc. Hort. Sc.* 106:220-232.
3. Shifriss, O. 1982. Identification of a selective suppressor gene in Cucurbita pepo L. *HortScience* 17:637-638.



Figure 1. Upper left, SD; upper right, JGA; bottom,  $F_1$

## Control of Chlorophyll During Plant Development: Hypothesis

Oved Shifriss

21 Walter Avenue, Highland Park, NJ 08904

The term "control" in the title pertains to a series of steps that transforms proplastids into chloroplasts, the organelles of chlorophyll synthesis. These steps occur in competent cells that are exposed to light. According to present hypothesis there are two systems of control: one at the organelle level and another at the organismal level. The organelle system controls the steps that lead to normal chloroplasts under favorable intracellular conditions. But intracellular conditions potentially vary in different organs and at different stages during plant development. Furthermore, these conditions are affected by fluctuations in the external environment. The organismal system, acting as a buffer to such variations, tends to maintain favorable internal conditions for effective control by the organelle system. The focus here is on the organismal system.

The control at the organismal level is perceived as a homeostat of plastid transformation (HPT). The term "homeostat" is derived from the concept of homeostasis. The HPT consists of different nuclear genes that act in a selective manner, singly or in combination, as homeostatic regulators. Thus, the capacity of competent cells to transform proplastids into chloroplasts in different organs and at different developmental stages is sustained by these regulators. Some mutants of these regulators adversely affect or completely block the course of plastid transformation.

In a broader sense, HPT enables higher plants to carry on photosynthesis persistently and efficiently throughout life, assuming normal fluctuations in the external environment. HPT probably played a role in the evolution of higher organisms. This is because persistent production of photosynthates during plant development was advantageous not only to the producers, the autotrophs, but also to their animal predators, the heterotrophs.

The above hypothesis originated from studies of precocious depletion of chlorophyll in Cucurbita. The supporting evidence is based on the identification of two groups of genes that are unique in their specific effects.

The first group targets specific organs selectively. This group consists of gene B and its selective activators and selective suppressors. B is a major nuclear element that brings about precocious depletion of chlorophyll in fruits in all known genetic backgrounds. But B can be expressed or suppressed in other organs (e.g., leaf blades, stems) depending on the presence of selective activators such as Ses-B+ and Ac-B or selective suppressors such as Ses-B and Ac-B+. These findings suggested that the action of B, B+, Ses-B+, Ac-B and Ac-B+ is organ-specific, and that B+, Ses-B, and Ac-B+ are effective homeostatic regulators. The information on the behavior of gene B has been published, but see also the two preceding articles in the present issue of CGC Report.

The second group of genes targets leaf blades at a particular time during plant development. Usually, the first five to seven sequential leaves on the main stem are not affected (Shifriss, unpublished). A similar manifes-

tation is exhibited by certain cultivars of Amaranthus tricolor (e.g., 'Illumination') except that in these cultivars the entire shoot tip is affected sometime during development. As a result, the upper portion of an affected plant is completely devoid of chlorophyll. Separate progenies obtained from self-pollination of the upper and lower portions of such a plant behave developmentally in identical manner.

The time and extent of gene expression in both groups are highly affected by non-genetic fluctuations. This is particular true for heterozygotes.

The hypothesis of homeostatic regulators can be tested. First, consider the future synthesis of two isogenic B+ inbreds: one carrying Ses-B and another, Ses-B+. These inbreds will appear indistinguishable phenotypically. However, when tested for photosynthetic activity in diverse environments the difference between them will become evident. Either the Ses-B inbred will be consistently superior over the Ses-B+ inbred or each will be superior in a different ecological niche. Second, molecular analysis will demonstrate that the DNA sequences of some of the homeostatic regulators in Cucurbita are shared by many distantly related species of higher plants, and that these sequences influence the potential of crop yield.

While light triggers the process of plastid transformation, the evidence in Cucurbita and other taxa suggests the existence of an hierarchy of regulators that sustains this process during development. Any alternative to the HPT hypothesis should offer a more convincing interpretation for the kinds of specificity manifested by some of the mutants that affect plastid transformation as well as for the widespread distribution of such genes as Ses-B and Ses-B+ among the B+ cultivars of Cucurbita.

Determination of Molecular Weight of Chloroplast DNA of Cucurbita pepo L. using Different Restriction Enzymes.

Lim, H. T. and C. Boyer

Department of Horticulture, Pennsylvania State University, University Park, PA 16802

Chloroplasts contain their own complement of DNA as well as protein synthesis apparatus. The chloroplast DNA (cpDNA) exists as covalently closed circular molecular molecules, ranging in size from 120 to 180 kilobase pairs (kbp) in flowering plant species (4). Chloroplasts, however, are not autonomous: the biogenesis of chloroplasts requires the coordinative expression of both specific nuclear genes and chloroplast genes.

In order to understand mechanisms that control the expression of nuclear and chloroplast genes, one prerequisite is the ability to physically purify the chloroplast DNA and to know genetic organization of the chloroplast DNA. The first introductory study for estimating molecular weight among members of Cucurbitaceae was conducted by Juvik and Palmer (3). However, only the ranges and numbers of fragments produced by different restriction endonucleases were reported. In this report, a rapid method of restriction enzyme analysis of the squash cpDNA is described in some detail and the size of C. pepo chloroplast genome is estimated.

**Chloroplast Isolation:** Squash (Cucurbita pepo L. ) chloroplasts were extracted from young leaves according to the protocol of Gounaris *et al.* (1) with following modifications. The crude extraction of chloroplasts was resuspended in homogenized buffer and collected by centrifugation at 1500 xg for 15 min. Instead of using discontinuous sucrose gradient centrifugation to purify chloroplasts (2,3), a continuous sucrose gradient was used to remove contaminating nuclear DNA. The resuspended pellet was loaded onto a 30-60% w/v gradient of sucrose, and spun at 100,000 xg in a SW-27 rotor at 4 C for 1 hr. The chloroplast bands were collected, diluted with a equal volume of TE buffer, and centrifuged at 2,500 xg for 5 min.

**Isolation of cpDNA:** The chloroplast pellet was resuspended in 5 ml of the homogenization buffer, to which 1/10 volumes of 1 mg/ml RNase A and 2 ml of 10% w/v sodium sarkosinate were added. The suspension was incubated at room temperature for 30 min. for chloroplast lysis. The DNA sample was extracted with an equal volume of buffer-saturated phenol, three times with 4 ml of phenol and 2 ml of chloroform, and twice with water-saturated n-butanol. DNA was precipitated at -70 C for 1 hr by adding 1 ml of 7.5 M ammonium acetate and 2.5 volumes of absolute ethanol. The Precipitated DNA was collected by centrifugation at 10,000 xg for 10 min, and DNA pellet was washed with 70% ethanol, dried under nitrogen gas, and dissolved in TE buffer and stored at -20 C.

**Digestion of cpDNA with restriction endonucleases:** The chloroplast DNA were digested with selected restriction endonucleases under the conditions recommended by the suppliers. Restriction fragments of plastid DNA were separated by electrophoresis in 0.5-1.7% agarose gels, depending on the size of fragments.

Table 1. Numbers, sizes (in Kbp) and stoichiometries (brackets) of squash cpDNA restriction fragments generated by different endonuclease restriction enzymes.

Fragment nos.	Sal	Pvu II	Bgl I	Sac II	Pst I
1	47.7(2x)	57.3	47.5	29(2x)	29.9(2x)
2	26.3	28.6	35.3	25.4	25.2
3	21.1	19.5	22.8	20.5	21.0
4	18.8	16.2	21.1	16.6	13.5
5	2.4(2x)	14.2	11.1	15.3	11.9
6		10.5	7.4	12.8	10.0
7		7.9	6.5(2x)	10.7	8.4
8		6.1(2x)	4.3(2x)	5.4	6.1
9				1.6	4.3(2x)
10					1.4
11					0.6
<b>Total</b>	<b>166.4</b>	<b>166.4</b>	<b>166.7</b>	<b>166.2</b>	<b>166.5</b>

The previously reported method for cpDNA isolation is very time-consuming and tedious (2,3). The proposed method was modified to avoid the pronase treatment and CsCl density centrifugation, which are replaced with phenol and phenol/chloroform treatment (1).

The length of the restriction fragments was easily determined by calibrating the gel. This was done by running Lambda DNA digested with Hind III and Zho I in another slot of the same gel. The molecular weights of fragments larger than 30 kbp were estimated as the sum of subfragments derived from second digestion. For the five enzymes reported, the size of C. pepo DNA is estimated at 166 Kbp (Table 1) and work is in progress to prepare a detailed restriction enzyme map for C. pepo cpDNA.

#### Literature Cited

1. Gounaris, I, C.B. Michalowski, J.J. Bohnert and C.A. Price. 1986. Restriction and gene maps of plastid DNA from Capsicum annuum. *Current Genet.* 12:219-224.
2. Palmer, J.D. 1988. Isolation and structural analysis of chloroplast DNA. In: Weissbach. A and Wissbach. H. (ed) *Methods for Plant Molecular Biology*. Academic Press, pp 105-124.
3. Juvik J.A. and Palmer, J.D. 1984. Potential of restriction endonuclease analysis of chloroplast DNA for the determination of phylogenetic relationships among members of Cucurbitaceae. *C.G.C.* 7:66-68.
4. Palmer, J.D. 1982. Physical and gene mapping of chloroplast DNA from Atriplex triangularis and Cucumis sativa. *Nucl. Acids Res.* 10:1593-1605.

## Taxonomic Position of Round Melon (Praecitrullus fistulosus)

V.S. Sujatha and V.S. Seshadri

Division of Vegetable Crops, Indian Agricultural Research Institute, New Delhi 110012, India

Round melon or 'tinda' is an Asian cucurbit having a chromosome number of  $x=12$ . This taxon was earlier considered as a botanical variety of watermelon, Citrullus lanatus ( $x=11$ ). Pangalo (8), however, identified distinct morphological and cytological differences between C. vulgaris var. fistulosus (tinda) and C. lanatus (syn. C. vulgaris). There is now general agreement among botanists and cytologists in that round melon requires a separate taxonomic status from watermelon. Khoshoo and Vij (6) and Trivedi and Roy (12) suggested a separate species status for round melon in the genus Citrullus. However, many other scientists are of the opinion that round melon should be put in a different genus, separate from Citrullus (2,4,7,11). Shimotsu (10) was of the opinion that round melon with  $x=12$  should be placed in the genus Cucumis, along with C. melo whose chromosome number is also 12. However, histological studies by Fursa (3) and analysis of leaf phenolics by Kaur et al. (5) brought out distinct differences between the two taxa.

Tinda is not crossable with either watermelon or muskmelon, but isozymes provided additional evidence for comparison of the two species. Round melon was compared with watermelon and muskmelon for two enzyme systems, peroxidase (PRX) and glutamate oxaloacetate transaminase (GOT). Polyacrylamide gel electrophoresis was carried out at 50°C, using vertical slab gels and a constant current of 40 mA per slab. The gel buffer for all analyses was pH 9.0 tris-chloride, and the electrode buffer was pH 8.3 tris-glycine. Bromophenol blue (0.2%) in imidazole buffer (pH 7.0) was used as a tracer dye, and relative mobility ( $R_m$ ) was calculated. Peroxidase analyses were made on roots and hypocotyls of 4-5 week old seedlings, with gel concentration of 7% acrylamide and staining adopted from Conklin and Smith (1). Glutamate oxaloacetate transaminase analyses were made on 3-4 day old seedlings, with 9.5% acrylamide gel concentration and staining technique adopted from Shaw and Koen (9).

Seven peroxidase isozymes were found (Fig. 1) at  $R_m$  0.01, 0.04, 0.11, 0.15, 0.44, 0.47, 0.76), different in electrophoretic mobility from the six isozymes found in Citrullus lanatus ( $R_m=0.07, 0.12, 0.19, 0.43, 0.54, 0.57$ ) and the eight isozymes of Cucumis melo ( $R_m=0.05, 0.15, 0.443, 0.48, 0.52, 0.56, 0.61, 0.73$ ). In the GOT zymogram, the three isozymes of Praecitrullus ( $R_m=0.13, 0.26, 0.30$ ) were different from the two found in Citrullus lanatus ( $R_m=0.22, 0.25$ ) and the four isozymes found in Cucumis melo ( $R_m=0.17, 0.23, 0.34, 0.38$ ).

Thus, it was found that there was no similarity of Praecitrullus with Citrullus lanatus or Cucumis melo for PRX or GOT, although Zamir et al. (13) noticed similarity between C. lanatus and C. colocynthis for GOT and PRX zymograms. The present study substantiates Pangalo's classification of round melon in a genus separate from that of watermelon.



Comparing Praecitrullus with Cucumis melo, it was found that the two species did not have any PRX or GOT isozymes in common. The isozyme at GOT<sub>4</sub> which was present in the 12 Cucumis species analysed was absent in Praecitrullus. Thus, the present study disputes the argument of Shimotsuma (10) that round melon should be placed in the genus Cucumis. The Indian round melon or 'tinda' is unrelated to and different from muskmelon and watermelon. The present study supports Pangalo's classification of 'tinda' under a new genus, 'Praecitrullus'.

#### Literature Cited

1. Conklin, M.E. and H.H. Smith. 1971. Peroxidase isozymes. A measure of molecular variation in ten herbaceous species of Datura. Amer. J. Botany 58:688.
2. Dass, H.C., G.S. Randhawa and M. Kaur. 1974. Phylogenetic studies in Cucumerinae by leaf phenolics. Nucleus 17:103-109.
3. Fursa, T.B. 1974. The seed coat anatomy of watermelon as a taxonomic character. Trudy Po Prikladnoi Botanike, Genetikii Selektivii, 51(3):39-48.
4. Guljaev, V.A. 1963. Comparative embryology of the Cucurbitaceae and its significance for the taxonomy of the family. Botanicheskij Zhurnal 48:80-88.
5. Kaur, M., H.C. Dass and G.S. Randhawa. 1973. Systematic status of round melon, Citrullus vulgaris var. fistulosus as studied by leaf phenolics. Curr. Sci. 42:730-731.
6. Khoshoo, T.N. and S.P. Vij. 1963. Biosystematics of Citrullus vulgaris var. fistulosus. Caryologia 16:541-552.
7. Kurt, J.K., S.D. Deena and D.W. Hugh. 1985. Allozyme differentiation in the Cucurbita pepo complex. C. pepo var. medullosa var. C. taxana. Econ. Bot. 39:289-299.
8. Pangalo, K.I. 1938. Living ancestors of cultivated watermelon. C.R. (Doklady) Acad. Sci. URSS. 10:599-600.
9. Shaw, C.R. and A.L. Koen. 1968. Starch gel zone electrophoresis of enzymes. In I. Smith (ed.) Chromatographic and Electrophoretic Techniques. Vol. 2, 2nd ed. John Wiley, NY.
10. Shimotsuma, M. 1961. Chromosome number of Citrullus species. Chromosome Information Service, Tokyo 2:14-16.
11. Shimotsuma, M. 1963. Cytogenetics and evolutionary studies in the genus Citrullus, Seiken Zihō 15:23-24.
12. Trivedi, R.N. and R.P. Roy. 1970. Cytological studies in Cucumis and Citrullus. Cytologia 35:561-569.

13. Zamir, D., N. Navot and J. Rudich. 1984. Enzyme polymorphism in Citrullus lanatus and Citrullus colocynthis in Israel and Sinae. Plant Systematics Evol. 146:163-170.

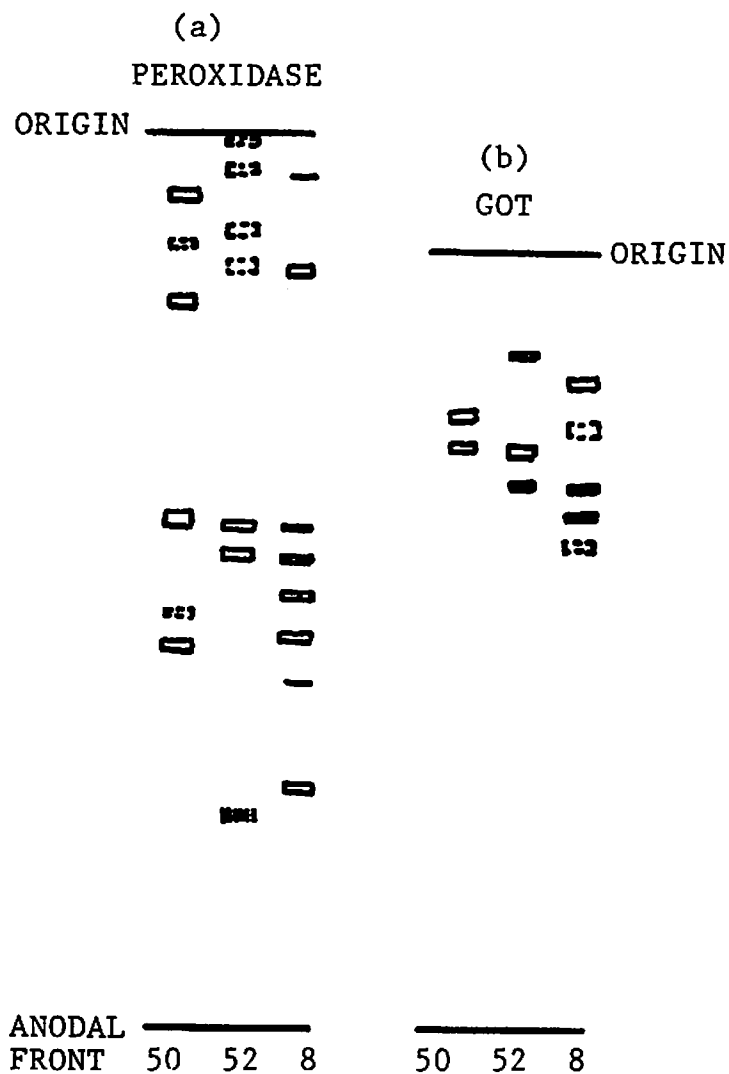


Figure 1. Peroxidase and GOT zymograms of Citrullus lanatus (50), Praecitrullus fistulosus (52) and Cucumis melo (8).

## Allozyme Studies in the Benincaseae

D. S. Decker-Walters and T. W. Walters

Department of Botany, University of Guelph, Guelph, Ontario, N1G 2W1, Canada

We employed starch gel electrophoresis to evaluate allozyme activity and variation in six genera in the tribe Benincaseae (Cucurbitaceae).

Germplasm accessions of the domesticated species, Benincasa hispida (Thunb.) Cogn. (winter-melon), Citrullus lanatus (Thunb.) Mats. & Nakai (watermelon), Lagenaria siceraria (Mol.) Standley (bottle gourd), Luffa acutangula (L.) Roxb. (ridged loofah), and Luffa cylindrica (L.) M. J. Roem. (smooth loofah), were obtained from commercial and private sources. Five and fifteen different cultivars of B. hispida and Lagenaria siceraria, respectively, were included in our experiments. The winter-melon cultivars represented the major morphological groupings in the species (2). One bottle gourd cultivar came directly from Niger, Africa, three were from Mexico, and three were from Taiwan. Germplasm representing wild Bryonia dioica Jacq. (bryony), Citrullus colocynthis (L.) Schrad., and Ecballium elaterium (L.) A. Richard (squirting-cucumber) was procured from the Botanical Gardens at Caen and Bordeaux, France. Selfs of C. lanatus, Lagenaria siceraria, and both species of Luffa aided genetic interpretation of enzyme banding patterns.

Cotyledons of young seedlings provided the electrophoretic sample. We assayed over 40 enzymes using a variety of gel buffer systems. Reasonable scoring was possible for about half of those, including aspartate aminotransferase (AAT), aconitase (ACO), acid phosphatase (ACP), adenylate kinase (ADK), catechol oxidase (CO), glutamate dehydrogenase (GDH), glucose-6-phosphate isomerase (GPI), glycerate dehydrogenase (G2D), glyceraldehyde-3-phosphate dehydrogenase (G3PDH), glucose-6-phosphate dehydrogenase (G6PDH), isocitrate dehydrogenase (IDH), leucine aminopeptidase (LAP), malate dehydrogenase (MDH), 'malic' enzyme (ME), menadione reductase (MNR), mannose-6-phosphate isomerase (MPI), peptidase (PEP), phosphogluconate dehydrogenase (PGD), phosphoglucomutase (PGM), and shikimate dehydrogenase (SKDH). Germination difficulties prevented the inclusion of the wild species in assays of AAT, CO, MNR, MPI, and PEP.

Most species displayed relatively little genetic variation. In spite of morphological diversity, allozyme variation in the winter-melon was limited to ADK, MDH, ME, and SKDH. Polymorphism within and among

cultivars of the bottle gourd was detected in ACO, ADK, G6PDH, LAP, ME, PGD, and SKDH. When African and Oriental accessions differed genetically, Mexican cultivars often exhibited both sets of alleles. Although little variation was observed in species of loofah, variation between them was detected in approximately 70% of the scorable enzyme systems. Allozyme variation within and between species of *Citrullus* was similar to that found in a previous study (1). In our study, ACO and GDH were additional variable enzymes. Bryony appeared to be the most genetically diverse species; polymorphism was detected in ACO, GDH, GPI, G2D, G3PDH, IDH, MDH, PGM, and SKDH. Variation in the squirting-cucumber could not be properly assessed since few individuals were tested.

Limited variability within species and similarity in band migration among genera provided reasonable justification for attempting generic comparisons. Enzyme systems in which bands from different genera comigrated and homology was assumed included AAT, ADK, CO, GPI, G2D, G3PDH, MDH, ME, MNR, MPI, PEP, PGD, and PGM. Figure 1 represents our interpretation of genetic relationships as revealed by these generic comparisons. Shorter lines represent a larger proportion of shared allozyme alleles. *Bryonia* and *Ecballium* are compared to each other and to the remaining group of genera as a whole.

#### Literature Cited

1. Navot, N., and D. Zamir. 1987. Isozyme and seed protein phylogeny of the genus *Citrullus* (Cucurbitaceae). *Plant Systematics and Evolution* 156:61-67.
2. Walters, T.W., and D.S. Decker-Walters. 1989. Systematic re-evaluation of *Benincasa hispida* (Cucurbitaceae). *Economic Botany* (in press).

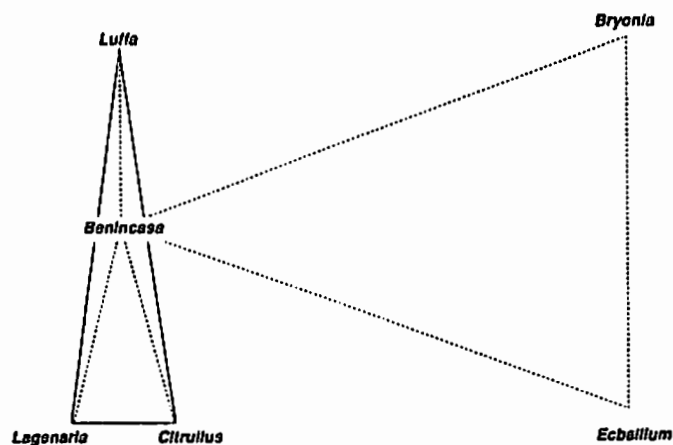


Figure 1. Allozyme relationships among genera in the Benincaseae.

Gene List for Cucumber

Lawrence K. Pierce and Todd C. Wehner

Agrigenetics, California, and Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609.

Lists of the known genes for the Cucurbitaceae have been published previously in HortScience and the report of the Cucurbit Genetics Cooperative. However, in the interest of updating and collecting the information on cucumber in one place, following is a complete list of the 105 known genes for *Cucumis sativus* L.

<u>Gene symbol</u>	<u>Preferred Synonym</u>	<u>Character</u>	<u>References</u>
a	-	<i>androecious</i> . Produces primarily staminate flowers if recessive for F. A from MSU 713-5 and Gy 14A; a from An-11 and An-314, 2 selections from 'E-e-szan' of China.	45
ap	-	<i>apetalous</i> . Male sterile. Anthers become sepal-like. Ap from 'Butchers Disease Resisting'; ap from 'Butchers Disease Resisting Mutant'.	29
Ar	-	<i>Anthracnose resistance</i> . One of several genes for resistance to <i>Colletotrichum lagenarium</i> . Ar from PI 175111, PI 175120, PI 179676, PI 183308, PI 183445; ar from 'Palmetto' and 'Santee'.	9
B	-	<i>Black or brown spines</i> . Dominant to white spines on fruit. B from 'Richard's Invincible', 'Nezhin', 'Muron' and 'Everyday'; b from 'White Spine', 'Vyaznikov', 'Berlizov' and 'Vickery'.	15, 31, 33, 36 86, 87, 95, 103
B-2	-	<i>Black spine-2</i> . Interacts with B to produce F <sub>2</sub> of 15 black : 1 white spine. B-2 from Wisc. 9362; b-2 from PI 212233 and 'Pixie'.	79
B-3	-	<i>Black spines-3</i> . Interacts with B-4 to produce an F <sub>2</sub> of 9 black : 7 white spine. B-3 from LJ 90430; b-3 from MSU 41.	17
B-4	-	<i>Black spine-4</i> . Interacts conversely of B-3. B-4 from LJ 90430; b-4 from MSU 41.	17
bi	-	<i>bitterfree</i> . All plant parts lacking cucurbitacins. Bi from a Dutch variety; bi from an 'Improved Long Green' selection.	6
bl	t	<i>blind</i> . Terminal bud lacking after temperature shock. Bl from 'Perseus' and inbred BDR; bl from 'Hunderup' and inbred HP3.	12
bla	-	<i>blunt leaf</i> . Leaves have obtuse apices and reduced lobing and serration. bla from a mutant of 'Wisc. SMR-18'.	66
Bt	-	<i>Bitter fruit</i> . Fruit with extreme bitter flavor. Bt from PI 173889 (Wild Hanzil Medicinal Cucumber); bt from 'Model', 'National' and 'Long Green'.	8
bu	-	<i>bush</i> . Shortened internodes. Bu from 'Wisc. SMR 12' and others; bu from 'KapAhk 1'.	64
Bw	-	<i>Bacterial wilt resistance</i> . Resistance to <i>Erwinia tracheiphila</i> . Bw from PI 200818; bw from 'Marketer'.	56, 73

<u>Gene symbol</u>		<u>Character</u>	<u>References</u>
<u>Preferred</u>	<u>Synonym</u>		
c	-	cream mature fruit color. Interaction with R is evident in the F <sub>2</sub> ratio of 9 red (R +) : 3 orange (R c) : 3 yellow (++) : 1 cream (+ c).	33
Cca	-	<i>Corynespora cassicola</i> resistance. Resistance to target leaf spot; dominant to susceptibility. Cca from Royal Sluis Hybrid 72502; cca from GY 3.	3
Ccu	-	<i>Cladosporium cucumerinum</i> resistance. Resistance to scab. Ccu from line 127.31, a selfed progeny of 'Longfellow'; ccu from 'Davis Perfect' and other selections.	2,4,5,7
cd	-	chlorophyll deficient. Seedling normal at first, later becoming light green; lethal unless grafted. Cd from normal progeny of the backcross of MSU 713-5 x 'Midget' to 'Midget'; cd from a mutant selection of the same source.	11
cl	-	closed flower. Male and female flowers do not open; male sterile (non-fertile pollen). cl from a Korean line.	30
cla	-	<i>Colletotrichum lagenarium</i> resistance. Resistance to race 1 of anthracnose; recessive to susceptibility. Cla from 'Wisc. SMR 18'; cla from SC 19B.	3
Cm	-	<i>Corynespora melonis</i> resistance. Resistance to <i>C. melonis</i> dominant to susceptibility. Cm from 'Spotvrie'; cm from 'Esvier'.	89
Cmv	-	Cucumber mosaic virus resistance. One of several genes for resistance to CMV. Cmv from 'Wisc. SMR 12', 'Wisc. SMR 15' and 'Wisc. SMR 18', which all get their resistance from 'Chinese Long' except 'Wisc. SMR 15' which also gets it from 'Tokyo Long Green'. cmv from 'National Pickling' and Wisc. SR 6.	84,93
co	-	green corolla. Green petals which turn white with age and enlarged reproductive organs; female sterile. co is from a selection of 'Extra Early Prolific'.	18,32
cor-1	-	cordate leaves-1. Leaves are cordate. cor-1 from 'Nezhinskii'.	28
cor-2	cor	cordate leaves-2. Leaves are nearly round with revolute margins and no serration. Insect pollination is hindered by short calyx segments which tightly clasp the corolla preventing full opening. cor-2 from an induced mutant of 'Lemon'.	67
cp	-	compact. Reduced internode length, poorly developed tendrils, small flowers. Cp from 'Chipper', Gy 3, 'Poinsett', 'Tablegreen 65' and PG 57; cp from PI 308916.	39
cr	-	crinkled leaf. Leaves and seed are crinkled.	57
cs	-	carpel splitting. Fruits develop deep longitudinal splits. Cs from Gy 14A; cs from TAMU 1043 and TAMU 72210 which are second and fifth generation selections of MSU 3249 x SC 25.	13,60
D	g	Dull fruit skin. Dull skin of American cultivars, dominant to glossy skin of most European cultivars. D from 'Vickery', 'Nezhin'; d from 'Everyday' and 'Galakhov'.	62,86,87

Gene symbol		Character	References
Preferred	Synonym		
de	I	<i>determinate habit</i> . Short vine with stem terminating in flowers; modified by <i>In-de</i> and other genes; degree of dominance depends on gene background. <i>De</i> from 'Stono', 'Straight Eight', 'SMR 58', MR 17, MR 25, 'Palmetto', 'Nappa', 'Highmoor', 'Burpee's Extra Early', 'Ashley', 'SMR 17', CU 54-467, CU 55-610, CU 56-388, 'Marketer' and 'Tokyo'; <i>de</i> from Penn 76.60G, Minn 158.60, 'Hardin's PG 57', 'Hardin's Tree Cucumber' and S2-1 (an inbred selection from Line 541).	20,26 33,56
df	-	<i>delayed flowering</i> . Flowering delayed by long photoperiod; associated with seed dormancy. <i>Df</i> from 'Marketer', Wisc. 1606, Wisc. 1909 and Wisc. 1548; <i>df</i> from 'Baroda' (PI 212896) and PI 215589 ( <i>C. hardwickii</i> ).	19,83
di	-	<i>Diabrotica resistance</i> . Resistance to the spotted and banded cucumber beetle. <i>di</i> from 'Eversweet'.	14
dl	-	<i>delayed growth</i> . Reduced growth rate; shortening of hypocotyl and first internodes. <i>Dl</i> from 'Marketer', 'Marketmore' and 'Tablegreen'; <i>dl</i> from 'Dwarf Marketmore' and 'Dwarf Tablegreen' both deriving dwarfness from 'Hardin's PG 57'.	49
dm	P	<i>downy mildew resistance</i> . One of several genes for resistance to <i>Pseudoperonospora cubensis</i> . <i>Dm</i> from Sluis & Groot Line 4285; <i>dm</i> from 'Poinsett'.	36,85,90
dvl	dl	<i>divided leaf</i> . True leaves are partly or fully divided, often resulting in compound leaves with 2 to 5 leaflets and having incised corollas. <i>Dvl</i> from 'Levo'; <i>dvl</i> from lot 318 and 319.	55
dw	-	<i>dwarf</i> . Short internodes. <i>dw</i> from an induced mutant of 'Lemon'.	70
Es-1	-	<i>Empty chambers-1</i> . Carpels of fruits separated from each other, leaving a small to large cavity in the seed cell. <i>Es-1</i> from PP-2-75; <i>es-1</i> from Gy-30-75.	48
Es-2	-	<i>Empty chambers-2</i> . Carpels of fruits separated from each other, leaving a small to large cavity in the seed cell. <i>Es-2</i> from PP-2-75; <i>es-2</i> from Gy-30-75.	48
F	Acr, acr <sup>F</sup> , D, st	<i>Female</i> . High degree of female sex expression; interacts with <i>a</i> and <i>M</i> ; strongly modified by environment and gene background. <i>F</i> and <i>f</i> are from the variety 'Japanese'.	25,42,43 62,82,87
fa	-	<i>fasciated</i> . Plants have flat stems, short internodes, and rugose leaves. <i>fa</i> was from a selection of 'White Lemon'.	65,81
Fba	-	<i>Flower bud abortion</i> . Preanthesis abortion of floral buds, ranging from 10 to 100%. <i>Fba</i> from MSU 713-5; <i>fba</i> from MSU 0612.	50
Foc	-	<i>Fusarium oxysporum f. sp. cucumerinum resistance</i> . Resistance to <i>Fusarium</i> wilt; dominant to susceptibility. <i>Foc</i> from Wisc. 248; <i>foc</i> from 'Shimshon'.	52
g	-	<i>golden leaves</i> . Golden color of lower leaves. <i>G</i> and <i>g</i> are both from different selections of 'Nezhin'.	87
gb	n	<i>gooseberry fruit</i> . Small, oval shaped fruits. <i>Gb</i> from 'Nezhin'; <i>gb</i> from the 'Klin mutant'.	87

<u>Gene symbol</u>	<u>Preferred Synonym</u>	<u>Character</u>	<u>References</u>
<i>gc</i>	-	<i>golden cotyledon</i> . Butter colored cotyledons; seedlings die after 6 to 7 days. <i>Gc</i> from 'Burpless Hybrid'; <i>gc</i> from a mutant of 'Burpless Hybrid'.	97
<i>gi</i>	-	<i>ginko</i> . Leaves reduced and distorted, resembling leaves of Ginkgo; male and female sterile. Complicated background: It was in a segregating population whose immediate ancestors were offspring of crosses and BC's involving 'National', 'Chinese Long', 'Tokyo Long Green', 'Vickery', 'Early Russian', 'Ohio 31' and an unnamed white spine slicer.	37
<i>gl</i>	-	<i>glabrous</i> . Foliage lacking trichomes; fruits without spines. <i>Gl</i> from 'Mayak 422' and 'Odnostebelnyi'; <i>gl</i> from NCSU 75 and M834-6.	35, 69
<i>glb</i>	-	<i>glabrate</i> . Stem and petioles glabrous, laminae slightly pubescent. <i>Glb</i> from a mutant of 'Burpless Hybrid'; <i>glb</i> from 'Burpless Hybrid'.	100
<i>gy</i>	-	<i>gynoecious</i> . Recessive gene for high degree of female sex expression. <i>Gy</i> and <i>gy</i> are both found in different selections (S10) made from 'Borszagowski'.	47
<i>H</i>	-	<i>Heavy netting of fruit</i> . Dominant to no netting and completely linked or pleiotropic with black spines ( <i>B</i> ) and red mature fruit color ( <i>R</i> ).	33, 87
<i>I</i>	-	<i>Intensifier of P</i> . Modifies effect of <i>P</i> on fruit warts in <i>Cucumis sativus</i> var. <i>tuberculatus</i> .	87
<i>In-de</i>	<i>In(de)</i>	<i>Intensifier of de</i> . Reduces internode length and branching of <i>de</i> plants. <i>In-de</i> and <i>in-de</i> are from different selections ((S5-1 & S5-6, respectively) from a determinant inbred S2-1 which is a selection of line 541.	26
<i>In-F</i>	<i>F</i>	<i>Intensifier of female sex expression</i> . Increases degree of female sex expression of <i>F</i> plants. <i>In-F</i> from monoecious line 18-1; <i>in-F</i> from MSU 713-5.	44
<i>l</i>	-	<i>locule number</i> . Many fruit locules and pentamerous androecium; 5 locules recessive to the normal number of 3.	103
<i>lh</i>	-	<i>long hypocotyl</i> . As much as a 3 fold increase in hypocotyl length. <i>Lh</i> from MSU 713-5; <i>lh</i> from a 'Lemon' mutant.	72
<i>ll</i>	-	<i>little leaf</i> . Normal sized fruits on plants with miniature leaves and smaller stems. <i>Ll</i> from Wisc. 2757; <i>ll</i> from 'Little John'.	27, 94
<i>ls</i>	-	<i>light sensitive</i> . Pale and smaller cotyledons, lethal at high light intensity. <i>Ls</i> from 'Burpless Hybrid'; <i>ls</i> from a mutant of 'Burpless Hybrid'.	99
<i>m</i>	<i>a, g</i>	<i>andromonoecious</i> . Plants are andromonoecious if ( <i>m</i> +); monoecious if (++) ; gynoecious if (+ <i>F</i> ) and hermaphroditic if ( <i>m F</i> ). <i>M</i> from 'Chicago Pickling' and 'Long Green'; <i>m</i> from 'Lemon'.	74, 82, 87, 91 103
<i>m-2</i>	<i>h</i>	<i>andromonoecious-2</i> . Bisexual flowers with normal ovaries.	34, 47
<i>mp</i>	<i>pf<sup>+</sup>, pfd, pFP</i>	<i>multi-pistillate</i> . Several pistillate flowers per node, recessive to single pistillate flower per node. <i>Mp</i> from Gy 14A and CU 551F; <i>mp</i> from MSU 604G and MSU 598G.	24, 51



<u>Gene symbol</u>	<u>Preferred Synonym</u>	<u>Character</u>	<u>References</u>
<i>Mp-2</i>	-	Multi-pistillate. Several pistillate flowers per node. Single dominant gene with several minor modifiers. <i>Mp-2</i> from MSU 3091-1; <i>mp-2</i> from Gy 3.	88
<i>ms-1</i>	-	male sterile-1. Male flowers abort before anthesis; partially female sterile. <i>ms-1</i> from 'Black Diamond' and 'A&C'.	71,81
<i>ms-2</i>	-	male sterile-2. Male sterile; pollen abortion occurs after first mitotic division of the pollen grain nucleus. <i>Ms-2</i> from 'Burpless Hybrid'; <i>ms-2</i> from a mutant of 'Burpless Hybrid'.	98
<i>n</i>	-	negative geotropic peduncle response. Pistillate flowers grow upright; recessive grow to pendant position of most cultivars.	58
<i>ns</i>	-	numerous spines. Few spines on the fruit is dominant to many. <i>Ns</i> from 'Spartan Salad', 'Wisc. SMR-18' and 'Gy 2 cp cp'; <i>ss</i> from 'Wisc. 2757'.	22,23
<i>O</i>	<i>y</i>	Orange-yellow corolla. Orange-yellow dominant to light yellow. <i>O</i> and <i>o</i> are both from 'Nezhin'.	87
<i>opp</i>	-	opposite leaf arrangement. Opposite leaf arrangement is recessive to alternate and has incomplete penetrance. <i>opp</i> from 'Lemon'.	68
<i>P</i>	-	Prominent tubercles. Prominent on yellow rind of <i>Cucumis sativus</i> var. <i>tuberculatus</i> , incompletely dominant to brown rind without tubercles. <i>P</i> from 'Klin'; <i>p</i> from 'Nezhin'.	87
<i>Pc</i>	<i>P</i>	Parthenocarpy. Sets fruit without pollination. <i>Pc</i> from 'Spotvrie'; <i>pc</i> from MSU 713-205.	59,61,96
<i>pl</i>	-	pale lethal. Slightly smaller pale green cotyledons; lethal after 6 to 7 days. <i>Pl</i> from 'Burpless Hybrid'; <i>pl</i> from a mutant of 'Burpless Hybrid'.	100
<i>pm-1</i>	-	powdery mildew resistance-1. Resistance to <i>Spherotheca fuliginia</i> . <i>pm-1</i> from 'Natsufushinari'.	31,40,80
<i>pm-2</i>	-	powdery mildew resistance-2. Resistance to <i>Spherotheca fuliginia</i> . <i>pm-2</i> from 'Natsufushinari'.	31,40,80
<i>pm-3</i>	-	powdery mildew resistance-3. Resistance to <i>Spherotheca fuliginia</i> . <i>pm-3</i> found in PI 200815 and PI 200818.	40,80
<i>pm-h</i>	<i>s,pm</i>	powdery mildew resistance expressed by the hypocotyl. Resistance to powdery mildew as noted by no fungal symptoms appearing on seedling cotyledons is recessive to susceptibility. <i>Pm-h</i> from 'Wisc. SMR-18'; <i>pm-h</i> from 'Gy 2 cp cp', 'Spartan Salad' and 'Wisc. 2757'.	22,80
<i>pr</i>	-	protruding ovary. Exserted carpels.	103
<i>psl</i>	<i>pl</i>	<i>Pseudomonas lachrymans</i> resistance. resistance to <i>Pseudomonas lachrymans</i> is recessive. <i>Psl</i> from 'National Pickling' and 'Wisc. SMR 18'; <i>psl</i> from MSU 9402 and Gy 14A.	1
<i>R</i>	-	Red mature fruit. Interacts with <i>c</i> ; linked or pleiotropic with <i>B</i> and <i>H</i> .	33
<i>rc</i>	-	revolute cotyledon. Cotyledons short, narrow and cupped downwards; enlarged perianth. <i>Rc</i> from 'Burpless Hybrid'; <i>rc</i> from 'Burpless Hybrid' mutant.	102
<i>ro</i>	-	rosette. Short internodes, muskmelon-like leaves. <i>ro</i> from 'Mergurk', the result of a cross involving a mix of cucumber and muskmelon pollen.	76

<u>Gene symbol</u>		<u>Character</u>	<u>References</u>
<u>Preferred</u>	<u>Synonym</u>		
s	f, a	spine size and frequency. Many small fruit spines, characteristic of European cultivars is recessive to the few large spines of most American cultivars. S from 'Vickery', 'Vyaznikov' and 'Berlizov'; s from 'Everyday', 'Nezhin' and 'Muron'.	13, 62 86, 87
s-2	-	spine-2. Acts in duplicate recessive epistatic fashion with s-3 to produce many small spines on the fruit. S-2 from Gy 14; s-2 from TAMU 72210.	13
s-3	-	spine-3. Acts in duplicate recessive epistatic fashion with s-2 to produce many small spines on the fruit. S-3 from Gy 14; s-3 from TAMU 72210.	13
sa	-	salt tolerance. Tolerance to high salt levels is attributable to a major gene in the homozygous recessive state and may be modified by several minor genes. Sa from PI 177361; sa from PI 192940.	38
sc	cm	stunted cotyledons. Small concavely curved cotyledons; stunted plants with cupped leaves; abnormal flowers. Wisc. 9594 and Wisc. 9597 were used as heterozygous parents.	77, 78
Sd	-	Sulfer dioxide resistance. Less than 20% leaf damage in growth chamber. Sd from 'National Pickling'; sd from 'Chipper'.	10
sp	-	short petiole. Leaf petioles of first nodes 20% the length of normal. sp from Russian mutant line 1753.	53
ss	-	small spines. Large, coarse fruit spines is dominant to small, fine fruit spines. Ss from 'Spartan Salad', 'Wisc. SMR-18' and 'Gy 2 cp cp'; ss from 'Wisc. 2757'.	22, 23
T	-	Tall plant. Tall height incompletely dominant to short height.	33
td	-	tendriless. Tendrils lacking; associated with misshapen ovaries and brittle leaves. Td from 'Model' and SC 8M ('Pixie'); td from a mutant of 'Southern Pickler'.	75
te	-	tender skin of fruit. Thin, tender skin of some European cultivars; recessive to thick tough skin of most American cultivars. Te from 'Vickery'; te from 'Everyday'.	62, 86
Tr	-	Trimonoecious. Producing male, bisexual and female flowers in this sequence during plant development. Tr from Tr-12, a selection of a Japanese variety belonging to the Fushinari group; tr from H-7-25, MOA-309, MOA-303 and AH-311-3.	46
Tu	-	Tuberculate fruit. Warty fruit characteristic of American cultivars is dominant to smooth, non-warty fruits characteristic of European cultivars. Tu from 'White Spine' and 'Vickery'; tu from 'Richard's Invincible' and 'Everyday'	5, 62 86, 95
u	M	uniform immature fruit color. Uniform color of European cultivars recessive to mottled or stippled color of most American cultivars. U from 'Vickery'; u from 'Everyday'.	5, 86
ul	-	umbrella leaf. Leaf margins turn down at low relative humidity making leaves look cupped. Source of ul unknown.	54

<u>Gene symbol</u>	<u>Preferred Synonym</u>	<u>Character</u>	<u>References</u>
v	-	virescent. Yellow leaves becoming green.	62,87
vvi	-	variegated virescent. Yellow cotyledons, becoming green; variegated leaves.	2
w	-	white immature fruit color. White is recessive to green. W from 'Vaughan', 'Clark's Special', 'Florida Pickle' and 'National Pickling'; w from 'Bangalore'.	15
wf	-	White flesh. Intense white flesh color is recessive to dingy white; acts with yf to produce F <sub>2</sub> of 12 white (++) and + wf) : 3 yellow (yf +) : 1 orange (yf wf). Wf from EG and G6, each being dingy white (++) : wf from NPI which is orange (yf wf).	41
Wmv	-	Watermelon mosaic virus resistance. Resistance to strain 2 of watermelon mosaic virus. Wmv from 'Kyoto 3 Feet'; wmv from 'Bet-Alfa'.	16
wmv-1-1	-	watermelon mosaic virus-1 resistance. Resistance to strain 1 of watermelon mosaic virus by limited systemic translocation; lower leaves may show severe symptoms. Wmv-1-1 from Wisc. 2757; wmv-1-1 from 'Surinam'.	92
yc-1	-	yellow cotyledons-1. Cotyledons yellow at first, later turning green. Yc-1 from Ohio M.R. No. 25; yc-1 from a mutant of Ohio M.R. No. 25.	1
yc-2	-	yellow cotyledons-2. Virescent cotyledons. Yc-2 from 'Burpless Hybrid'; yc-2 from a mutant of 'Burpless Hybrid'.	101,102
yf	v	yellow flesh. Interacts with wf to produce F <sub>2</sub> of 12 white (++) and + wf) : 3 yellow (yf +) : 1 orange (yf wf). Yf from 'Natsufushinari' which has an intense white flesh (Yf wf); yf from PI 200815 which has a yellow flesh (yf Wf).	41
yg	gr	yellow-green immature fruit color. Recessive to dark green and epistatic to light green.	103
yp	-	yellow plant. Light yellow green foliage; slow growth.	2
zymv	-	zucchini yellows mosaic virus. Inheritance is incomplete. Believed to be inherited in a recessive fashion with the source of resistance being 'TMG-1'.	63

#### Literature Cited

1. Aalders, L. E. 1959. 'Yellow Cotyledon', a new cucumber mutation. Can. J. Cyt. 1:10-12.
2. Abul-Hayja, Z., P. H. Williams. 1976. Inheritance of two seedling markers in cucumber. HortScience 11:145.
3. Abul-Hayja, Z., P. H. Williams and C. E. Peterson. 1978. Inheritance of resistance to anthracnose and target leaf spot in cucumbers. Plant Dis. Rptr. 62:43-45.
4. Abul-Hayja, Z., P. H. Williams and E. D. P. Whelan. 1975. Independence of scab and bacterial wilt resistance and ten seedling markers in cucumber. HortScience 10:423-424.

5. Andeweg, J. M. 1956. The breeding of scab-resistant frame cucumbers in the Netherlands. *Euphytica* 5:185-195.
6. Andeweg, J. M. and J. W. DeBruyn. 1959. Breeding non-bitter cucumbers. *Euphytica* 8:13-20.
7. Bailey, R. M. and I. M. Burgess. 1934. Breeding cucumbers resistant to scab. *Proc. Amer. Soc. Hort. Sci.* 32:474-476.
8. Barham, W. S. 1953. The inheritance of a bitter principle in cucumbers. *Proc. Amer. Soc. Hort. Sci.* 62:441-442.
9. Barnes, W. C. and W. M. Epps. 1952. Two types of anthracnose resistance in cucumbers. *Plant Dis. Rptr.* 36:479-480.
10. Bressen, R. A., L. LeCureux, L. G. Wilson, P. Filner and L. R. Baker. 1981. Inheritance of resistance to sulfur dioxide in cucumber. *HortScience* 16:332-333.
11. Burnham, M., S. C. Phatak and C. E. Peterson. 1966. Graft-aided inheritance study of a chlorophyll deficient cucumber. *Proc. Amer. Soc. Hort. Sci.* 89:386-389.
12. Carlsson, G. 1961. Studies of blind top shoot and its effect on the yield of greenhouse cucumbers. *Acta Agr. Scand.* 11:160-162.
13. Carruth, N. M. 1975. A genetic study of the inheritance of rupturing carpel in fruit of cucumber, *Cucumis sativus* L. Ph.D. Dis., Texas A&M Univ., College Station.
14. Chambliss, O. L. 1978. Cucumber beetle resistance in the Cucurbitaceae: Inheritance and breeding. *HortScience* 13:366 (Abstr.)
15. Cochran, F. D. 1938. Breeding cucumbers for resistance to downy mildew. *Proc. Amer. Soc. Hort. Sci.* 35:541-543.
16. Cohen, S., E. Gertman and N. Kedar. 1971. Inheritance of resistance to melon mosaic virus in cucumbers. *Phytopathology* 61:253-255.
17. Cowen, N. M. and D. B. Hesel. 1983. Inheritance of 2 genes for spine color and linkages in a cucumber cross. *J. Hered.* 74:308-310.
18. Currence, T. M. 1954. Vegetable crops breeding. Mimeographed teaching manual, Univ. Minn.
19. Della Vecchia, P. T., C. E. Peterson and J. E. Staub. 1982. Inheritance of short-day response to flowering in crosses between a *Cucumis sativus* var. *hardwickii* (R.) Alef. line and *Cucumis sativus* L. lines. *Cucurbit Genet. Coop. Rpt.* 5:4.
20. Denna, D. W. 1971. Expression of determinate habit in cucumbers. *J. Amer. Soc. Hort. Sci.* 96:277-279.

21. Dessert, J. M., L. R. Baker and J. F. Fobes. 1982. Inheritance of reaction to *Pseudomonas lachrymans* in pickling cucumber. *Euphytica* 31:847-856.
22. Fanourakis, N. E. 1984. Inheritance and linkage studies of the fruit epidermis structure and investigation of linkage relations of several traits and of meiosis in cucumber. Ph.D. Thesis. Univ. of Wisconsin, Madison.
23. Fanourakis, N. E. and P. W. Simon. 1987. Analysis of genetic linkage in the cucumber. *J. Hered.* 78:238-242.
24. Fujieda, K., V. Fujita, Y. Gunji and K. Takahashi. 1982. The inheritance of plural-pistillate flowering in cucumber. *J. Jap. Soc. Hort. Sci.* 51:172-176.
25. Galun, E. 1961. Study of the inheritance of sex expression in the cucumber. The interaction of major genes with modifying genetic and non-genetic factors. *Genetica* 32:134-163.
26. George, W. L., Jr. 1970. Genetic and environmental modification of determinant plant habit in cucumbers. *J. Amer. Soc. Hort. Sci.* 95:583-586.
27. Goode, M. J., J. L. Bowers and A. Bassi, Jr. 1980. Little-leaf, a new kind of pickling cucumber plant. *Ark. Farm Res.* 29:4.
28. Gornitskaya, I. P. 1967. A spontaneous mutant of cucumber variety Nezhinskii 12. *Genetika* 3(11):169.
29. Grimby, P. E. 1980. An apetalous male sterile mutant in cucumber. *Cucurbit Genet. Coop. Rpt.* 3:9.
30. Groff, D. and M. L. Odland. 1963. Inheritance of closed-flower in the cucumber. *J. Hered.* 54:191-192.
31. Hujieda, K. and R. Akiya. 1962. Genetic study of powdery mildew resistance and spine color on fruit in cucumber. *J. Jap. Soc. Hort. Sci.* 31:30-32.
32. Hutchins, A. E. 1935. The inheritance of a green flowered variation in *Cucumis sativus*. *Proc. Amer. Soc. Hort. Sci.* 33:513.
33. Hutchins, A. E. 1940. Inheritance in the cucumber. *J. Agr. Res.* 60:117-128.
34. Iezzoni, A. F., C. E. Peterson and G. E. Tolla. 1982. Genetic analysis of two perfect flowered mutants in cucumber. *J. Amer. Soc. Hort. Sci.* 107:678-681.
35. Inggamer, H. and O. M. B. de Ponti. 1980. The identity of genes for glabrousness in *Cucumis sativus* L. *Cucurbit. Genet. Coop. Rpt.* 3:14.
36. Jenkins, J. M., Jr. 1946. Studies on the inheritance of downy mildew resistance. *J. Hered.* 37:267-276.
37. John, C. A. and J. D. Wilson. 1952. A "ginko leafed" mutation in the cucumber. *J. Hered.* 43:47-48.
38. Jones, R. W. 1984. Studies related to genetic salt tolerance in the cucumber, *Cucumis sativus* L. Ph.D. Thesis Texas A&M Univ., College Station.

39. Kauffman, C. S. and R. L. Lower. 1976. Inheritance of an extreme dwarf plant type in the cucumber. *J. Amer. Soc. Hort. Sci.* 101:150-151.
40. Kooistra, E. 1968. Powdery mildew resistance in cucumber. *Euphytica* 17:236-244.
41. Kooistra, E. 1971. Inheritance of flesh and skin colors in powdery mildew resistant cucumbers (*Cucumis sativus* L.). *Euphytica* 20:521-523.
42. Kubicki, B. 1965. New possibilities of applying different sex types in cucumber breeding. *Genet. Polonica* 6:241-250.
43. Kubicki, B. 1969. Investigations of sex determination in cucumber (*Cucumis sativus* L.). IV. Multiple alleles of locus *Acr*. *Genet. Polonica* 10:23-68.
44. Kubicki, B. 1969. Investigations of sex determination in cucumber (*Cucumis sativus* L.). V. Genes controlling intensity of femaleness. *Genet. Polonica* 10:69-86.
45. Kubicki, B. 1969. Investigations on sex determination in cucumbers (*Cucumis sativus* L.). VI. Androecism. *Genet. Polonica* 10:87-99.
46. Kubicki, B. 1969. Investigations of sex determination in cucumber (*Cucumis sativus* L.). VII. Trimonoecism. *Genet. Polonica* 10:123-143.
47. Kubicki, B. 1974. New sex types in cucumber and their uses in breeding work. *Proc. XIX Intl. Hort. Congr.* 3:475-485.
48. Kubicki, B. and A. Korzeniewska. 1983. Inheritance of the presence of empty chambers in fruit as related to the other fruit characters in cucumbers (*Cucumis sativus* L.). *Genet. Polonica* 24:327-342.
49. Miller, G. A. and W. L. George, Jr. 1979. Inheritance of dwarf determinate growth habits in cucumber. *J. Amer. Soc. Hort. Sci.* 104:114-117.
50. Miller, J. C., Jr. and J. E. Quisenberry. 1978. Inheritance of flower bud abortion in cucumber. *HortScience* 13:44-45.
51. Nandgaonker, A. K. and L. R. Baker. 1981. Inheritance of multi-pistillate flowering habit in gynoecious pickling cucumber. *J. Amer. Soc. Hort. Sci.* 106:755-757.
52. Netzer, D., S. Niegro and F. Galun. 1977. A dominant gene conferring resistance to *Fusarium* wilt in cucumber. *Phytopathology* 67:525-527.
53. den Nijs, A. P. M. and I. W. Boukema. 1985. Short petiole, a useful seedling marker for genetic studies in cucumber. *Cucurbit Genet. Coop. Rpt.* 8:7-8.
54. den Nijs, A. P. M. and O. M. B. de Ponti. 1983. Umbrella leaf: a gene for sensitivity to low humidity in cucumber. *Cucurbit Genet. Coop. Rpt.* 6:24.
55. den Nijs, A. P. M. and H. O. Mackiewicz. 1980. "Divided leaf", a recessive seedling marker in cucumber. *Cucurbit Genet. Coop. Rpt.* 3:24.

56. Nuttall, W. W. and J. J. Jasmin. 1958. The inheritance of resistance to bacterial wilt (*Erwinia tracheiphila* [E. F. SM.] Holland) in cucumber. *Can. J. Plant Sci.* 38:401-404.
57. Odland, M. L. and D. W. Groff. 1963. Inheritance of crinkled-leaf cucumber. *Proc. Amer. Soc. Hort. Sci.* 83:536-537.
58. Odland, M. L. and D. W. Groff. 1963. Linkage of vine type and geotropic response with sex forms in cucumber *Cucumis sativus* L. *Proc. Amer. Soc. Hort. Sci.* 82:358-369.
59. Pike, L. M. and C. E. Peterson. 1969. Inheritance of parthenocarpy in the cucumber (*Cucumis sativus* L.). *Euphytica* 18:101-105.
60. Pike L. M. and T. F. Carruth. 1977. A genetic study of the inheritance of rupturing carpel in fruit of cucumber, *Cucumis sativus* L. *HortScience* 12:235 (Abstr.).
61. de Ponti, O. M. and F. Garretsen. 1976. Inheritance of parthenocarpy in pickling cucumbers (*Cucumis sativus* L.) and linkage with other characters. *Euphytica* 25:633-642.
62. Poole, C. F. 1944. Genetics of cultivated cucurbits. *J. Hered.* 35:122-128.
63. Provvidenti, R. 1985. Sources of resistance to viruses in two accessions of *Cucumis sativus*. *Cucurbit Genet. Coop. Rpt.* 8:12.
64. Pyzenkov, V. I. and G. A. Kosareva. 1981. A spontaneous mutant of the dwarf type. *Bull. Appl. Bot. Pl. Breeding* 69:15-21.
65. Robinson, R. W. 1978. Fasciation in the cucumber. *Cucurbit Genet. Coop. Rpt.* 1:11a.
66. Robinson, R. W. 1987. Blunt leaf apex, a cucumber mutant induced by a chemical mutagen. *Cucurbit Genet. Coop. Rpt.* 10:6.
67. Robinson, R. W. 1987. Cordate, a leaf shape gene with pleiotropic effects on flower structure and insect pollination. *Cucurbit Genet. Coop. Rpt.* 10:8.
68. Robinson, R. W. 1987. Inheritance of opposite leaf arrangement in *Cucumis sativus* L. *Cucurbit Genet. Coop. Rpt.* 10:10.
69. Robinson, R. W. and W. Mishanec. 1964. A radiation-induced seedling marker gene for cucumbers. *Veg. Improv. Newsl.* 6:2.
70. Robinson, R. W. and W. Mishanec. 1965. A new dwarf cucumber. *Veg. Improv. Newsl.* 7:23.
71. Robinson, R. W. and W. Mishanec. 1967. Male sterility in the cucumber. *Veg. Improv. Newsl.* 9:2.
72. Robinson, R. W. and J. W. Shail. 1981. A cucumber mutant with increased hypocotyl and internode length. *Cucurbit Genet. Coop. Rpt.* 4:19-20.

73. Robinson, R. W. and T. W. Whitaker. 1974. Cucumis In: R. C. King (ed), Handbook of Genetics. Vol. 2. Plenum Press, NY.
74. Rosa, J. T. 1928. The inheritance of flower types in *Cucumis* and *Citrullis*. Hilgardia 3:233-250.
75. Rowe, J. T. and J. L. Bowers. 1965. The inheritance and potential of an irradiation induced tendrillless character in cucumbers. Proc. Amer. Soc. Hort. Sci. 86:436-441.
76. de Ruiter, A. C., B. J. van der Knap and R. W. Robinson. 1980. Rosette, a spontaneous cucumber mutant arising from cucumber-muskmelon pollen. Cucurbit Genet. Coop. Rpt. 3:4.
77. Shanmugasundaram, S. and P. H. Williams. 1971. A Cotyledon marker gene in cucumbers. Veg. Improv. Newsl. 13:4.
78. Shanmugasundaram, S., P. H. Williams and C. E. Peterson. 1971. A recessive cotyledon marker gene in cucumber with pleiotropic effects. HortScience 7:555-556.
79. Shanmugasundaram, S., P. H. Williams and C. E. Peterson. 1971. Inheritance of fruit spine color in cucumber. HortScience 6:213-214.
80. Shanmugasundaram, S., P. H. Williams and C. E. Peterson. 1971. Inheritance of resistance to powdery mildew in cucumber. Phytopathology 61:1218-1221.
81. Shifriss, O. 1950. Spontaneous mutations in the American varieties of *Cucumis sativus* L. Proc. Amer. Soc. Hort. Sci. 55:351-357.
82. Shifriss, O. 1961. Sex control in cucumbers. J. Hered. 52:5-12.
83. Shifriss, O. and W. L. George, Jr. 1965. Delayed germination and flowering in cucumbers. Nature 506:424-425.
84. Shifriss, O., C. H. Myers and C. Chupp. 1942. Resistance to mosaic virus in cucumber. Phytopathology 32:773-784.
85. Shimizu, S., K. Kanazawa and A. Kato. 1963. Studies on the breeding of cucumber for resistance to Downy Mildew. Part 2. Difference of resistance to Downy mildew among the cucumber varieties and the utility of the cucumber variety resistance to Downy Mildew. Bul. Hort. Res. Sta. Japan. Ser. A No.2:80-81.
86. Strong, W. J. 1931. Breeding experiments with the cucumber (*Cucumis sativus* L.). Sci. Agr. 11:333-346.
87. Tkachenko, N. N. 1935. Preliminary results of a genetic investigation of the cucumber, *Cucumis sativus* L. Bul. Appl. Pl. Breeding, Ser. 2, 9:311-356.
88. Thaxton, P. M. 1974. A genetic study of the clustering characteristic of pistillate flowers in the cucumber, *Cucumis sativus* L. M.S. Thesis, Texas A&M Univ., College Station.



89. van Es, J. 1958. Bladruuresistantie by Konkommers. Zaabelangen 12:116-117.
90. van Vliet, G. J. A. and W. D. Meysing. 1974. Inheritance of resistance to *Pseudoperonospora cubensis* Rost. in cucumber (*Cucumis sativus* L.). Euphytica 23:251-255.
91. Wall, J. R. 1967. Correlated inheritance of sex expression and fruit shape in *Cucumis*. Euphytica 23:251-255.
92. Wang, Y. J., R. Provvidenti and R. W. Robinson. 1984. Inheritance of resistance in cucumber to watermelon mosaic virus. Phytopathology 51:423-428.
93. Wasuwat, S. L. and J. C. Walker. 1961. Inheritance of resistance in cucumber to cucumber mosaic virus. Phytopathology 51:423-428.
94. Wehner, T. C., J. E. Staub and C. E. Peterson. 1987. Inheritance of LittleLeaf and multi-branched plant type in cucumber. Cucurbit Genet. Coop. Rept. 10:33.
95. Wellington, R. 1913. Mendellian inheritance of epidermal characters in the fruit of *Cucumis sativus*. Science 38:61.
96. Wellington, R. and L. R. Hawthorn. 1928. A parthenocarpic hybrid derived from a cross between and English forcing cucumber and the Arlington White Spine. Proc. Amer. Soc. Hort. Sci. 25:97-100.
97. Whelan, E. D. P. 1971. Golden cotyledon: a radiation-induced mutant in cucumber. HortScience 6:343.
98. Whelan, E. D. P. 1972. A cytogenetic study of a radiation-induced male sterile mutant of cucumber. J. Amer. Soc. Hort. Sci. 97:506-509.
99. Whelan, E. D. P. 1972. Inheritance of a radiation-induced light sensitive mutant of cucumber. J. Amer. Soc. Hort. Sci. 97:765-767.
100. Whelan, E. D. P. 1973. Inheritance and linkage relationship of two radiation-induced seedling mutants of cucumber. Can. J. Genet. Cyt. 15:597-603.
101. Whelan, E. D. P. and B. B. Chubey. 1973. Chlorophyll content of new cotyledon mutants of cucumber. HortScience 10:267-269.
102. Whelan, E. D. P., P. H. Williams and A. Abul-Hayja. 1975. The inheritance of two induced cotyledon mutants of cucumber. HortScience 10:267-269.
103. Younger, V. B. 1952. A study of the inheritance of several characters in the cucumber. Ph.D. Thesis, Univ. of Minnesota, St. Paul.
104. Zijlstra, S. 1987. Further linkage studies in *Cucumis sativus* L. Cucurbit Genet. Coop. Rpt. 10:39.

**CUCURBIT GENETICS COOPERATIVE REPORT  
CUMULATIVE INDEX  
REPORTS 1-11 INCLUSIVE (1978-88)**

The CGC index was generated from two major categories of key phrases: [1] commodity (or scientific name), and [2] subject area. Each paper appearing in CGC Reports 1-11 has been cross-indexed under one or more subjects. The citation number in **boldface** refers to the CGC Report Number; the number following the colon refers to the page number for that particular Report.

T. Ng, CGC Chair

<b>cucumber (<i>Cucumis sativus</i>)</b>		
"divided leaf" recessive seedling marker	3:024	improving tetraploid fertility
"umbrella leaf" sensitivity to humidity	6:024	in vitro adventitious bud formation
a revision on controlled pollination	11:008	in vitro propagation
adventitious bud formation in vitro	2:002	inbreds via full-sib family selection
allelism tests with glabrous mutants	10:007	inbreeding & seed traits of compact type
apetalous male sterile mutant	3:009	inbreeding by full-sib family selection
AVG-induced staminate flowers	3:022	inbreeding effects on family performance
bacterial wilt resistance & sex	2:008	independence of gl and yc
blunt leaf apex, an induced mutation	10:006	induced chlorosis in glabrous types
border row competition effects on yield	6:038	induced male flowers in gynoecious lines
<i>C. hardwickii</i> as a germplasm source	1:005	inheritance of opposite leaf arrangement
callus & somatic embryos	11:001	inheritance of short-day response
callus initiation from fruit	9:003	interaction of cucurbitacin genes
chlorlurenol, seed coats & parthenocarpy	7:012	intermediary inheritance of glabrousness
cluster analysis of trial environments	11:013	interspecific cross with muskmelon
compact & vining isoline yields	5:006	interspecific grafting with <i>C. hardwickii</i>
cordate leaf gene effects	10:008	isozyme analysis of the megurk
determinate locus & lateral branching	7:003	isozyme polymorphisms
development of tropical gynoecious lines	11:017	lack of chilling resistance
early generation testing	7:019	lateral pollen tube growth in ovary
embryogenesis from cotyledon callus	11:003	leaf area prediction for field plants
end border effects on plot yield	7:031	leaf galactinol synthase activity
estimating genetic variance & covariance	8:026	leaf peroxidase & anthracnose resistance
ethylene and hermaphroditism	4:008	leafminer resistance screening
evaluation of fruit quality	11:025	linkage in 'Lemon' cucumber
factors affecting length/diameter ratio	8:029	linkage of male sterility & sex
fasciation	1:011	linkage of powdery mildew genes
fasciation & opposite leaf arrangement	11:019	linkage of WMV-1 resistance
fermentation & storage on germination	4:013	littleleaf and multi-branched types
fertilizer & seedling test for gynoecey	9:051	longevity of seed
fruit shape and sex expression	1:010	low temperature adaptation
fruit size effect on quality	3:015	low temperature seed germination
further linkage studies	10:039	low-temperature germination ability
further results of linkage studies	9:055	mapping the cucumber genome
fusarium wilt resistance	1:003	maternal & embryonic control of seed
genes for glabrousness	3:014	measuring foliar diseases
germplasm resources from Spain	9:010	morphological and anatomical comparisons
Giemsa C-banding procedure	8:013	multiple-harvest vs. once-over yield
glabrous trait and whitefly control	2:005	mutagenic experiments
grafting and fruit set	3:017	near-isogenic lines of several varieties
greenhouse & field fruit set	10:002	non-bitter resistance to <i>T. urticae</i>
growth analysis for plant habit and yield	7:017	non-bitterness source
GxE interaction for yield	10:025	non-destructive leaf area measurement
gynoecey stability & silver thiosulfate	10:018	optimum plot size for once-over harvest
heat unit summation & harvest prediction	8:009	partial dominance to powder mildew
heritability of fruit number	3:010	pathogenicity of <i>Didymella bryoniae</i>
heterosis estimates w/gynoeceous inbred	3:020	perfect-flowered mutants
homo- & heterogeneous population yields	7:033	performance of types for fresh-market
hypocotyl & internode length mutant	4:019	photosynthetic rate & chlorophyll
imposed stress & sex expression	10:013	plant density & multiple-harvest yield
improvement for increased fruit yield	6:018	plant form and pickleworm infestation
improvement for increased fruit yield	7:009	pleiotropic effects of glabrous gene
improving powdery mildew resistance	11:022	plot allocations for once-over harvest
		pollen receptivity of stigmatic areas

## CGC CUMULATIVE INDEX

### Reports 1-11 Inclusive (1978-88)

<p>pot size effect on growth &amp; flowering ..... 9:047</p> <p>powdery mildew and leafspot resistance ..... 10:001</p> <p>powdery mildew resistance ..... 2:010</p> <p>principal component analysis ..... 9:027</p> <p>recording comments while collecting data ..... 8:031</p> <p>regeneration &amp; flowers from excised seed ..... 11:005</p> <p>resistance to <i>Didymella bryoniae</i> ..... 4:006</p> <p>resistance to <i>Rhizoctonia damping-off</i> ..... 9:005</p> <p>resistance to the pickleworm ..... 6:035</p> <p><i>Rhizoctonia</i> fruit rot resistance ..... 1:004</p> <p><i>Rhizoctonia</i> fruit rot resistance ..... 7:025</p> <p>rooting cuttings w/poor water quality ..... 9:012</p> <p>rosette mutant from mentor pollination ..... 3:004</p> <p>screening for belly rot resistance ..... 6:029</p> <p>screening for pickleworm resistance ..... 1:016</p> <p>season-location combinations &amp; yield ..... 10:027</p> <p>second long hypocotyl mutant at lh locus ..... 6:013</p> <p>seed characteristics of compact plants ..... 4:002</p> <p>seed number per mature fruit ..... 11:015</p> <p>seed quality from compact plants ..... 4:004</p> <p>seedling test for <i>Rhizoctonia</i> resistance ..... 10:031</p> <p>segregation of determinate (<i>de</i>) allele ..... 8:002</p> <p>sex type, growth habit &amp; fruit length ..... 5:012</p> <p>shoot tip growth on 9 N sources in vitro ..... 5:010</p> <p>short petiole, a useful seedling marker ..... 8:007</p> <p>short-day treatment and flowering ..... 5:002</p> <p>silver nitrate &amp; GA on gynoecey ..... 1:008</p> <p>silver nitrate &amp; gynoeceious cuttings ..... 7:006</p> <p>single-plant vs. multiple harvest yield ..... 5:014</p> <p>sources of resistance for <i>Rhizoctonia</i> ..... 7:023</p> <p>sources of virus resistance ..... 8:012</p> <p>spacing &amp; yield of hardwickii derivatives ..... 6:003</p> <p>spontaneous mutation ..... 1:015</p> <p>survey of breeding methods in the USA ..... 11:009</p> <p>temperature &amp; powdery mildew resistance ..... 2:009</p> <p>tests for fruit rot resistance ..... 9:041</p> <p>tissue culture propagation ..... 4:020</p> <p>twospotted spider mite resistance ..... 2:006</p> <p><i>Ulocladium cucurbitae</i> leafspot ..... 6:014</p> <p>update of gene list ..... 8:086</p> <p>variation for fruit soluble solids ..... 10:009</p> <p>vegetative phase &amp; partitioning ..... 7:014</p> <p>weighted selection indices ..... 5:018</p> <p>white spine effects on skin and fruit ..... 3:006</p> <p>yield evaluation of inbred lines ..... 8:018</p> <p><b>Cucumis spp.</b></p> <p>apomictic propagation of <i>C. ficifolius</i> ..... 10:035</p> <p><i>C. anguria</i> as a vegetable in Brazil ..... 8:081</p> <p>collection at the IVT ..... 3:068</p> <p>composition of nuclear DNA ..... 10:004</p> <p>cross of <i>C. anguria</i> &amp; <i>C. zeyheri</i> ..... 6:100</p> <p>cross with <i>C. africanus</i> &amp; <i>C. metuliferus</i> ..... 3:050</p> <p>cross with <i>C. africanus</i> &amp; <i>C. metuliferus</i> ..... 3:060</p> <p>cross with <i>C. africanus</i> &amp; <i>C. metuliferus</i> ..... 4:050</p>	<p>disease resistance in wild species ..... 2:044</p> <p>dormancy ..... 1:036</p> <p>electrophoretic comparison of six species ..... 7:027</p> <p>electrophoretic variation w/ wild species ..... 8:022</p> <p>embryo culture ..... 3:034</p> <p>embryo size in <i>C. sativus</i> x <i>C. melo</i> ..... 7:094</p> <p>embryo stage and in vitro culture ..... 4:048</p> <p>green mottle mosaic virus resistance ..... 5:057</p> <p>identification of <i>Cucumis</i> taxa ..... 3:055</p> <p>in vitro culture for seed germination ..... 2:046</p> <p>in vitro culture of <i>C. zeyheri</i> embryos ..... 5:054</p> <p>interspecific crosses ..... 1:039</p> <p>interspecific crosses with <i>C. africanus</i> ..... 4:058</p> <p>interspecific hybridization ..... 1:040</p> <p>isozyme electrophoresis ..... 1:039</p> <p>karyo-morphology of <i>C. callosus</i> ..... 3:063</p> <p>malate dehydrogenase in African species ..... 9:018</p> <p>mentor pollen and interspecific hybrids ..... 2:043</p> <p>mentor pollen in an interspecific cross ..... 6:094</p> <p>monogenic andromonoecy in tetraploid ..... 7:100</p> <p>nuclear DNA variation ..... 7:097</p> <p>pollen mother cell meiosis in a haploid ..... 10:037</p> <p>pollen resistance to gamma irradiation ..... 8:082</p> <p>pollen tube growth w/interspecific cross ..... 3:052</p> <p>rectifying accession names at IVT ..... 5:059</p> <p>regeneration from explant-derived calli ..... 9:108</p> <p>resistance to downy mildew and scab ..... 10:021</p> <p>response to 3 <i>Meloidogyne</i> spp. .... 4:053</p> <p>species crosses w/controlled conditions ..... 4:056</p> <p>taxonomy of <i>C. callosus</i> (wild melon) ..... 3:066</p> <p>taxonomy of <i>Dosakaya</i> (acid melon) ..... 3:064</p> <p>white fly resistance ..... 1:038</p> <p><b>Cucurbita spp.</b></p> <p>age &amp; plant part effects on cucurbitacins ..... 8:071</p> <p>age and seed explant organogenesis ..... 9:093</p> <p>anther and ovule culture ..... 10:092</p> <p>attempted cross w/<i>C. moschata</i> and <i>C. pepo</i> ..... 2:032</p> <p>beetle control with bitter fruit baits ..... 6:079</p> <p>bitter hybrids as <i>Diabrotica</i> baits ..... 3:044</p> <p>bitter substances attract <i>Diabrotica</i> ..... 2:038</p> <p>bitterness &amp; corn rootworm beetle control ..... 4:037</p> <p>blossom aroma and <i>Diabrotica</i> attraction ..... 11:076</p> <p>breeding CMV resistant <i>C. pepo</i> ..... 6:082</p> <p>breeding for CMV resistance ..... 8:074</p> <p><i>C. fraterna</i>, progenitor of <i>C. pepo</i> ..... 10:069</p> <p><i>C. martinezii</i> versus <i>C. okeechobeensis</i> ..... 3:045</p> <p><i>C. moschata</i> planted at four latitudes ..... 9:102</p> <p>chloroplast DNA &amp; phylogenetic analysis ..... 7:066</p> <p>coadaptation of gene B ..... 4:044</p> <p>collection of Zambian cucurbit germplasm ..... 7:089</p> <p>compact mutations induced by EMS ..... 1:034</p> <p>compatibility in an interspecific cross ..... 10:088</p> <p>cross of <i>C. pepo</i> and <i>C. martinezii</i> ..... 2:035</p> <p>crossing <i>C. pepo</i> &amp; <i>C. ecuadorensis</i> ..... 3:042</p>
---	---

# CGC CUMULATIVE INDEX

## Reports 1-11 Inclusive (1978-88)

cucurbitacin baits to control <i>Diabrotica</i> .....	11:079	resistance to trifluralin toxicity .....	4:035
cucurbitacin poisonings in humans .....	6:073	response to 3 <i>Meloidogyne</i> spp. ....	4:053
cucurbitacins & <i>Diabrotica</i> attack .....	5:042	seed coats in normal & hull-less pumpkin .....	5:051
cultivar sensitivity to ethephon .....	8:067	seed increase of Mexican collection .....	4:036
derivatives of 'Fordhook Zucchini' .....	4:034	seed size & vegetative growth of squash .....	10:078
downy mildew resistance .....	10:087	seedling test for <i>P. capsici</i> resistance .....	9:088
electrophoretic analysis of pollen .....	2:039	sex expression & ethephon response .....	1:033
electrophoretic cultivar classification .....	10:083	sex expression in <i>C. foetidissima</i> .....	2:036
embryo culture of two species .....	7:069	silvery leaves & virus infection .....	4:042
embryos & plants from unfertilized ovules .....	8:066	silvery-leaf trait .....	7:081
environmental effects on pollen longevity .....	6:091	silvery-leaf trait in <i>C. pepo</i> .....	5:048
epidemics of ZYMV and other viruses .....	7:078	sources of virus resistance in <i>C. maxima</i> .....	5:046
esterase/peroxidase w/interspecific cross .....	1:029	spectra of silvery and non-silvery leaves .....	6:089
fruit color & large fruit in <i>C. moschata</i> .....	10:091	spotting of <i>C. pepo</i> fruits .....	6:087
fruit color in BwB+ <i>C. pepo</i> plants .....	10:100	squash & honey bees as pollinators .....	3:048
fruit color with interspecific cross .....	10:090	squash breeding .....	10:093
fruit skin color in <i>C. moschata</i> .....	10:084	stigmatic lobe pollination .....	3:048
fruit thinning & dry matter accumulation .....	6:072	systematics of the melon-squash .....	3:047
GA-improved seed germination .....	3:043	taxonomy and rarity of <i>C. okeechobeensis</i> .....	11:083
gene flow w/ <i>C. mixta</i> and wild <i>Cucurbita</i> .....	7:076	TLC and HPLC tests for cucurbitacins .....	8:069
germplasm resources from Spain .....	11:086	tolerance to squash leaf curl .....	7:071
green corolla mutant .....	10:103	trisomic identification of linkage groups .....	7:096
gynoecey in an interspecific cross .....	1:031	update of gene list .....	11:096
high-female lines w/interspecific crosses .....	8:078	variation in an interspecific cross .....	10:085
hybridization of <i>C. foetidissima</i> .....	10:072	versatility of feral buffalo gourd .....	1:025
improving seed yield in hull-less <i>C. pepo</i> .....	11:072	virus studies with <i>C. foetidissima</i> .....	4:041
independence of Ses-B and M in <i>C. pepo</i> .....	7:064	white cotyledons in <i>C. pepo</i> .....	5:039
inheritance of bitterness in <i>C. pepo</i> .....	10:076	zucchini yellow mosaic virus in USA .....	7:080
inheritance of bush habit in <i>C. pepo</i> .....	11:070	zucchini yellow mosaic virus in USA .....	9:096
insect associations in Illinois .....	1:030	ZYMV resistance in <i>C. moschata</i> .....	10:080
intense bitterness in zucchini .....	6:075	ZYMV resistance in interspecific cross .....	11:074
internode length in <i>C. pepo</i> x <i>C. moschata</i> .....	9:091		
interspecific hybridization of <i>C. pepo</i> .....	6:092	<b>cucurbitacins</b>	
interspecific trisomics .....	2:037	cucumber, interaction of cucurbitacin genes .....	11:023
isozyme electrophoretic analysis .....	1:028	cucumber, non-bitter resistance to <i>T. urticae</i> .....	6:027
isozyme linkage with WMV2 resistance .....	7:086	cucumber, non-bitterness source .....	4:011
isozyme variants in <i>C. pepo</i> .....	9:104	<i>Cucurbita</i> spp., age & plant part effects on cucurbitacins .....	8:071
isozymes indicate ancient tetraploid .....	7:084	<i>Cucurbita</i> spp., beetle control with bitter fruit baits .....	6:079
lack of seed transmission of ZYMV .....	10:081	<i>Cucurbita</i> spp., bitter hybrids as <i>Diabrotica</i> baits .....	3:044
lack of ZYMV resistance in <i>C. maxima</i> .....	8:076	<i>Cucurbita</i> spp., bitter substances attract <i>Diabrotica</i> .....	2:038
light & fruit affect internode elongation .....	2:040	<i>Cucurbita</i> spp., bitterness & corn rootworm beetle control ..	4:037
multiple virus resistance .....	1:026	<i>Cucurbita</i> spp., Cucurbitacin baits to control <i>Diabrotica</i> ....	11:079
natural and induced mutations .....	1:035	<i>Cucurbita</i> spp., cucurbitacin poisonings in humans .....	6:073
natural hybridization of <i>C. scabridifolia</i> .....	10:074	<i>Cucurbita</i> spp., cucurbitacins & <i>Diabrotica</i> attack .....	5:042
natural hybrids of <i>C. sororia</i> & <i>C. mixta</i> .....	7:073	<i>Cucurbita</i> spp., inheritance of bitterness in <i>C. pepo</i> .....	10:076
non-destructive seed fatty acid analysis .....	4:036	<i>Cucurbita</i> spp., intense bitterness in zucchini .....	6:075
non-genetic variability of calabaza color .....	9:100	<i>Cucurbita</i> spp., TLC and HPLC tests for cucurbitacins .....	8:069
nuclear gene & plastid-specific aldolase .....	7:088		
overcoming silvering disorder .....	6:070	<b>cucurbits (general)</b>	
overview - the <i>Cucurbita</i> spp. ....	6:077	anthracnose resistance in cucurbits .....	6:066
parthenocarpic and normal fruit growth .....	6:084	cold tolerance in the Cucurbitaceae .....	10:104
parthenocarpic fruit set in zucchini .....	5:044	cucurbit germplasm collections from China .....	11:093
productivity of bush & vine winter squash .....	5:040	electronic clipboard for field data .....	9:037
regreening of <i>C. pepo</i> fruits .....	6:086	gene nomenclature for the Cucurbitaceae .....	1:042
relationship between B genes of 2 species .....	9:097	occurrence of ZYM virus in the U.S. ....	6:099

# CGC CUMULATIVE INDEX

## Reports 1-11 Inclusive (1978-88)

pathogenicity of <i>Erysiphe cichoracearum</i> .....	11:087	muskmelon, evaluating downy mildew resistance .....	7:038
root knot nematode resistance .....	6:096	muskmelon, fusarium wilt screening with peat pellets .....	6:043
salinity responses among wild cucurbits .....	11:091	muskmelon, gummy stem blight resistant breeding line ....	8:046
seedling nematode-test reliability .....	7:092	muskmelon, inheritance of downy mildew resistance .....	8:036
<b>cultural practices</b>		muskmelon, inoculation conditions for <i>Alternaria</i> .....	7:055
cucumber, fertilizer & seedling test for gynocy .....	9:051	muskmelon, <i>M. roridum</i> effects on seeds & seedlings .....	8:044
cucumber, plant density & multiple-harvest yield .....	10:029	muskmelon, monitoring powdery mildew races .....	7:058
muskmelon, improving fruit set by hand pollination .....	2:022	muskmelon, multiple disease-resistant casaba .....	4:024
watermelon, culture and yield with tetraploids .....	6:059	muskmelon, reaction to powdery mildew in Israel .....	11:047
<b>cytogenetics</b>		muskmelon, recessive powdery mildew resistance .....	7:045
cucumber, Giemsa C-banding procedure .....	8:013	muskmelon, resistance to three pests .....	1:019
<i>Cucumis</i> spp., karyo-morphology of <i>C. callosus</i> .....	3:063	muskmelon, screening for <i>Myrothecium</i> resistance .....	9:058
<i>Cucumis</i> spp., pollen mother cell meiosis in a haploid ....	10:037	muskmelon, sources of sudden wilt resistance .....	6:049
<i>Cucurbita</i> spp., interspecific trisomics .....	2:037	watermelon, anthracnose resistance and pale leaf .....	2:029
muskmelon, B-chromosome variation .....	8:055	watermelon, cultivar interaction w/ <i>Fusarium oxysporum</i> ....	8:062
muskmelon, chiasma frequency in different sex forms ....	6:054	watermelon, hypersensitivity to anthracnose infection .....	4:032
watermelon, evidence for a tetrasomic line .....	11:057	watermelon, new disease in Tunisia .....	4:030
watermelon, seedlessness via reciprocal translocation ....	11:060	watermelon, resistance to <i>M. citrullina</i> .....	1:024
<b>disease (bacteria)</b>		watermelon, seedling fusarium wilt resistance .....	11:068
cucumber, bacterial wilt resistance & sex .....	2:008	watermelon, single gene for anthracnose resistance? .....	11:064
muskmelon, response to bacterial wilt .....	5:026	watermelon, susceptibility to anthracnose .....	6:062
watermelon, bacterial rind necrosis in North Carolina .....	5:036	<b>disease (viruses)</b>	
<b>disease (fungi)</b>		cucumber, linkage of WMV-1 resistance .....	10:024
cucumber, fusarium wilt resistance .....	1:003	cucumber, sources of virus resistance .....	8:012
cucumber, improving powdery mildew resistance .....	11:022	<i>Cucumis</i> spp., green mottle mosaic virus resistance .....	5:057
cucumber, leaf peroxidase & anthracnose resistance .....	11:020	<i>Cucurbita</i> spp., breeding CMV resistant <i>C. pepo</i> .....	6:082
cucumber, linkage of powdery mildew genes .....	1:011	<i>Cucurbita</i> spp., breeding for CMV resistance .....	8:074
cucumber, measuring foliar diseases .....	6:010	<i>Cucurbita</i> spp., epidemics of ZYMV and other viruses ....	7:078
cucumber, partial dominance to powder mildew .....	6:007	<i>Cucurbita</i> spp., isozyme linkage with WMV2 resistance ....	7:086
cucumber, pathogenicity of <i>Didymella bryoniae</i> .....	4:017	<i>Cucurbita</i> spp., lack of seed transmission of ZYMV .....	10:081
cucumber, powdery mildew and leafspot resistance .....	10:001	<i>Cucurbita</i> spp., lack of ZYMV resistance in <i>C. maxima</i> ....	8:076
cucumber, powdery mildew resistance .....	2:010	<i>Cucurbita</i> spp., multiple virus resistance .....	1:026
cucumber, resistance to <i>Didymella bryoniae</i> .....	4:006	<i>Cucurbita</i> spp., silvery leaves & virus infection .....	4:042
cucumber, resistance to <i>Rhizoctonia damping-off</i> .....	9:005	<i>Cucurbita</i> spp., sources of virus resistance in <i>C. maxima</i> ...	5:046
cucumber, <i>Rhizoctonia</i> fruit rot resistance .....	1:004	<i>Cucurbita</i> spp., tolerance to squash leaf curl .....	7:071
cucumber, <i>Rhizoctonia</i> fruit rot resistance .....	7:025	<i>Cucurbita</i> spp., virus studies with <i>C. foetidissima</i> .....	4:041
cucumber, screening for belly rot resistance .....	6:029	<i>Cucurbita</i> spp., zucchini yellow mosaic virus in USA .....	7:080
cucumber, seedling test for <i>Rhizoctonia</i> resistance .....	10:031	<i>Cucurbita</i> spp., zucchini yellow mosaic virus in USA .....	9:096
cucumber, sources of resistance for <i>Rhizoctonia</i> .....	7:023	<i>Cucurbita</i> spp., ZYMV resistance in <i>C. moschata</i> .....	10:080
cucumber, temperature & powdery mildew resistance .....	2:009	<i>Cucurbita</i> spp., ZYMV resistance in interspecific cross ....	11:074
cucumber, tests for fruit rot resistance .....	9:041	general, occurrence of ZYM virus in the U.S. ....	6:099
cucumber, <i>Ulocladium cucurbitae</i> leafspot .....	6:014	<i>Lagenaria</i> spp., virus resistance sources for <i>L. siceraria</i> ....	4:038
<i>Cucumis</i> spp., disease resistance in wild species .....	2:044	muskmelon, CMV transmission by <i>A. gossypii</i> .....	3:030
<i>Cucumis</i> spp., resistance to downy mildew and scab .....	10:021	muskmelon, cucumber green mottle mosaic virus .....	10:058
<i>Cucurbita</i> spp., downy mildew resistance .....	10:087	muskmelon, interaction with ZYMV .....	7:043
<i>Cucurbita</i> spp., interspecific hybridization of <i>C. pepo</i> ....	6:092	muskmelon, resistance to yellowing disease .....	11:052
<i>Cucurbita</i> spp., overcoming silvering disorder .....	6:070	muskmelon, squash mosaic virus resistance .....	10:056
<i>Cucurbita</i> spp., seedling test for <i>P. capsici</i> resistance .....	9:088	muskmelon, tolerance to watermelon mosaic virus II .....	1:020
general, anthracnose resistance in cucurbits .....	6:066	muskmelon, two alleles for WMV-1 resistance .....	6:052
general, pathogenicity of <i>Erysiphe cichoracearum</i> .....	11:087	watermelon, reaction of <i>C. colocynthis</i> to viruses .....	9:082
muskmelon, controversy on fusarium wilt resistance .....	10:060	watermelon, screening for watermelon mosaic viruses ....	7:061
		<b>environmental stress</b>	
		cucumber, fermentation & storage on germination .....	4:013

# CGC CUMULATIVE INDEX

## Reports 1-11 Inclusive (1978-88)

<p>cucumber, imposed stress &amp; sex expression ..... 10:013</p> <p>cucumber, induced chlorosis in glabrous types ..... 10:007</p> <p>cucumber, lack of chilling resistance ..... 11:029</p> <p>cucumber, low temperature adaptation ..... 2:013</p> <p>cucumber, low temperature seed germination ..... 4:012</p> <p>cucumber, low-temperature germination ability ..... 5:016</p> <p>cucumber, rooting cuttings w/poor water quality ..... 9:012</p> <p>Cucurbita spp., resistance to trifluralin toxicity ..... 4:035</p> <p>general, cold tolerance in the Cucurbitaceae ..... 10:104</p> <p>general, salinity responses among wild cucurbits ..... 11:091</p> <p>muskmelon, cold germinability ..... 8:041</p> <p>muskmelon, differences in low temperature growth ..... 2:023</p> <p>muskmelon, methodology and NaCl stress response ..... 7:049</p> <p>muskmelon, salt tolerance among Spanish cultivars ..... 10:041</p> <p>watermelon, ozone and sulfur dioxide sensitivity ..... 8:059</p> <p><b>extranuclear inheritance</b></p> <p>muskmelon, maternal effects on seedling growth ..... 9:068</p> <p><b>flowering</b></p> <p>cucumber, AVG-induced staminate flowers ..... 3:022</p> <p>cucumber, bacterial wilt resistance &amp; sex ..... 2:008</p> <p>cucumber, cordate leaf gene effects ..... 10:008</p> <p>cucumber, fruit shape and sex expression ..... 1:010</p> <p>cucumber, induced male flowers in gynocious lines ..... 2:014</p> <p>cucumber, inheritance of short-day response ..... 5:004</p> <p>cucumber, interspecific grafting with <i>C. hardwickii</i> ..... 2:011</p> <p>cucumber, linkage of male sterility &amp; sex ..... 1:013</p> <p>cucumber, perfect-flowered mutants ..... 3:012</p> <p>cucumber, pot size effect on growth &amp; flowering ..... 9:047</p> <p>cucumber, regeneration &amp; flowers from excised seed ..... 11:005</p> <p>cucumber, short-day treatment and flowering ..... 5:002</p> <p>cucumber, silver nitrate &amp; GA on gynoecey ..... 1:008</p> <p>Cucurbita spp., gynoecey in an interspecific cross ..... 1:031</p> <p>Cucurbita spp., sex expression &amp; ethephon response ..... 1:033</p> <p>muskmelon, monoecious sex expression ..... 3:032</p> <p>muskmelon, multiple-flowering character ..... 10:045</p> <p>muskmelon, perfect flower induction ..... 3:035</p> <p>muskmelon, regulation of gynomonoeceous expression ..... 1:018</p> <p><b>fruit</b></p> <p>cucumber, callus initiation from fruit ..... 9:003</p> <p>cucumber, factors affecting length/diameter ratio ..... 8:029</p> <p>cucumber, fasciation ..... 1:011</p> <p>cucumber, fasciation &amp; opposite leaf arrangement ..... 11:019</p> <p>cucumber, fruit shape and sex expression ..... 1:010</p> <p>cucumber, fruit size effect on quality ..... 3:015</p> <p>cucumber, seed number per mature fruit ..... 11:015</p> <p>cucumber, sex type, growth habit &amp; fruit length ..... 5:012</p> <p>cucumber, variation for fruit soluble solids ..... 10:009</p> <p>cucumber, white spine effects on skin and fruit ..... 3:006</p> <p>Cucurbita spp., fruit color &amp; large fruit in <i>C. moschata</i> ..... 10:091</p> <p>Cucurbita spp., fruit color in BwB+ <i>C. pepo</i> plants ..... 10:100</p>	<p>Cucurbita spp., fruit color with interspecific cross ..... 10:090</p> <p>Cucurbita spp., fruit skin color in <i>C. moschata</i> ..... 10:084</p> <p>Cucurbita spp., fruit thinning &amp; dry matter accumulation ... 6:072</p> <p>Cucurbita spp., light &amp; fruit affect internode elongation .... 2:040</p> <p>Cucurbita spp., non-genetic variability of calabaza color ... 9:100</p> <p>Cucurbita spp., parthenocarpic and normal fruit growth .... 6:084</p> <p>Cucurbita spp., regreening of <i>C. pepo</i> fruits ..... 6:086</p> <p>Cucurbita spp., spotting of <i>C. pepo</i> fruits ..... 6:087</p> <p>Cucurbita spp., stigmatic lobe pollination ..... 3:048</p> <p>muskmelon, a fasciated mutant ..... 11:037</p> <p>muskmelon, climacteric and nonclimacteric ripening ..... 7:041</p> <p>muskmelon, fruit quality &amp; seed characters ..... 7:046</p> <p>muskmelon, inheritance mode of fruit characters ..... 8:034</p> <p>muskmelon, sex form and fruit shape ..... 4:026</p> <p><b>fruit set</b></p> <p>cucumber, chlorflurenol, seed coats &amp; parthenocarpy ..... 7:012</p> <p>cucumber, grafting and fruit set ..... 3:017</p> <p>cucumber, greenhouse &amp; field fruit set ..... 10:002</p> <p>cucumber, heritability of fruit number ..... 3:010</p> <p>Cucurbita spp., fruit thinning &amp; dry matter accumulation ... 6:072</p> <p>Cucurbita spp., parthenocarpic fruit set in zucchini ..... 5:044</p> <p>muskmelon, ethylene &amp; fruit set ..... 5:033</p> <p>muskmelon, improved BA method to promote fruit set ..... 6:051</p> <p>muskmelon, improving fruit set by hand pollination ..... 2:022</p> <p>muskmelon, promoting fruit set with BA and AVG ..... 5:023</p> <p><b>genotype x environment interaction</b></p> <p>cucumber, cluster analysis of trial environments ..... 11:013</p> <p>cucumber, GxE interaction for yield ..... 10:025</p> <p>cucumber, season-location combinations &amp; yield ..... 10:027</p> <p>Cucurbita spp., <i>C. moschata</i> planted at four latitudes ..... 9:102</p> <p>Cucurbita spp., non-genetic variability of calabaza color ... 9:100</p> <p>muskmelon, genotype-environment interactions ..... 5:031</p> <p><b>germplasm evaluation</b></p> <p>cucumber, cluster analysis of trial environments ..... 11:013</p> <p>cucumber, estimating genetic variance &amp; covariance ..... 8:026</p> <p>cucumber, fertilizer &amp; seedling test for gynoecey ..... 9:051</p> <p>cucumber, leafminer resistance screening ..... 3:005</p> <p>cucumber, non-bitter resistance to <i>T. urticae</i> ..... 6:027</p> <p>cucumber, performance of types for fresh-market ..... 9:053</p> <p>cucumber, plot allocations for once-over harvest ..... 9:044</p> <p>cucumber, principal component analysis ..... 9:027</p> <p>cucumber, recording comments while collecting data ..... 8:031</p> <p>cucumber, resistance to <i>Rhizoctonia</i> damping-off ..... 9:005</p> <p>cucumber, screening for belly rot resistance ..... 6:029</p> <p>cucumber, season-location combinations &amp; yield ..... 10:027</p> <p>cucumber, seedling test for <i>Rhizoctonia</i> resistance ..... 10:031</p> <p>cucumber, tests for fruit rot resistance ..... 9:041</p> <p>cucumber, weighted selection indices ..... 5:018</p> <p>Cucumis spp., disease resistance in wild species ..... 2:044</p> <p>Cucurbita spp., relationship between B genes of 2 species ... 9:097</p> <p>Cucurbita spp., seedling test for <i>P. capsici</i> resistance ..... 9:088</p> <p>general, electronic clipboard for field data ..... 9:037</p>
--	--

# CGC CUMULATIVE INDEX

## Reports 1-11 Inclusive (1978-88)

<p>general, root knot nematode resistance ..... 6:096</p> <p>muskmelon, cultivar characterization ..... 8:039</p> <p>muskmelon, evaluating downy mildew resistance ..... 7:038</p> <p>muskmelon, fusarium wilt screening with peat pellets ..... 6:043</p> <p>muskmelon, <i>M. roridum</i> effects on seeds &amp; seedlings ..... 8:044</p> <p>muskmelon, reaction to powdery mildew in Israel ..... 11:047</p> <p>muskmelon, screening for <i>Myrothecium</i> resistance ..... 9:058</p> <p>watermelon, evaluation of African germplasm ..... 11:069</p> <p>watermelon, ozone and sulfur dioxide sensitivity ..... 8:059</p> <p>watermelon, reaction of <i>C. colocynthis</i> to viruses ..... 9:082</p> <p><b>germplasm resources</b></p> <p>cucumber, <i>C. hardwickii</i> as a germplasm source ..... 1:005</p> <p>cucumber, germplasm resources from Spain ..... 9:010</p> <p>cucumber, near-isogenic lines of several varieties ..... 8:004</p> <p>cucumber, partial dominance to powder mildew ..... 6:007</p> <p>cucumber, powdery mildew and leafspot resistance ..... 10:001</p> <p>cucumber, sources of resistance for <i>Rhizoctonia</i> ..... 7:023</p> <p><i>Cucumis</i> spp., collection at the IVT ..... 3:068</p> <p><i>Cucumis</i> spp., rectifying accession names at IVT ..... 5:059</p> <p><i>Cucurbita</i> spp., collection of Zambian cucurbit germplasm ..... 7:089</p> <p><i>Cucurbita</i> spp., derivatives of 'Fordhook Zucchini' ..... 4:034</p> <p><i>Cucurbita</i> spp., fruit color &amp; large fruit in <i>C. moschata</i> ..... 10:091</p> <p><i>Cucurbita</i> spp., germplasm resources from Spain ..... 11:086</p> <p><i>Cucurbita</i> spp., seed increase of Mexican collection ..... 4:036</p> <p><i>Cucurbita</i> spp., sources of virus resistance in <i>C. maxima</i> ..... 5:046</p> <p>general, cucurbit germplasm collections from China ..... 11:093</p> <p><i>Lagenaria</i> spp., virus resistance sources for <i>L. siceraria</i> ..... 4:038</p> <p>muskmelon, collecting germplasm in Spain ..... 11:054</p> <p>muskmelon, germplasm resources from Spain ..... 9:060</p> <p>muskmelon, resistance to <i>Aphis gossypii</i> ..... 11:050</p> <p>muskmelon, resistance to yellowing disease ..... 11:052</p> <p>muskmelon, sources of sudden wilt resistance ..... 6:049</p> <p>watermelon, germplasm resources ..... 10:064</p> <p>watermelon, seedling fusarium wilt resistance ..... 11:068</p> <p><b>grafting</b></p> <p>cucumber, grafting and fruit set ..... 3:017</p> <p>cucumber, interspecific grafting with <i>C. hardwickii</i> ..... 2:011</p> <p><b>growth (reproductive)</b></p> <p>cucumber, heat unit summation &amp; harvest prediction ..... 8:009</p> <p><i>Cucurbita</i> spp., light &amp; fruit affect internode elongation ..... 2:040</p> <p><i>Cucurbita</i> spp., parthenocarpic and normal fruit growth ..... 6:084</p> <p><i>Cucurbita</i> spp., stigmatic lobe pollination ..... 3:048</p> <p>muskmelon, multiple-flowering character ..... 10:045</p> <p><b>growth (vegetative)</b></p> <p>cucumber, determinate locus &amp; lateral branching ..... 7:003</p> <p>cucumber, heat unit summation &amp; harvest prediction ..... 8:009</p> <p>cucumber, leaf area prediction for field plants ..... 9:015</p> <p>cucumber, pot size effect on growth &amp; flowering ..... 9:047</p> <p>cucumber, vegetative phase &amp; partitioning ..... 7:014</p> <p><i>Cucumis</i> spp., dormancy ..... 1:036</p>	<p><i>Cucurbita</i> spp., light &amp; fruit affect internode elongation ..... 2:040</p> <p><i>Cucurbita</i> spp., seed size &amp; vegetative growth of squash ..... 10:078</p> <p>muskmelon, differences in low temperature growth ..... 2:023</p> <p>muskmelon, <i>M. roridum</i> effects on seeds &amp; seedlings ..... 8:044</p> <p>muskmelon, maternal effects on seedling growth ..... 9:068</p> <p><b>growth regulators</b></p> <p>cucumber, AVG-induced staminate flowers ..... 3:022</p> <p>cucumber, chlorflurenol, seed coats &amp; parthenocarp ..... 7:012</p> <p>cucumber, ethylene and hermaphroditism ..... 4:008</p> <p>cucumber, induced male flowers in gynocious lines ..... 2:014</p> <p>cucumber, silver nitrate &amp; GA on gynoccy ..... 1:008</p> <p>cucumber, silver nitrate &amp; gynocious cuttings ..... 7:006</p> <p><i>Cucumis</i> spp., cross with <i>C. africanus</i> &amp; <i>C. metuliferus</i> ..... 3:060</p> <p><i>Cucurbita</i> spp., cultivar sensitivity to ethephon ..... 8:067</p> <p><i>Cucurbita</i> spp., GA-improved seed germination ..... 3:043</p> <p><i>Cucurbita</i> spp., sex expression &amp; ethephon response ..... 1:033</p> <p>muskmelon, ethylene &amp; fruit set ..... 5:033</p> <p>muskmelon, improved BA method to promote fruit set ..... 6:051</p> <p>muskmelon, perfect flower induction ..... 3:035</p> <p>muskmelon, promoting fruit set with BA and AVG ..... 5:023</p> <p>muskmelon, silver nitrate &amp; perfect flowers ..... 8:057</p> <p><b>in vitro culture</b></p> <p>cucumber, adventitious bud formation in vitro ..... 2:002</p> <p>cucumber, callus &amp; somatic embryos ..... 11:001</p> <p>cucumber, callus initiation from fruit ..... 9:003</p> <p>cucumber, embryogenesis from cotyledon callus ..... 11:003</p> <p>cucumber, in vitro adventitious bud formation ..... 3:002</p> <p>cucumber, in vitro propagation ..... 1:001</p> <p>cucumber, regeneration &amp; flowers from excised seed ..... 11:005</p> <p>cucumber, shoot tip growth on 9 N sources in vitro ..... 5:010</p> <p>cucumber, tissue culture propagation ..... 4:020</p> <p><i>Cucumis</i> spp., cross with <i>C. africanus</i> &amp; <i>C. metuliferus</i> ..... 3:050</p> <p><i>Cucumis</i> spp., embryo culture ..... 3:034</p> <p><i>Cucumis</i> spp., embryo stage and in vitro culture ..... 4:048</p> <p><i>Cucumis</i> spp., in vitro culture for seed germination ..... 2:046</p> <p><i>Cucumis</i> spp., in vitro culture of <i>C. zeyheri</i> embryos ..... 5:054</p> <p><i>Cucumis</i> spp., regeneration from explant-derived calli ..... 9:108</p> <p><i>Cucurbita</i> spp., age and seed explant organogenesis ..... 9:093</p> <p><i>Cucurbita</i> spp., anther and ovule culture ..... 10:092</p> <p><i>Cucurbita</i> spp., embryo culture of two species ..... 7:069</p> <p><i>Cucurbita</i> spp., embryos &amp; plants from unfertilized ovules ..... 8:066</p> <p>muskmelon, embryoid-like structures from callus ..... 6:056</p> <p>muskmelon, embryos &amp; plants from oval cultures ..... 10:062</p> <p>muskmelon, in vitro callus &amp; shoot induction ..... 3:027</p> <p>muskmelon, isolation of leaf cells and protoplasts ..... 11:035</p> <p>muskmelon, plant regeneration from callus ..... 11:033</p> <p>muskmelon, protoplast fusion with two species ..... 9:070</p> <p>muskmelon, regeneration from cotyledon protoplasts ..... 9:074</p> <p>watermelon, potential uses of micropropagation ..... 1:021</p> <p><b>insects</b></p> <p>cucumber, glabrous trait and whitefly control ..... 2:005</p> <p>cucumber, leafminer resistance screening ..... 3:005</p>
---	--

# CGC CUMULATIVE INDEX

## Reports 1-11 Inclusive (1978-88)

<p>cucumber, non-bitter resistance to <i>T. urticae</i> ..... 6:027</p> <p>cucumber, plant form and pickleworm infestation ..... 2:016</p> <p>cucumber, resistance to the pickleworm ..... 6:035</p> <p>cucumber, screening for pickleworm resistance ..... 1:016</p> <p>cucumber, twospotted spider mite resistance ..... 2:006</p> <p><i>Cucumis</i> spp., response to 3 <i>Meloidogyne</i> spp. .... 4:053</p> <p><i>Cucumis</i> spp., white fly resistance ..... 1:038</p> <p><i>Cucurbita</i> spp., beetle control with bitter fruit baits ..... 6:079</p> <p><i>Cucurbita</i> spp., bitter hybrids as <i>Diabrotica</i> baits ..... 3:044</p> <p><i>Cucurbita</i> spp., bitter substances attract <i>Diabrotica</i> ..... 2:038</p> <p><i>Cucurbita</i> spp., bitterness &amp; corn rootworm beetle control .. 4:037</p> <p><i>Cucurbita</i> spp., blossom aroma and <i>Diabrotica</i> attraction .. 11:076</p> <p><i>Cucurbita</i> spp., cucurbitacin baits to control <i>Diabrotica</i> .... 11:079</p> <p><i>Cucurbita</i> spp., cucurbitacins &amp; <i>Diabrotica</i> attack ..... 5:042</p> <p><i>Cucurbita</i> spp., insect associations in Illinois ..... 1:030</p> <p><i>Cucurbita</i> spp., response to 3 <i>Meloidogyne</i> spp. .... 4:053</p> <p><i>Cucurbita</i> spp., squash &amp; honey bees as pollinators ..... 3:048</p> <p>general, root knot nematode resistance ..... 6:096</p> <p>general, seedling nematode-test reliability ..... 7:092</p> <p>muskmelon, CMV transmission by <i>A. gossypii</i> ..... 3:030</p> <p>muskmelon, cucumber beetle susceptibility ..... 6:041</p> <p>muskmelon, leaf miner resistance ..... 4:024</p> <p>muskmelon, resistance to <i>Aphis gossypii</i> ..... 11:050</p> <p>muskmelon, resistance to three pests ..... 1:019</p> <p>watermelon, <i>Diabrotica</i> resistance and plant form ..... 2:028</p> <p>watermelon, resistance to cucumber beetles ..... 1:023</p> <p><b>Interspecific hybridization</b></p> <p>cucumber, grafting and fruit set ..... 3:017</p> <p>cucumber, heritability of fruit number ..... 3:010</p> <p>cucumber, heterosis estimates w/gynocious inbred ..... 3:020</p> <p>cucumber, interspecific cross with muskmelon ..... 1:006</p> <p>cucumber, isozyme analysis of the megurk ..... 2:017</p> <p>cucumber, rosette mutant from mentor pollination ..... 3:004</p> <p><i>Cucumis</i> spp., cross of <i>C. anguria</i> &amp; <i>C. zeyheri</i> ..... 6:100</p> <p><i>Cucumis</i> spp., cross with <i>C. africanus</i> &amp; <i>C. metuliferus</i> .... 3:050</p> <p><i>Cucumis</i> spp., cross with <i>C. africanus</i> &amp; <i>C. metuliferus</i> .... 3:060</p> <p><i>Cucumis</i> spp., cross with <i>C. africanus</i> &amp; <i>C. metuliferus</i> .... 4:050</p> <p><i>Cucumis</i> spp., embryo size in <i>C. sativus</i> x <i>C. melo</i> ..... 7:094</p> <p><i>Cucumis</i> spp., interspecific crosses ..... 1:039</p> <p><i>Cucumis</i> spp., interspecific crosses with <i>C. africanus</i> ..... 4:058</p> <p><i>Cucumis</i> spp., interspecific hybridization ..... 1:040</p> <p><i>Cucumis</i> spp., mentor pollen and interspecific hybrids ..... 2:043</p> <p><i>Cucumis</i> spp., mentor pollen in an interspecific cross ..... 6:094</p> <p><i>Cucumis</i> spp., pollen tube growth w/interspecific cross .... 3:052</p> <p><i>Cucumis</i> spp., species crosses w/controlled conditions .... 4:056</p> <p><i>Cucurbita</i> spp., attempted cross w/<i>C. moschata</i> and <i>C. pepo</i> ..... 2:032</p> <p><i>Cucurbita</i> spp., compatibility in an interspecific cross ..... 10:088</p> <p><i>Cucurbita</i> spp., cross of <i>C. pepo</i> and <i>C. martinii</i> ..... 2:035</p> <p><i>Cucurbita</i> spp., crossing <i>C. pepo</i> &amp; <i>C. ecuadorensis</i> ..... 3:042</p> <p><i>Cucurbita</i> spp., esterase/peroxidase w/interspecific cross .. 1:029</p> <p><i>Cucurbita</i> spp., fruit color with interspecific cross ..... 10:090</p> <p><i>Cucurbita</i> spp., gene flow w/<i>C. mixta</i> and wild <i>Cucurbita</i> ... 7:076</p> <p><i>Cucurbita</i> spp., gynocery in an interspecific cross ..... 1:031</p> <p><i>Cucurbita</i> spp., high-female lines w/interspecific crosses ... 8:078</p>	<p><i>Cucurbita</i> spp., hybridization of <i>C. foetidissima</i> ..... 10:072</p> <p><i>Cucurbita</i> spp., internode length in <i>C. pepo</i> x <i>C. moschata</i> . 9:091</p> <p><i>Cucurbita</i> spp., interspecific hybridization of <i>C. pepo</i> ..... 6:092</p> <p><i>Cucurbita</i> spp., interspecific trisomics ..... 2:037</p> <p><i>Cucurbita</i> spp., natural hybridization of <i>C. scabridifolia</i> .... 10:074</p> <p><i>Cucurbita</i> spp., natural hybrids of <i>C. sororia</i> &amp; <i>C. mixta</i> .... 7:073</p> <p><i>Cucurbita</i> spp., variation in an interspecific cross ..... 10:085</p> <p><i>Cucurbita</i> spp., ZYMV resistance in interspecific cross ..... 11:074</p> <p>muskmelon, interspecific cross with cucumber ..... 1:006</p> <p>muskmelon, pollen germination in interspecific cross ..... 2:020</p> <p>muskmelon, protoplast fusion with two species ..... 9:070</p> <p><b>Isozymes</b></p> <p>cucumber, isozyme analysis of the megurk ..... 2:017</p> <p>cucumber, isozyme polymorphisms ..... 6:032</p> <p><i>Cucumis</i> spp., electrophoretic comparison of six species ... 7:027</p> <p><i>Cucumis</i> spp., electrophoretic variation w/ wild species .... 8:022</p> <p><i>Cucumis</i> spp., isozyme electrophoresis ..... 1:039</p> <p><i>Cucumis</i> spp., malate dehydrogenase in African species ... 9:018</p> <p><i>Cucurbita</i> spp., electrophoretic analysis of pollen ..... 2:039</p> <p><i>Cucurbita</i> spp., electrophoretic cultivar classification ..... 10:083</p> <p><i>Cucurbita</i> spp., esterase/peroxidase w/interspecific cross .. 1:029</p> <p><i>Cucurbita</i> spp., isozyme electrophoretic analysis ..... 1:028</p> <p><i>Cucurbita</i> spp., isozyme linkage with WMV2 resistance .... 7:086</p> <p><i>Cucurbita</i> spp., isozyme variants in <i>C. pepo</i> ..... 9:104</p> <p><i>Cucurbita</i> spp., isozymes indicate ancient tetraploid ..... 7:084</p> <p>watermelon, isozyme analysis of parents and hybrids ..... 11:057</p> <p><b>Lagenaria spp.</b></p> <p>virus resistance sources for <i>L. siceraria</i> ..... 4:038</p> <p><b>leaf</b></p> <p>cucumber, "divided leaf" recessive seedling marker ..... 3:024</p> <p>cucumber, allelism tests with glabrous mutants ..... 10:007</p> <p>cucumber, fasciation &amp; opposite leaf arrangement ..... 11:019</p> <p>cucumber, genes for glabrousness ..... 3:014</p> <p>cucumber, glabrous trait and whitefly control ..... 2:005</p> <p>cucumber, induced chlorosis in glabrous types ..... 10:007</p> <p>cucumber, inheritance of opposite leaf arrangement ..... 10:010</p> <p>cucumber, pleiotropic inheritance of glabrousness ..... 6:008</p> <p>cucumber, leaf area prediction for field plants ..... 9:015</p> <p>cucumber, leaf galactinol synthase activity ..... 6:025</p> <p>cucumber, leaf peroxidase &amp; anthracnose resistance ..... 11:020</p> <p>cucumber, non-destructive leaf area measurement ..... 9:033</p> <p>cucumber, photosynthetic rate &amp; chlorophyll ..... 9:024</p> <p>cucumber, pleiotropic effects of glabrous gene ..... 1:014</p> <p><i>Cucurbita</i> spp., silvery leaves &amp; virus infection ..... 4:042</p> <p><i>Cucurbita</i> spp., silvery-leaf trait ..... 7:081</p> <p><i>Cucurbita</i> spp., silvery-leaf trait in <i>C. pepo</i> ..... 5:048</p> <p><i>Cucurbita</i> spp., spectra of silvery and non-silvery leaves .... 6:089</p> <p>muskmelon, isolation of leaf cells and protoplasts ..... 11:035</p> <p>watermelon, anthracnose resistance and pale leaf ..... 2:029</p>
---	---



# CGC CUMULATIVE INDEX

## Reports 1-11 Inclusive (1978-88)

<b>light</b>			
cucumber, adventitious bud formation in vitro .....	2:002	evaluating downy mildew resistance .....	7:038
cucumber, photosynthetic rate & chlorophyll .....	9:024	flava - a chlorophyll deficient mutant .....	9:067
Cucurbita spp., light & fruit affect internode elongation ....	2:040	fruit quality & seed characters .....	7:046
Cucurbita spp., spectra of silvery and non-silvery leaves ....	6:089	fusarium wilt screening with peat pellets .....	6:043
		genetic linkages .....	8:050
<b>linkage</b>		genotype-environment interactions .....	5:031
cucumber, allelism tests with glabrous mutants .....	10:007	germplasm resources from Spain .....	9:060
cucumber, bacterial wilt resistance & sex .....	2:008	gummy stem blight resistant breeding line .....	8:046
cucumber, further linkage studies .....	10:039	improved BA method to promote fruit set .....	6:051
cucumber, further results of linkage studies .....	9:055	improving fruit set by hand pollination .....	2:022
cucumber, independence of gl and yc .....	10:011	improving self-pollination .....	1:017
cucumber, linkage in 'Lemon' cucumber .....	1:012	in vitro callus & shoot induction .....	3:027
cucumber, linkage of male sterility & sex .....	1:013	independent assortment of yg and red stem .....	6:047
cucumber, linkage of powdery mildew genes .....	1:011	inheritance mode of fruit characters .....	8:034
cucumber, linkage of WMV-1 resistance .....	10:024	inheritance of downy mildew resistance .....	8:036
cucumber, mapping the cucumber genome .....	6:022	inheritance of gynocious sex type .....	10:047
cucumber, sex type, growth habit & fruit length .....	5:012	inoculation conditions for Alternaria .....	7:055
cucumber, update of gene list .....	8:086	interaction with ZYMV .....	7:043
Cucurbita spp., independence of Ses-B and M in C. pepo ..	7:064	interspecific cross with cucumber .....	1:006
Cucurbita spp., isozyme linkage with WMV2 resistance ....	7:086	isolation of leaf cells and protoplasts .....	11:035
Cucurbita spp., trisomic identification of linkage groups ....	7:096	leaf miner resistance .....	4:024
Cucurbita spp., update of gene list .....	11:096	linkage of red stem and ms-1 .....	6:048
muskmelon, genetic linkages .....	8:050	linkage of Vat and Fn .....	5:029
muskmelon, independent assortment of yg and red stem ..	6:047	linkage studies .....	7:051
muskmelon, linkage of red stem and ms-1 .....	6:048	locating genes .....	10:051
muskmelon, linkage of Vat and Fn .....	5:029	locating ms-4 and virescent mutants .....	9:064
muskmelon, linkage studies .....	7:051	long internode mutant .....	6:045
muskmelon, locating genes .....	10:051	M. roridum effects on seeds & seedlings .....	8:044
muskmelon, locating ms-4 and virescent mutants .....	9:064	maternal effects on seedling growth .....	9:068
muskmelon, update of gene list .....	9:111	methodology and NaCl stress response .....	7:049
watermelon, glabrous & ms segregation in tetraploid .....	9:084	monitoring powdery mildew races .....	7:058
watermelon, update of gene list .....	10:106	monoecious sex expression .....	3:032
		multiple disease-resistant casaba .....	4:024
<b>muskmelon (Cucumis melo)</b>		multiple-flowering character .....	10:045
a fasciated mutant .....	11:037	n-pentane for mixing pollen .....	7:054
androecious sex form .....	5:024	new plant type .....	4:024
artificial pollination techniques .....	10:043	observations on "birdsnest" types .....	5:028
B-chromosome variation .....	8:055	perfect flower induction .....	3:035
chiasma frequency in different sex forms .....	6:054	plant regeneration from callus .....	11:033
climacteric and nonclimacteric ripening .....	7:041	pollen germination in interspecific cross .....	2:020
CMV transmission by A. gossypii .....	3:030	promoting fruit set with BA and AVG .....	5:023
cold germinability .....	8:041	protoplast fusion with two species .....	9:070
collecting germplasm in Spain .....	11:054	reaction to powdery mildew in Israel .....	11:047
compatibility among botanical varieties .....	9:078	recessive powdery mildew resistance .....	7:045
controversy on fusarium wilt resistance .....	10:060	regeneration from cotyledon protoplasts .....	9:074
cucumber beetle susceptibility .....	6:041	regulation of gynomonocious expression .....	1:018
cucumber green mottle mosaic virus .....	10:058	resistance to Aphis gossypii .....	11:050
cultivar characterization .....	8:039	resistance to three pests .....	1:019
development of gynocious lines .....	10:049	resistance to yellowing disease .....	11:052
differences in low temperature growth .....	2:023	response to bacterial wilt .....	5:026
dwarf breeding .....	1:017	rooting of stem cuttings .....	11:043
embryoid-like structures from callus .....	6:056	salt tolerance among Spanish cultivars .....	10:041
embryos & plants from oval cultures .....	10:062	screening for Myrothecium resistance .....	9:058
ethylene & fruit set .....	5:033	sex form and fruit shape .....	4:026
		silver nitrate & perfect flowers .....	8:057

# CGC CUMULATIVE INDEX

## Reports 1-11 Inclusive (1978-88)

<p>sources of sudden wilt resistance ..... 6:049</p> <p>squash mosaic virus resistance ..... 10:056</p> <p>stability of male sterile-1 ..... 3:031</p> <p>third male sterile gene ..... 6:046</p> <p>tolerance to watermelon mosaic virus II ..... 1:020</p> <p>two alleles for WMV-1 resistance ..... 6:052</p> <p>update of gene list ..... 9:111</p> <p>x-ray detection of haploid embryos ..... 11:039</p> <p><b>mutants</b></p> <p>cucumber, "divided leaf" recessive seedling marker ..... 3:024</p> <p>cucumber, "umbrella leaf" sensitivity to humidity ..... 6:024</p> <p>cucumber, allelism tests with glabrous mutants ..... 10:007</p> <p>cucumber, apetalous male sterile mutant ..... 3:009</p> <p>cucumber, blunt leaf apex, an induced mutation ..... 10:006</p> <p>cucumber, cordate leaf gene effects ..... 10:008</p> <p>cucumber, determinate locus &amp; lateral branching ..... 7:003</p> <p>cucumber, genes for glabrousness ..... 3:014</p> <p>cucumber, glabrous trait and whiteness control ..... 2:005</p> <p>cucumber, hypocotyl &amp; internode length mutant ..... 4:019</p> <p>cucumber, independence of gl and yc ..... 10:011</p> <p>cucumber, intermediary inheritance of glabrousness ..... 6:008</p> <p>cucumber, littleleaf and multi-branched types ..... 10:033</p> <p>cucumber, near-isogenic lines of several varieties ..... 8:004</p> <p>cucumber, perfect-flowered mutants ..... 3:012</p> <p>cucumber, pleiotropic effects of glabrous gene ..... 1:014</p> <p>cucumber, rosette mutant from mentor pollination ..... 3:004</p> <p>cucumber, second long hypocotyl mutant at lh locus ..... 6:013</p> <p>cucumber, segregation of determinate (de) allele ..... 8:002</p> <p>cucumber, short petiole, a useful seedling marker ..... 8:007</p> <p>cucumber, update of gene list ..... 8:086</p> <p>cucumber, white spine effects on skin and fruit ..... 3:006</p> <p>Cucumis spp., monogenic andromonoecy in tetraploid ..... 7:100</p> <p>Cucurbita spp., coadaptation of gene B ..... 4:044</p> <p>Cucurbita spp., fruit color in BwB + C. pepo plants ..... 10:100</p> <p>Cucurbita spp., green corolla mutant ..... 10:103</p> <p>Cucurbita spp., silvery-leaf trait ..... 7:081</p> <p>Cucurbita spp., update of gene list ..... 11:096</p> <p>Cucurbita spp., white cotyledons in C. pepo ..... 5:039</p> <p>muskmelon, a fasciated mutant ..... 11:037</p> <p>muskmelon, flava - a chlorophyll deficient mutant ..... 9:067</p> <p>muskmelon, independent assortment of yg and red stem .. 6:047</p> <p>muskmelon, linkage of red stem and ms-1 ..... 6:048</p> <p>muskmelon, locating genes ..... 10:051</p> <p>muskmelon, locating ms-4 and virescent mutants ..... 9:064</p> <p>muskmelon, long internode mutant ..... 6:045</p> <p>muskmelon, new plant type ..... 4:024</p> <p>muskmelon, recessive powdery mildew resistance ..... 7:045</p> <p>muskmelon, third male sterile gene ..... 6:046</p> <p>muskmelon, update of gene list ..... 9:111</p> <p>watermelon, 'Moon and Stars' variegation ..... 6:068</p> <p>watermelon, pale seedling character ..... 3:039</p> <p>watermelon, update of gene list ..... 10:106</p>	<p><b>mutation &amp; mutagenesis</b></p> <p>cucumber, blunt leaf apex, an induced mutation ..... 10:006</p> <p>cucumber, mutagenic experiments ..... 1:013</p> <p>cucumber, rosette mutant from mentor pollination ..... 3:004</p> <p>cucumber, spontaneous mutation ..... 1:015</p> <p>Cucurbita spp., compact mutations induced by EMS ..... 1:034</p> <p>Cucurbita spp., natural and induced mutations ..... 1:035</p> <p>muskmelon, x-ray detection of haploid embryos ..... 11:039</p> <p>watermelon, seedlessness via reciprocal translocation ..... 11:060</p> <p><b>nucleic acids</b></p> <p>Cucumis spp., composition of nuclear DNA ..... 10:004</p> <p>Cucumis spp., nuclear DNA variation ..... 7:097</p> <p>Cucurbita spp., chloroplast DNA &amp; phylogenetic analysis ... 7:066</p> <p>Cucurbita spp., nuclear gene &amp; plastid-specific aldolase ... 7:088</p> <p><b>photoperiodism</b></p> <p>cucumber, inheritance of short-day response ..... 5:004</p> <p>cucumber, short-day treatment and flowering ..... 5:002</p> <p><b>plant habit &amp; morphology</b></p> <p>cucumber, compact &amp; vining isoline yields ..... 5:006</p> <p>cucumber, growth analysis for plant habit and yield ..... 7:017</p> <p>cucumber, inbreeding &amp; seed traits of compact type ..... 6:004</p> <p>cucumber, littleleaf and multi-branched types ..... 10:033</p> <p>cucumber, maternal &amp; embryonic control of seed ..... 5:008</p> <p>cucumber, morphological and anatomical comparisons .... 8:015</p> <p>cucumber, plant form and pickleworm infestation ..... 2:016</p> <p>cucumber, seed characteristics of compact plants ..... 4:002</p> <p>cucumber, seed quality from compact plants ..... 4:004</p> <p>cucumber, sex type, growth habit &amp; fruit length ..... 5:012</p> <p>Cucurbita spp., compact mutations induced by EMS ..... 1:034</p> <p>Cucurbita spp., inheritance of bush habit in C. pepo ..... 11:070</p> <p>Cucurbita spp., productivity of bush &amp; vine winter squash .. 5:040</p> <p>muskmelon, dwarf breeding ..... 1:017</p> <p>muskmelon, new plant type ..... 4:024</p> <p>muskmelon, observations on "birdsnest" types ..... 5:028</p> <p>watermelon, Diabrotica resistance and plant form ..... 2:028</p> <p><b>ploidy</b></p> <p>cucumber, improving tetraploid fertility ..... 7:012</p> <p>Cucumis spp., monogenic andromonoecy in tetraploid .... 7:100</p> <p>Cucurbita spp., interspecific trisomics ..... 2:037</p> <p>Cucurbita spp., isozymes indicate ancient tetraploid ..... 7:084</p> <p>Cucurbita spp., trisomic identification of linkage groups .... 7:096</p> <p>muskmelon, x-ray detection of haploid embryos ..... 11:039</p> <p>watermelon, culture and yield with tetraploids ..... 6:059</p> <p>watermelon, direct seeding of seedless triploids ..... 2:027</p> <p>watermelon, evidence for a tetrasomic line ..... 11:057</p> <p>watermelon, glabrous &amp; ms segregation in tetraploid ..... 9:084</p> <p>watermelon, improvement with polyploidy ..... 2:025</p> <p>watermelon, seedlessness via reciprocal translocation ..... 11:060</p>
--	--

# CGC CUMULATIVE INDEX

## Reports 1-11 Inclusive (1978-88)

<b>pollen</b>	
cucumber, lateral pollen tube growth in ovary .....	6:020
cucumber, rosette mutant from mentor pollination .....	3:004
Cucumis spp., cross with <i>C. africanus</i> & <i>C. metuliferus</i> ....	3:060
Cucumis spp., embryo size in <i>C. sativus</i> x <i>C. melo</i> .....	7:094
Cucumis spp., mentor pollen and interspecific hybrids .....	2:043
Cucumis spp., mentor pollen in an interspecific cross .....	6:094
Cucumis spp., pollen mother cell meiosis in a haploid .....	10:037
Cucumis spp., pollen resistance to gamma irradiation .....	8:082
Cucumis spp., pollen tube growth w/interspecific cross ....	3:052
Cucurbita spp., electrophoretic analysis of pollen .....	2:039
Cucurbita spp., environmental effects on pollen longevity ..	6:091
muskmelon, n-pentane for mixing pollen .....	7:054
muskmelon, pollen germination in interspecific cross .....	2:020
muskmelon, x-ray detection of haploid embryos .....	11:039
<b>pollination</b>	
cucumber, a revision on controlled pollination .....	11:008
cucumber, cordate leaf gene effects .....	10:008
cucumber, improving tetraploid fertility .....	7:012
cucumber, pollen receptivity of stigmatic areas .....	3:025
Cucumis spp., apomictic propagation of <i>C. ficifolius</i> .....	10:035
Cucumis spp., cross with <i>C. africanus</i> & <i>C. metuliferus</i> ....	3:060
Cucumis spp., cross with <i>C. africanus</i> & <i>C. metuliferus</i> ....	4:050
Cucumis spp., species crosses w/controlled conditions ....	4:056
Cucurbita spp., embryos & plants from unfertilized ovules ..	8:066
Cucurbita spp., squash & honey bees as pollinators .....	3:048
Cucurbita spp., stigmatic lobe pollination .....	3:048
muskmelon, artificial pollination techniques .....	10:043
muskmelon, compatibility among botanical varieties .....	9:078
muskmelon, ethylene & fruit set .....	5:033
muskmelon, improving fruit set by hand pollination .....	2:022
muskmelon, improving self-pollination .....	1:017
watermelon, outcrossing .....	10:066
<b>postharvest physiology</b>	
muskmelon, climacteric and nonclimacteric ripening .....	7:041
<b>quality</b>	
cucumber, evaluation of fruit quality .....	11:025
cucumber, factors affecting length/diameter ratio .....	8:029
cucumber, fruit size effect on quality .....	3:015
cucumber, variation for fruit soluble solids .....	10:009
Cucurbita spp., intense bitterness in zucchini .....	6:075
muskmelon, fruit quality & seed characters .....	7:046
<b>rooting</b>	
cucumber, rooting cuttings w/poor water quality .....	9:012
muskmelon, rooting of stem cuttings .....	11:043
<b>seed &amp; seed characters</b>	
cucumber, chlorflurenol, seed coats & parthenocarpy .....	7:012
cucumber, fermentation & storage on germination .....	4:013
cucumber, inbreeding & seed traits of compact type .....	6:004
cucumber, longevity of seed .....	10:012
cucumber, maternal & embryonic control of seed .....	5:008
cucumber, regeneration & flowers from excised seed .....	11:005
cucumber, seed characteristics of compact plants .....	4:002
cucumber, seed number per mature fruit .....	11:015
cucumber, seed quality from compact plants .....	4:004
Cucumis spp., apomictic propagation of <i>C. ficifolius</i> .....	10:035
Cucumis spp., cross with <i>C. africanus</i> & <i>C. metuliferus</i> ....	3:050
Cucurbita spp., improving seed yield in hull-less <i>C. pepo</i> ...	11:072
Cucurbita spp., lack of seed transmission of ZYMV .....	10:081
Cucurbita spp., non-destructive seed fatty acid analysis ....	4:036
Cucurbita spp., parthenocarpic and normal fruit growth ....	6:084
Cucurbita spp., seed coats in normal & hull-less pumpkin ..	5:051
Cucurbita spp., seed size & vegetative growth of squash ...	10:078
muskmelon, fruit quality & seed characters .....	7:046
watermelon, seed length classes .....	3:038
<b>seed germination</b>	
cucumber, fermentation & storage on germination .....	4:013
cucumber, low temperature seed germination .....	4:012
cucumber, low-temperature germination ability .....	5:016
Cucumis spp., in vitro culture for seed germination .....	2:046
Cucumis spp., interspecific crosses with <i>C. africanus</i> .....	4:058
Cucurbita spp., GA-improved seed germination .....	3:043
muskmelon, cold germinability .....	8:041
muskmelon, <i>M. roridum</i> effects on seeds & seedlings .....	8:044
watermelon, direct seeding of seedless triploids .....	2:027
watermelon, factors delaying seed germination .....	6:064
<b>selection</b>	
cucumber, early generation testing .....	7:019
cucumber, improvement for increased fruit yield .....	6:018
cucumber, improvement for increased fruit yield .....	7:009
cucumber, inbreds via full-sib family selection .....	7:008
cucumber, inbreeding by full-sib family selection .....	6:016
cucumber, inbreeding effects on family performance .....	7:021
cucumber, screening for pickteworm resistance .....	1:016
cucumber, sources of resistance for <i>Rhizoctonia</i> .....	7:023
cucumber, survey of breeding methods in the USA .....	11:009
Cucurbita spp., squash breeding .....	10:093
general, seedling nematode-test reliability .....	7:092
<b>sex expression</b>	
cucumber, apetalous male sterile mutant .....	3:009
cucumber, AVG-induced staminate flowers .....	3:022
cucumber, bacterial wilt resistance & sex .....	2:008
cucumber, development of tropical gynocious lines .....	11:017
cucumber, ethylene and hermaphroditism .....	4:008
cucumber, fertilizer & seedling test for gynoecey .....	9:051
cucumber, fruit shape and sex expression .....	1:010
cucumber, gynoecey stability & silver thiosulfate .....	10:018
cucumber, heterosis estimates w/gynocious inbred .....	3:020
cucumber, imposed stress & sex expression .....	10:013
cucumber, induced male flowers in gynocious lines .....	2:014
cucumber, linkage of male sterility & sex .....	1:013
cucumber, perfect-flowered mutants .....	3:012

# CGC CUMULATIVE INDEX

## Reports 1-11 Inclusive (1978-88)

cucumber, sex type, growth habit & fruit length .....	5:012	isozyme analysis of parents and hybrids .....	11:057
cucumber, silver nitrate & GA on gynoecy .....	1:008	new disease in Tunisia .....	4:030
cucumber, silver nitrate & gynoecious cuttings .....	7:006	outcrossing .....	10:066
cucumber, spacing & yield of hardwickii derivatives .....	6:003	ozone and sulfur dioxide sensitivity .....	8:059
Cucumis spp., monogenic andromonoecy in tetraploid ....	7:100	pale seedling character .....	3:039
Cucurbita spp., gynoecy in an interspecific cross .....	1:031	potential uses of micropropagation .....	1:021
Cucurbita spp., high-female lines w/interspecific crosses ...	8:078	reaction of <i>C. colocynthis</i> to viruses .....	9:082
Cucurbita spp., sex expression & ethephon response .....	1:033	resistance to cucumber beetles .....	1:023
Cucurbita spp., sex expression in <i>C. foetidissima</i> .....	2:036	resistance to <i>M. citrullina</i> .....	1:024
muskmelon, androecious sex form .....	5:024	screening for watermelon mosaic viruses .....	7:061
muskmelon, chiasma frequency in different sex forms .....	6:054	seed length classes .....	3:038
muskmelon, development of gynoecious lines .....	10:049	seedlessness via reciprocal translocation .....	11:060
muskmelon, inheritance of gynoecious sex type .....	10:047	seedling fusarium wilt resistance .....	11:068
muskmelon, monoecious sex expression .....	3:032	single gene for anthracnose resistance? .....	11:064
muskmelon, perfect flower induction .....	3:035	susceptibility to anthracnose .....	6:062
muskmelon, regulation of gynomonoecious expression .....	1:018	update of gene list .....	10:106
muskmelon, sex form and fruit shape .....	4:026		
muskmelon, silver nitrate & perfect flowers .....	8:057	<b>yield</b>	
muskmelon, stability of male sterile-1 .....	3:031	cucumber, border row competition effects on yield .....	6:038
muskmelon, third male sterile gene .....	6:046	cucumber, compact & vining isoline yields .....	5:006
		cucumber, end border effects on plot yield .....	7:031
<b>spacing</b>		cucumber, growth analysis for plant habit and yield .....	7:017
cucumber, compact & vining isoline yields .....	5:006	cucumber, heat unit summation & harvest prediction .....	8:009
cucumber, spacing & yield of hardwickii derivatives .....	6:003	cucumber, heritability of fruit number .....	3:010
		cucumber, homo- & heterogeneous population yields .....	7:033
<b>taxonomy</b>		cucumber, improvement for increased fruit yield .....	6:018
Cucumis spp., identification of <i>Cucumis</i> taxa .....	3:055	cucumber, improvement for increased fruit yield .....	7:009
Cucumis spp., taxonomy of <i>C. callosus</i> (wild melon) .....	3:066	cucumber, multiple-harvest vs. once-over yield .....	5:020
Cucumis spp., taxonomy of <i>Dosakaya</i> (acid melon) .....	3:064	cucumber, optimum plot size for once-over harvest .....	7:035
Cucurbita spp., <i>C. fraterna</i> , progenitor of <i>C. pepo</i> .....	10:069	cucumber, plant density & multiple-harvest yield .....	10:029
Cucurbita spp., <i>C. martinii</i> versus <i>C. okeechobeensis</i> ....	3:045	cucumber, single-plant vs. multiple harvest yield .....	5:014
Cucurbita spp., overview - the <i>Cucurbita</i> spp. ....	6:077	cucumber, spacing & yield of hardwickii derivatives .....	6:003
Cucurbita spp., systematics of the melon-squash .....	3:047	cucumber, vegetative phase & partitioning .....	7:014
Cucurbita spp., taxonomy and rarity of <i>C. okeechobeensis</i> ..	11:083	cucumber, yield evaluation of inbred lines .....	8:018
general, gene nomenclature for the Cucurbitaceae .....	1:042	<i>Cucurbita</i> spp., fruit thinning & dry matter accumulation ...	6:072
		<i>Cucurbita</i> spp., improving seed yield in hull-less <i>C. pepo</i> ..	11:072
<b>utilization</b>		<i>Cucurbita</i> spp., productivity of bush & vine winter squash ..	5:040
Cucumis spp., <i>C. anguria</i> as a vegetable in Brazil .....	8:081	watermelon, culture and yield with tetraploids .....	6:059
<i>Cucurbita</i> spp., versatility of feral buffalo gourd .....	1:025		
<b>watermelon (<i>Citrullus lanatus</i>)</b>			
'Moon and Stars' variegation .....	6:068		
anthracnose resistance and pale leaf .....	2:029		
bacterial rind necrosis in North Carolina .....	5:036		
cultivar interaction w/ <i>Fusarium oxysporum</i> .....	8:062		
culture and yield with tetraploids .....	6:059		
<i>Diabrotica</i> resistance and plant form .....	2:028		
direct seeding of seedless triploids .....	2:027		
evaluation of African germplasm .....	11:069		
evidence for a tetrasomic line .....	11:057		
factors delaying seed germination .....	6:064		
germplasm resources .....	10:064		
glabrous & ms segregation in tetraploid .....	9:084		
hypersensitivity to anthracnose infection .....	4:032		
improvement with polyploidy .....	2:025		

## Cucurbit Genetics Cooperative Membership Directory

### Individual Members

- Adams, Howard** Northrup King & Co., 10290 Greenway Rd., Naples, FL, 33962.
- Adelberg, Jeffrey W.** Clemson Univ./EREC, P.O. Box 247, Blackville, SC, 29817.
- Alexandrova, Maria Maritza** Inst. Vegetable Crops, Plovdiv 4003, Bulgaria.
- Andres, T.C.** NYAES, Dept. Seed & Vegetable Sciences, Hedrick Hall, Geneva, NY, 14456.
- Arend, Wim van der** Nunhems Zaden B.V., P.O. Box 4005, 6080 AA Haalen, The Netherlands.
- Ayuso, Ma Cruz** PetoSeed Iberica, S.A., Carretera de Malaga, 34, 04710 Santa Maria del Aguila, Almeria, Spain.
- Baker, L.R.** Asgrow Seed Company, 7171 Portage Ave., Kalamazoo, MI, 49001.
- Balgooyen, Bruce** 4550 Besser Court, Chico, CA, 95926.
- Barham, Warren S.** 7401 Crawford Drive, Gilroy, CA, 95020.
- Baumgartner, Oswald** Saatzucht Gleisdorf, Ges.m.b.h. & Co. KG, Am Tieberhof 33, 8200 Gleisdorf, Austria.
- Blokland, G.D. van** Royal Sluis, Postbox 22, 1600 AA Enkhuizen, The Netherlands.
- Bohn, G.W.** 1094 Klish Way, Del Mar, CA, 92014.
- Boorsma, P.A.** Vegetable Research, Sluis & Groot, P.O. Box 26, 1600 AA Enkhuizen, The Netherlands.
- Bowman, Richard** Vlastic Foods, Inc., West Bloomfield, MI, 48033.
- Boyer, Charles** Department of Horticulture, 101 Tyson Building, The Pennsylvania State University, University Park, PA, 16802.
- Carey, Edward E.** CIP, AA 5969, Lima, Peru.
- Chambliss, O.L.** Department of Horticulture, Auburn University, Auburn, AL, 36830.
- Chambonnet, Daniel** Station d'Amelioration des Plantes Maraicheres, B.P. 94, 84140 Montfavet, France.
- Chen, Fure-Chyi** Dept. Horticulture, Taiwan Agr. Res. Inst., Wu-feng, Taichung, Taiwan 41301, Republic of China.
- Chen, N.C.** W. Atlee Burpee Company, 335 S. Briggs Road, Santa Paula, CA, 93060.
- Chung, Paul** PetoSeed Company, Inc., Rt. 4, Box 1255, Woodland, CA, 95695.
- Clayberg, C.D.** Department of Horticulture, Waters Hall, Kansas St. University, Manhattan, KS, 66502.
- Cohen, Yigal** Department of Life Sciences, Bar-Ilan University, Ramat-Gan 52 100, Israel.
- Combat, Bruno** Societe L. Clause, Avenue L. Clause, 91221 Breigny-sur-Orge, France.
- Cox, Edward** Texas Agricultural Research Station, 2415 East Highway 83, Weslaco, TX, 78596.
- Coyne, Dermot P.** Dept. Horticulture, Univ. Nebraska, Rm. 386 Plant Science Hall, Lincoln, NE, 68583-0724.
- Crino', Paola** ENEA C.R.E. Casaccia, Dept. Agrobiotechnologies, P.O. Box 2400, 00100 - Roma A.D., Italy.
- Crubaugh, Linda** Department of Horticulture, 1575 Linden Drive, Univ. Wisconsin, Madison, WI, 53706.
- Cuartero, J.** Estacion Experimental La Mayora, Algarrobo-Costa (Malaga), Spain.
- Custers, J.B.M.** Inst. Horticultural Plant Breeding, P.O. Box 16, 6700 AA Wageningen, The Netherlands.
- Dane, Fenny** 1030 Sanders Street, Auburn, AL, 36830.
- de Groot, Ir. E** Veredeling Almeria, c/o Zaadunie B.V., Postbus 26, 1600 AA Enkhuizen, Netherlands.
- DeVerna, J.W.** Campbell Institute for Research and Technology, Route 1, Box 1314, Davis, CA, 95616.
- Drowns, Glenn R.R.** 1, Box 166, Calamus, IA, 52729.
- Dumlao, Rosa** Harris Moran Seed Co., P.O. Box 7307, Sun City, FL, 33586-7307.
- Dupuy, G.** Union des Cooperatives Agricoles Armagnac-Bigorre, Centre de Recherches, Mas d'Aptel, 30510 Generac, France.
- Eigsti, Nick** Northrup King Seed Co., 10290 Greenway Road, Naples, FL, 33961.
- Eigsti, Orié J.** 17305, SR 4, RR 1, Goshen, IN, 46526.
- Elmstrom, Gary** Univ. Florida Agriculture Res. Center, P.O. Box 388, Leesburg, FL, 32748.
- Eyberg, Dorothy A.** 8200 David C. Brown Highway, Naples, FL, 33999.
- Fassuliotis, George** U.S. Vegetable Laboratory, 2875 Savannah Highway, Charleston, SC, 29414.
- Fujieda, Kunimitsu** Faculty of Agriculture, Kyushu University, Hakozaki, Fukuoka 812, Japan.
- Gabelman, W.H.** Department of Horticulture, University of Wisconsin, Madison, WI, 53706.
- Gabert, August C.** ARCO Seed Company, 8850 59th Ave. NE, Brooks, OR, 97305-0008.
- Gabillard, D.** Vilmorin, La Costiere, Ledenon, 30210 Remoulins, France.

- Galun, Esra** The Weizman Institute of Science, Department of Plant Genetics, Rehovot 76100, Israel.
- Gautier, Graines** B.P. No. 1, 13630 Eyragues, France.
- Giraud, Christine** Les Graines Cailard, Domaine Du Moulin, 84260 Sarrians, France.
- Gomez-Guillamon, Maria Luisa** Estacion Experimental La Mayora, Algarrobo- Costa (Malaga), Spain.
- Gonon, Yves** Mas de Rouzel, Route de Generac, 3000 Nimes, France.
- Groff, David** Asgrow Seed Company, R.R. #1, Bridgeton, NJ, 08302.
- Grumet, Rebecca** Department of Horticulture, Plant and Soils Building, Michigan State University, East Lansing, MI, 48824-1325.
- Hagihara, Toshitsugu** Hagihara-Noujou 984, Hokigi, Tawaramotocho, Siki-gun Nara-ken, Japan.
- Hassan, Ahmed A.** Faculty of Agriculture, University of U.A.E., Box 15551, Al- Ain, United Arab Emirates.
- Hassan, Mohamed Nabil** Faculty of Agriculture, El-Minia University, El-Minia, Egypt.
- Havey, Michael J.** USDA/ARS, Department of Horticulture, University of Wisconsin, Madison, WI, 53706.
- Henderson, W.R.** Department of Horticultural Science, Box 5216, North Carolina St. University, Raleigh, NC, 27650-5216.
- Herman, Ran** "Zeraim" Seed Growers Company Ltd., Department of Breeding, Gedera, Israel.
- Herrington, Mark** Redlands Horticultural Research Station, Delancey Street, Ormiston, Queensland 4163, Australia.
- Hirabayashi, Tetsuo** Nihon Horticultural Production Institute, 207 Kamishiki, Matsudo-shi, Chiba-ken, Japan.
- Hollar, James C.** Hollar & Company, Inc., P.O. Box 204, Colusa, CA, 95932.
- Hollar, Larry A.** Hollar & Co., Inc., P.O. Box 106, Rocky Ford, CO, 81067.
- Holle, Miguel** Choquechuanca 851, Lima 27, Peru.
- Hung, Lih** #13, Alley 5, Lane 30, Chow-shan Road, Taipei, Taiwan, Republic of China.
- Hutton, Mark** Petoseed Co., Inc., R.R. 2, Box 80 A, Bridgeton, NJ, 08302.
- Igarashi, Isamu** Strawb & Lettuce Brdg Lab; Morioka Br, Natl Res Inst, Veg, Orn Plts & Tea; 92-Shimokuriyagawa, Morioka, Iwate, Japan 020-01.
- Ignart, Frederic** Ets TEZIER Centre de Recherche, Domaine de Maninct, Route de Beaumont, 26000 Valence, France.
- Iida, Akira** Minowa Noen, 63-1 Ichieda-cho, Yamato-Kohriyama City, Nara Pref., Japan, T639-11.
- Ito, Kimio** Morioka Branch, Natl. Res. Inst. Veg., Orn. Pl. & Tea, 92 Shimokuriyagawa, Morioka, Iwate 020-01, Japan.
- Jaramillo-Vasquez, Juan** ICA Horticultura, AA 233 Palmira, Colombia.
- Jarl, Carin I.** Biotechnology, Zaadunie BV, P.O. Box 26, 1600 AA Enkhuizen, The Netherlands.
- Jebari, Hager** Inst. Natl. de la Recherche Agronomique - Tunisie, 2 Av. de l'Independance, Ariana, Tunis, Tunisia.
- Juvik, John** Department of Horticulture, Vegetable Crops Building, University of Illinois, Urbana, IL, 61801.
- Kanno, Tsuguo** Cucurbitaceous Crops Brdg Lab, Ministry Agric, Natl Res Inst Vegetables, Orn. Plants & Tea, Ano, Ago-Gun, Mie, Japan 514-23.
- Karchi, Zvi** Div. Vegetable Crops, Agr. Research Org., Newe Ya'ar Experiment Station, P.O. Haifa, Israel.
- Katsiotis, Andreas** Dept. Agronomy, Univ. Wisconsin-Madison, 1575 Linden Drive, Madison, WI, 53706-1597.
- Kirkbride, Joseph H., Jr.** USDA, Agricultural Research Service, Plant Exploration & Taxonomy Lab, Bldg. 265, BARC-East, Beltsville, MD, 20705.
- Klapwijk, Ad. A.** TS Agro Research & Development B.V., P.O. Box 263, 3340 AG H.I. Ambacht, The Netherlands.
- Kuginuki, Yasuhisa** Natl. Research Inst. Vegetables, Orn. Plants & Tea, Ano, Age-Gun, Mie, Japan 514-23.
- Kuti, Joseph O.** College of Agric. & Home Econ., Texas A&I University, Kingsville, TX, 78363.
- Kwack, Soo Nyeon** Department of Horticultural Breeding, Mokpo Natl. Univ., Dorimri, Chonggyemyun, Muangun, Chonnam 580-41, Korea.
- Ladd, Krystyna M.** Northrup King Co. Research Center, P.O. Box 1827, Gilroy, CA, 95020.
- Lafond, M.D.** Vilmorin, La Menitre, 49250 Beaufort-en-Vallee, France.
- Laymon, Carol A.** Druiter Seeds, Inc., P.O. Box 20228, Columbus, OH, 43220.
- Lee, Alex** Neuman Seed Company, 2575 Pinewood St., Del Mar, CA, 92014.
- Leeuwen, Loes van** Sluis y Groot Semillas, Apartado 57, El Ejido (Almeria), Spain.
- Lin, Depai** Xinjiang August 1st Agricultural College, Department of Horticulture, Urumqi, People's Rep. China.
- Love, Stephen L.** University of Idaho, Research and Extension Center, Aberdeen, ID, 83210.
- Lower, R.L.** Office of the Dean & Director, 136 Agriculture Hall, Univ. Wisconsin, Madison, WI, 53706.
- Loy, J. Brent** Department of Plant Sciences, University of New Hampshire, Durham, NH, 03824.

- Lundin, Marianne** Weibullsholm Plant Breeding Institute, Box 250, S-261 24 Landskrona, Sweden.
- Mackay, Wayne A.** Department of Horticulture, University of Maryland, College Park, MD, 20742-5611.
- Mackiewicz, Henryk O.** UL Bosniowa 5 m 45, 05-800 Pruszkow, Poland.
- Maiero, Marisa** University of Maryland, Department of Horticulture, College Park, MD, 20742-5611.
- Maluf, Wilson Roberto** Bioplanta Tecnologia de Plantas Ltda., Caixa Postal 1141, 13100 Campinas SP, Brazil.
- Maneesinthu, Likhit** Chia Tai Company Limited, 299-301 Songsawad Road, Bangkok 10100, Thailand.
- McArdle, Richard** General Foods Technical Center, 555 South Broadway, Tarrytown, NY, 10591.
- McCreight, J.D.** USDA-ARS, 1636 E. Alisal St., Salinas, CA, 93915.
- McFerson, Jim** PetoSeed Co., Inc., RR 2, Box 80A, Bridgeton, NJ, 08302-8723.
- McGrath, D. J.** Horticultural Research Station, P.O. Box 538, Bowen. 4805. Queensland, Australia.
- Merrick, Laura C.** Department of Plant & Soil Sciences, 105 Deering Hall, University of Maine, Orono, ME, 04469.
- Miller, Chris** Scmillas Shell, Apartado de Correos 17, 04720 Agua Dulce, Almeria, Spain.
- Milotay, Peter** Vegetable Crops Research Institute, P.O. Box 116, Kecskemet, 6000, Hungary.
- Ming, Wang** Department of Horticulture, Northwestern Agricultural University, Wugong, Shaanxi, People's Rep. China.
- Mochizuki, Tatsuya** Agriculture, Forestry and Fisheries Research Council, Kasumigascki, Chiyoda, Tokyo 100, Japan.
- Monteiro, Antonio A.** Section of Horticulture, Inst. Superior de Agronomia, Techn. Univ. Lisbon, Lisbon, Portugal.
- Moraghan, Brian J.** Asgrow Seed Co., P.O. Box 667, Arvin, CA, 93203.
- Msikita, Weston** Department of Horticulture, 106B Hort. Field Lab., 1707 South Orchard, University of Illinois, Urbana, IL, 61801.
- Munger, H.M.** Cornell University, 410 Bradford Hall, Ithaca, NY, 14853.
- Murdock, Brent A.** Clemson University, Department of Horticulture, Clemson, SC, 29634-0375.
- Mutangadura, Tandai** Dept. Biological Sci., Univ. Zimbabwe, P.O. Box MP 167, Mount Pleasant, Harare, Zimbabwe.
- Mutschler, Martha A.** Department of Plant Breeding & Biometry, 252 Emerson Hall, Cornell University, Ithaca, NY, 14853.
- Nagai, Hiroshi** Instituto Agronomico, Cx Postal 28, 13.100-Campinas, Sp., Brazil.
- Navazio, John** College of the Atlantic, P.O. Box 603, Bar Harbor, ME, 04609.
- Nechama, Shulamit** Breeding Department, Mivhor Farm, Post Sde Gat 79570, Israel.
- Ng, Timothy J** Department of Horticulture, University of Maryland, College Park, MD, 20742-5611.
- Niego, Shlomo** Plant Genetics, The Weizman Institute of Science, Rehovot, Israel.
- Niemirowicz-Szczytt, Katarzyna** Dept. Genetics & Hort. Plant Breed., ul. Nowoursynowska 166, 02-766 Warszawa, Poland.
- Norton, J.D.** Department of Horticulture, Auburn University, Auburn, AL, 36830.
- Nuez, Fernando** Departamento de Genetica, E.T.S. Ingenieros Agronomos, Universidad Politecnica, Cno. de Vera, 14, Valencia-22, Spain.
- Oh, Dae-Geun** Department of Horticulture, Horticulture Building, Purdue University, West Lafayette, IN, 47907.
- Oizumi, Toshikatsu** Muskmelon Brdg Lab, Chiba Prefect Hort Res Station, 1762, Yamamoto, Tateyama, Chiba, Japan 294.
- Om, Y.H.** Horticulture Experiment Station, Office of Rural Development, Suweon 170, Korea.
- Oridate, Toshiroh** 15 Karasawa, Minami-ku, Yokohama-shi, Kanagawa-ken, Japan.
- Ortega, Sergio Garza** Universidad de Sonora, Escuela de Agricultura y Ganaderia, Hermosillo, Sonora, Mexico.
- Owens, Ken** PetoSeed Company, Inc., Rt. 4, Box 1225, Woodland, CA, 95695.
- Palmer, Mary Jean** Dept. Horticulture, Univ. Wisconsin, 1575 Linden Drive, Madison, WI, 53706.
- Paris, Harry** Division of Vegetable Crops, Agric. Research Org., Newe Ya-ar Expt. Station, P.O. Haifa, Israel.
- Park, Hyo Guen** Dept. Horticulture/Coll. Agriculture, Seoul National University, Suwon, Korea 440-744.
- Pierce, Lawrence** 1583 Endicott Drive, San Jose, CA, 95122.
- Pierce, Vicki** 1583 Endicott Drive, San Jose, CA, 95122.
- Pitrat, Michel** Centre de Recherches Agronomiques de Avignon, Stat. d'Amelior. des Plantes Mar., Domaine St.-Maurice, 84140 Montfavet, France.
- Poli, Virgil** Staunea de Cercetari Legumicole, Isalnita-Craiova, Romania.
- Poostchi, Iraj** 97 St. Marks Road, Henley-on-Thames RG9 1LP, England.
- Price, E. Glen** American Sunmelon, P.O. Box 153, Hinton, OK, 73047.
- Providenti, Rosario** Department of Plant Pathology, NYAES, Cornell University, Geneva, NY, 14456-0462.

- Ramachandran, C.** Department of Botany, Ohio State Univ., 1735 Neil Avenue, Columbus, OH, 43210-1293.
- Ray, Dennis** Department of Plant Sciences, University of Arizona, Tucson, AZ, 85721.
- Rhodes, Billy B.** Edisto Experiment Station, P.O. Box 247, Blacksville, SC, 29817.
- Rigert, Kathleen S.** Agri-Analysis Associates, P.O. Box 285, Davis, CA, 95617.
- Risser, Georgette** Centre de Recherches Agronomiques de Avignon, Stat. d'Amelior. des Plantes Mar., Domaine St.-Maurice, 84140 Montfavet, France.
- Robinson, R.W.** Department of Horticultural Science, New York St. Agr. Experiment Station, Geneva, NY, 14456.
- Rodriguez, Jose Pablo** 25 De Mayo 75, 2930-San Pedro, Buenos Aires, Republica Argentina.
- Rodriguez, Pilar C.** Asgrow Seed Co., Apdo. 175, 04700 El Ejido (Almeria), SPAIN.
- Roig, Luis A.** Departamental Biotechnology, E.T.S. Ingenieros Politecnica, Camino de Vera 14, 46022 - Valencia, Spain.
- Ruiter, Ir. A.C. de** Deruiterzonen Seed Comopany, Postbus 4, Bleiswijk, The Netherlands.
- Rumsey, Anthony E.** New World Seeds Pty Ltd., P.O. Box 18, Dural 2158, 22-24 Crosslands Road, Galston, N.S.W., Australia.
- Scheirer, Douglas M.** Libby, McNeill & Libby, Inc., P.O. Box 198, Morton, IL, 61550.
- Schnock, Martin G.** Norsingen, Fridolin-Mayer-Strasse 5, D-7801 Ehrenkirchen, Fed. Rep. Germany.
- Schroeder, R.H.** Harris Moran Seed Co., P.O. Box 2508, El Macero, CA, 95618.
- Sekioka, Terry T.** Kauia Branch Station, University of Hawaii, Kapaa, HI, 96746.
- Semillas Fito, S.A.,** AVDA, Marquest de Argentera, 19, Barcelona - 3, Spain.
- Seshadri, V.S.** Division of Vegetable Crops & Floriculture, Indian Agricultural Research Institute, New Delhi-110012, India.
- Sharma, Govind C.** Department of Natural Resources, Alabama A&M University, Normal, AL, 35762.
- Shifriss, Oved** 21 Walter Avenue, Highland Park, NJ, 08904.
- Shiga, Toshio** Plant Biotech. Ctr., Sakata Seed Corp., 358 Uchikoshi, Sodegaura, Chiba, 299-02, Japan.
- Simon, Philipp W.** 5125 Lake Mendota Drive, Madison, WI, 53705.
- Skirvin, Robert M.** Univ. Illinois, Dept. Horticulture, 1707 S. Orchard St., Urbana, IL, 61801.
- Sockell, M.** Amelioration des Plantes (Lab.), Univ. de Paris Xi, 91405 Orsay Cedex, France.
- Staub, Jack E.** USDA-ARS, Department of Horticulture, University of Wisconsin, Madison, WI, 53706.
- Stern, Joseph** Royal Sluis Inc., 1293 Harkins Road, Salinas, CA, 93901.
- Tasaki, Seikoh** AOS/Q-O2, Bloco-E, Apt. 603, CEP-70660, Brasilia DF, Brazil.
- Taurick, Gary** Ferry Morse Seed Company, P.O. Box 392, Sun Prairie, WI, 53590.
- Thomas, Claude E.** USDA-ARS, U.S. Vegetable Laboratory, 2875 Savannah Highway, Charleston, SC, 29407.
- Thomas, Paul** PetoSeed Co., Inc., Rt. 4, Box 1255, Woodland, CA, 95695.
- Tolla, Greg** Campbell Inst. Agric. Research & Techn., Napoleon, OH, 43545.
- Unander, David** P.O. Box 168, Downington, PA, 19335.
- Vakalounakis, Demetrios J.** Plant Protection Institute, P.O. Box 1802, Heraklion, Crete, Greece.
- Ventura, Yaacov Hazera Ltd.,** Breeding Department, Mivhor Farm, Post Sde Gat 79570, Israel.
- Verhoef, Ruud Bruinsma** Selectiebedrijven B.V., P.O. Box 24, 2670 AA Naaldwijk, The Netherlands.
- Walters, Deena Decker** Department of Botany, University of Guelph, Guelph, Ontario N1G 2W1, Canada.
- Watterson, Jon** PetoSeed Company, Inc., Rt. 4, Box 1255, Woodland, CA, 95695.
- Wehner, Todd C.** Department of Horticultural Science, Box 7609, North Carolina State University, Raleigh, NC, 27695-7609.
- Weichmann, J.** Vegetable Crops Sci. Inst., Technical Univ. Munich, 8050 Freising-Weihenstephan, Fed. Rep. Germany.
- Wessel-Beaver, Linda** Department of Agronomy & Soils, College of Agriculture, Univ. Puerto Rico, Mayaguez, PR, 00709.
- Whitaker, T.W.** P.O. Box 2763, La Jolla, CA, 92038.
- Whiteaker, Gary** Cannery Seed Corp., 221 East Main Street, Lewisville, ID, 83431.
- Williams, Tom V.** Northrup King & Co., 10290 Greenway Road, Naples, FL, 33962.
- Wyatt, Colen** PetoSeed Company, Inc., Rt. 4, Box 1255, Woodland, CA, 95695.
- Yamanaka, Hisako** Yamato-Noen Co., Ltd., 110, Byodobo-cho, Tenri - City NARA, Japan 632.
- Yeh, Shyi-Dong** Dept. Plant Pathology, National Chung Hsing Univ., Taichung, Taiwan, Republic of China.
- Yorty, Paul** Musser Seed Company, Box 1406, Twin Falls, ID, 83301.
- Yutaka, Tabei** Natl. Res. Inst. Vegetables, Orn. Plants & Tea, Ano, Age-Gun, Mie, Japan 514-23.
- Zuta, Zeev** Breeding Department, Shalem Farm, D.N. Or-Yehuda 60200, Israel.



### Library Memberships

**A.R. Mann Library** College on Human Ecology, New York State College of Agricultural & Life Sciences, Ithaca, NY, 14853.

**Biblioteca Instituto Valenciano de Investigaciones Agrarias** Apartado Oficial, Moncada, Valencia, Spain.

**BIOSEM** Attn: Sofia Ben Tahar, Campus Universitaire des Cezeaux, 24, Avenue des Landais, 63170 Aubierre, France.

**British Library, Document Supply Center** Serial Acquisitions, Boston Spa, Wetherby, West Yorkshire LS23 7BQ, England.

**Central Library of Agricultural Science** P.O. Box 12, Rehovot, 76 100, Israel.

**Del Monte Corp.** P.O. Box 36, San Leandro, CA, 94577.

**DNA Plant Technology, Inc.** Attn: Nergish Karanja, Librarian, 2611 Branch Pike, Cinnaminson, NJ, 08077.

**Estacion Experimental Menioza** Casilla de Correo 3, 5507 Lujan de

Cuyo, Mendoza, Republica Argentina.

**Estacion Experimental Santiago del Estero** Casilla de Correo 268, 4200 Santiago del Estero, Republica Argentina.

**I.N.R.A. Regie Centre Avignon** Domain St. Paul, Montfavet, France.

**Institut Za Povrtarsvo Palanka** Karadjordjeva 71, 11420 Smederevska Palanka, Yugoslavia.

**Institute National De La Rech. Agronom.** Laboratoire D'Amelioration des Plantes, University de Paris-Sud - Bat. 360, Centre D'Orsay, F, 91405 Orsay Cedex, France.

**Institute Za Ratarstvo 1 Povrtarstvo** Biblioteka, M. Gorkog 30, 21-000 Novi Sad, Yugoslavia.

**J.E. Ohsens Enke A/S** Roskildevej 325A, DK-2630, Tastrup, Denmark.

**National Vegetable Research Station** Attn: The Librarian, Wellesbourne, Warwick CV35 9EF, England.

**New York State Agricultural Experiment Station** Library, Jordan Hall, Geneva, NY, 14456.

**Robson Seed Farms** One Seneca Circle, Hall, NY, 14463.

**Sakata Seed America** Research Station, P.O. Box 6007, Salinas, CA, 93912.

**Servicio de Investigacion Agraria** Library, Departamento de Agricultura, Montanana, 176, Zaragoza, Spain.

**Swets North America** P.O. Box 517, Berwyn, PA, 19312.

**Taiwan Agricultural Research Institute** 189 Chung-cheng Road, Wan-feng, Wu-feng, Taichung, Taiwan, Republic of China.

**Universita degli Studi di Bari** Dipartimento di Patologia Vegetale, Via G. Amendola, 165/A, 70126 Bari, Italy.

**University of California, Davis** The Library, Davis, CA, 95616.

## Geographical Distribution of CGC Members in the United States

<p><b>Alabama</b> O.L. Chambliss Fenny Dane J.D. Norton Govind C. Sharma</p>	<p>Rosa Dumlao Nick Eigsti Gary Elmstrom Dorothy A. Eyberg Tom V. Williams</p>	<p>Marisa Maiero Timothy J Ng</p>	<p><b>Oklahoma</b> E. Glen Price</p>
<p><b>Arizona</b> Dennis Ray</p>	<p><b>Hawaii</b> Terry T. Sekioka</p>	<p><b>Michigan</b> L.R. Baker Richard Bowman Rebecca Grumet</p>	<p><b>Oregon</b> August C. Gabert</p>
<p><b>California</b> Bruce Balgooyen Warren S. Barham G.W. Bohn N.C. Chen Paul Chung J.W. DeVerna James C. Hollar Krystyna M. Ladd Alex Lee J.D. McCreight Brian J. Moraghan Ken Owens Lawrence Pierce Vicki Pierce Kathleen S. Rigert R.H. Schroeder Joseph Stern Paul Thomas Jon Watterson T.W. Whitaker Colen Wyatt</p>	<p><b>Idaho</b> Stephen L. Love Gary Whiteaker Paul Yorty</p>	<p><b>Nebraska</b> Dermot P. Coyne</p>	<p><b>Pennsylvania</b> Charles Boyer David Unander</p>
<p><b>Colorado</b> Larry A. Hollar</p>	<p><b>Illinois</b> John Juvik Weston Msikita Douglas M. Scheirer Robert M. Skirvin</p>	<p><b>New Hampshire</b> J. Brent Loy</p>	<p><b>Puerto Rico</b> Linda Wesscl-Beaver</p>
<p><b>Florida</b> Howard Adams</p>	<p><b>Indiana</b> Oric J. Eigsti Dae-Geun Oh</p>	<p><b>New Jersey</b> David Groff Mark Hutton Oved Shifriess Jim Snyder</p>	<p><b>South Carolina</b> Jeffrey W. Adelberg George Fassuliotis Brent A. Murdock Billy B. Rhodes Claude E. Thomas</p>
	<p><b>Iowa</b> Glenn Drowns</p>	<p><b>New York</b> T.C. Andrcs Richard McArdle H.M. Munger Martha A. Mutschler Rosario Provvidenti R.W. Robinson</p>	<p><b>Texas</b> Edward Cox Joseph O. Kuti</p>
	<p><b>Kansas</b> C.D. Clayberg</p>	<p><b>North Carolina</b> W.R. Henderson Todd C. Wehner</p>	<p><b>Wisconsin</b> Linda Crubaugh W.H. Gabelman Michael J. Havey Andreas Katsiotis R.L. Lower Mary Jean Palmer Philipp W. Simon Jack E. Staub Gary Taurick</p>
	<p><b>Maine</b> Laura C. Merrick John Navazio</p>	<p><b>Ohio</b> Carol A. Laymon C. Ramachandran Greg Tolla</p>	
	<p><b>Maryland</b> Joseph H. Kirkbride, Jr. Wayne A. Mackay</p>		

## CGC Members in Countries other than the United States

<b>Argentina</b> Jose Pablo Rodriguez	<b>England</b> Iraj Poostchi	<b>Zeev Zuta</b>	<b>Peru</b> Edward E. Carey Miguel Holle
<b>Australia</b> Mark Herrington D. J. McGrath Anthony E. Rumsey	<b>France</b> Daniel Chambonnet Bruno Combat G. Dupuy D. Gabillard Graincs Gautier Christine Giraud Yves Gonon Frederic Ignart M.D. Lafond Michel Pitrat Georgette Risser M. Sockell	<b>Italy</b> Paola Crino'	<b>Poland</b> Henryk O. Mackiewicz Katarzyna Niemirowicz-Szczytt
<b>Austria</b> Oswald Baumgartner	<b>Germany, Federal Republic of</b> Martin G. Schnock J. Weichmann	<b>Japan</b> Kunimitsu Fujieda Toshitsugu Hagihara Tetsuo Hirabayashi Isamu Igarashi Akira Iida Kimio Ito Tsuguo Kanno Yasuhisa Kuginuki Tatsuya Mochizuki Toshikatsu Oizumi Toshiroh Oridate Toshio Shiga Hisako Yamanaka Tabci Yutaka	<b>Portugal</b> Antonio A. Monteiro
<b>Brazil</b> Wilson Roberto Maluf Hiroshi Nagai Seikoh Tasaki	<b>Greece</b> Demetrios J. Vakalounakis	<b>Korea</b> Soo Nycon Kwack Y.H. Om Hyo Guen Park	<b>Romania</b> Virgil Poli
<b>Bulgaria</b> Maria Alexandrova	<b>Hungary</b> Peter Milotay	<b>Mexico</b> Sergio Garza Ortega	<b>Spain</b> Ma Cruz Ayuso J. Cuartero Marja Luisa Gomez-Guillamon Loes van Lecuwen Chris Miller Fernando Nuez Pilar C. Rodriguez Luis A. Roig Semillas Fito, S.A.
<b>Canada</b> Deena Decker Walters	<b>India</b> V.S. Seshadri	<b>Netherlands, The</b> P.A. Boorsma J.B.M. Custers Ir. E de Groot Ir. A.C. de Ruiten Carin I. Jarl Ad. A. Klapwijk Wim van der Arend G.D. van Blokland Ruud Verhoef	<b>Sweden</b> Marianne Lundin
<b>China, Peoples' Republic of</b> Depei Lin Wang Ming	<b>Israel</b> Yigal Cohen Esra Galun Ran Herman Zvi Karchi Shulamit Nechama Shlomo Niego Harry Paris Yaacov Ventura		<b>Thailand</b> Likhit Mancesinthu
<b>China, Republic of</b> Fure-Chyi Chen Lih Hung Shyi-Dong Yeh			<b>Tunisia</b> Hager Jebari
<b>Colombia</b> Juan Jaramillo-Vasquez			<b>United Arab Emirates</b> Ahmed A. Hassan
<b>Egypt</b> Mohamed Nabil Hassan			<b>Zimbabwe</b> Tandai Mutangadura

COVENANT AND  
BY-LAWS OF THE  
CUCURBIT GENETICS COOPERATIVE

ARTICLE I. Organization and Purposes

The Cucurbit Genetics Cooperative is an informal, unincorporated scientific society (hereinafter designated "CGC") organized without capital stock and intended not for business or profit but for the advancement of science and education in the field of genetics of cucurbits (Family: Cucurbitaceae). Its purposes include the following: to serve as a clearing house for scientists of the world interested in the genetics and breeding of cucurbits, to serve as a medium of exchange for information and materials of mutual interest, to assist in the publication of studies in the aforementioned field, and to accept and administer funds for the purposes indicated.

ARTICLE II. Membership and Dues

The membership of the CGC shall consist solely of active members; an active member is defined as any person who is actively interested in genetics and breeding of cucurbits and who pays biennial dues. Memberships are arranged by correspondence with the Chairman of the Coordinating Committee.

The amount of biennial dues shall be proposed by the Coordinating Committee and fixed, subject to approval at the Annual Meeting of the CGC. The amount of biennial dues shall remain constant until such time that the Coordinating Committee estimates that a change is necessary in order to compensate for a fund balance deemed excessive or inadequate to meet costs of the CGC.

Members who fail to pay their current biennial dues within the first six months of the biennium are dropped from active membership. Such members may be reinstated upon payment of the respective dues.

ARTICLE III. Committees

1. The Coordinating Committee shall govern policies and activities of the CGC. It shall consist of six members elected in order to represent areas of interest and importance in the field. The Coordinating Committee shall select its Chairman, who shall serve as a spokesman of the CGC, as well as its Secretary and Treasurer.

2. The Gene List Committee, consisting of five members, shall be responsible for formulating rules regulating the naming and symbolizing of genes, chromosomal alterations, or other hereditary modifications of the cucurbits. It shall record all newly reported mutations and periodically report lists of them in the Report of the CGC. It shall keep a record of all information pertaining to cucurbit linkages and periodically issue revised linkage maps in the Report of the CGC. Each committee member shall be responsible for genes and linkages of one of the following groups: cucumber, Cucurbita sp., muskmelon, watermelon, and other genera and species.

3. Other committees may be selected by the Coordinating Committee as the need for fulfilling other functions arises.

ARTICLE IV. Election and Appointment of Committees

1. The Chairman will serve an indefinite term while other members of the Coordinating Committee shall be elected for ten-year terms, replacement of a single retiring member taking place every other year. Election of a new member shall take place as follows: A Nominating Committee of three members shall be appointed by the Coordinating Committee. The aforesaid Nominating Committee shall nominate candidates for an anticipated opening on the Coordinating Committee, the number of nominees being at their discretion. The nominations shall be announced and election held by open ballot at the Annual Meeting of the CGC. The nominee receiving the highest number of votes shall be declared elected. The newly elected member shall take office immediately.

In the event of death or retirement of a member of the Coordinating Committee before the expiration of his/her term, he/she shall be replaced by an appointee of the Coordinating Committee.

Members of other committees shall be appointed by the Coordinating Committee.

ARTICLE V. Publications

1. One of the primary functions of the CGC shall be to issue an Annual Report each year. The Annual Report shall contain sections in which research results and information concerning the exchange of stocks can be published. It shall also contain the annual financial statement. Revised membership lists and other useful information shall be issued periodically. The Editor shall be appointed by the Coordinating Committee and shall retain office for as many years as the Coordinating Committee deems appropriate.

CGC 12:122 (1989)

Approvals:

W.P. Beards  
W. Beards

Joseph D. Norton  
J. D. Norton

R. W. Robinson  
R. W. Robinson

W. R. Henderson  
W. R. Henderson

Ken Robbins  
M. L. Robbins

R. L. Lower  
R. L. Lower

Approvals:

W.P. Beards  
W. Beards

Joseph D. Norton  
J. D. Norton

R. W. Robinson  
R. W. Robinson

W. R. Henderson  
W. R. Henderson

Ken Robbins  
M. L. Robbins

R. L. Lower  
R. L. Lower

2. Payment of biennial dues shall entitle each member to a copy of the Annual Report, newsletters, and any other duplicated information intended for distribution to the membership. The aforementioned publications shall not be sent to members who are in arrears in the payment of dues. Back numbers of the Annual Report, available indefinitely, shall be sold to active members at a rate determined by the Coordinating Committee.

**ARTICLE VI. Meetings**

An Annual Meeting shall be held at such time and place as determined by the Coordinating Committee. Members shall be notified of time and place of meetings by notices in the Annual Report or by notices mailed not less than one month prior to the meeting. A financial report and information on enrollment of members shall be presented at the Annual Meeting. Other business of the Annual Meeting may include topics of agenda selected by the Coordinating Committee or any items that members may wish to present.

**ARTICLE VII. Fiscal Year**

The fiscal year of the CGC shall end on December 31.

**ARTICLE VIII. Amendments**

These By-Laws may be amended by simple majority of members voting by mail ballot, provided a copy of the proposed amendments has been mailed to all the active members of the CGC at least one month previous to the balloting deadline.

**ARTICLE IX. General Prohibitions**

Notwithstanding any provision of the By-Laws or any other document that might be susceptible to a contrary interpretation:

1. The CGC shall be organized and operated exclusively for scientific and educational purposes.
2. No part of the net earnings of the CGC shall or may under any circumstances inure to the benefit of any individual.
3. No part of the activities of the CGC shall consist of carrying on propaganda or otherwise attempting to influence legislation of any political unit.

4. The CGC shall not participate in, or intervene in (including the publishing or distribution of statements), any political campaign on behalf of a candidate for public office.
5. The CGC shall not be organized or operated for profit.
6. The CGC shall not:
  - (a) lend any part of its income or corpus without the receipt of adequate security and a reasonable rate of interest to;
  - (b) pay any compensation in excess of a reasonable allowance for salaries or other compensation for personal services rendered to;
  - (c) make any part of its services available on a preferential basis to;
  - (d) make any purchase of securities or any other property, for more than adequate consideration in money's worth from;
  - (e) sell any securities or other property for less than adequate consideration in money or money's worth; or
  - (f) engage in any other transactions which result in a substantial diversion of income or corpus to any officer, member of the Coordinating Committee, or substantial contributor to the CGC.

The prohibitions contained in this subsection (6) do not mean to imply that the CGC may make such loans, payments, sales, or purchases to anyone else, unless authority be given or implied by other provisions of the By-laws.

**ARTICLE X. Distribution on Dissolution**

Upon dissolution of the CGC, the Coordinating Committee shall distribute the assets and accrued income to one or more scientific organizations as determined by the Committee, but which organization or organizations shall meet the limitations prescribed in sections 1-6 of Article IX.

<u>W. P. Bemis</u> W. Bemis (Cucurbits sp.)	<u>H. R. Henderson</u> W. R. Henderson (Watermelon)
<u>Joseph D. Norton</u> J. D. Norton (Muskmelon)	<u>Ken Robbins</u> M. L. Robbins (Cucumber)
<u>R. W. Robinson</u> R. W. Robinson (Other genes and species)	<u>R. L. Lower</u> R. L. Lower, Chairman

CGC 12:123 (1989)

Approvals:

<u>W. P. Bemis</u> W. Bemis	<u>Joseph D. Norton</u> J. D. Norton	<u>R. W. Robinson</u> R. W. Robinson
<u>H. R. Henderson</u> W. R. Henderson	<u>Ken Robbins</u> M. L. Robbins	<u>R. L. Lower</u> R. L. Lower

Cucurbit Genetics Cooperative

FINANCIAL STATEMENT

31 December 1988

Balance on 31 December 1987 \$2,190.78

Receipts

Dues and Back Issues	\$2,924.00	
Interest	\$ 170.96	
Total		+ \$3,094.96

Expenditures

Report No. 11 <sup>Z</sup>	\$1,301.32	
Membership Invoices <sup>Z</sup>	\$ 65.73	
Report No. 12 (Call for papers) <sup>Z</sup>	\$ 78.15	
Mailing back issue inventory from California to Maryland	\$ 105.17	
Back issue orders (envelopes & postage)	\$ 95.93	
Total		- \$1,646.30

---

Balance on 31 December 1988 \$3,639.44

<sup>Z</sup>Publishing and mailing