Cucurbit Genetics Cooperative

Report No. 13

June 1990

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

CGC Membership and Subscription Rates

Biennium	**Member**	**Library**
1990-91	$14.00 US*	$24.00 US

*Payment must be by a check drawn on a U.S. bank, or by a U.S. or International Postal Money Order. Checks and Money Orders should be made payable to "Cucurbit Genetics Cooperative." Airmail subscription rates for the CGC Report are also available upon request.

CGC Reports are issued on an annual basis. The Reports include articles submitted by members for the use of CGC members. 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 consent of the authors.

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Comments from the CGC Coordinating Committee

The Call for Papers for the 1991 Report (CGC Report No. 14) will be mailed in August 1990. 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.

Gary W. Elmstrom (muskmelon)
J. Brent Loy (*Cucurbita* spp.)
Dennis T. Ray (watermelon)
Richard W. Robinson (other genera)
Todd C. Wehner (cucumber)
Timothy J Ng, Chair

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 cucumber (*Cucumis sativus*), muskmelon (*Cucumis melo*), watermelon (*Citrullus lanatus*), 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 (see page 79) before selecting 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 while 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
Cucurbita 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	Watermelon:	Gary W. Elmstrom
Muskmelon:	J.D. McCreight		E. Glen Price
	Michel Pitrat		Billy B. Rhodes
Cucurbita spp.:	Richard W. Robinson		

13th Annual CGC Business Meeting
31 July 1989, Tulsa Oklahoma USA

The 13th Annual Business Meeting of the Cucurbit Genetics Cooperative was held on Monday, 31 July 1989, in conjunction with the 86th Annual Meeting of the American Society for Horticultural Science (ASHS) in Tulsa, Oklahoma. Despite being scheduled concurrent with an ASHS symposium on Biotechnology, 22 members and guests were in attendance. Minutes of the 12th Annual Business Meeting were approved as published in CGC Report 12:vii (1989).

CGC Report No. 12 was mailed on 3 June 1989. There were 300 copies printed; 216 copies were sent in the initial mailing (compared to 180 in 1988) and, with subsequent subscriptions, a total of 226 copies were mailed as of 19 July. A handout was distributed listing details of the CGC Reports during the period 1978-1989. All back issues of the CGC Reports were in stock, but inventory of CGC Reports Nos. 1 (1978) and 2 (1979) were down to approximately 10 copies each. CGC had 193 members in good standing, representing 33 countries in addition to the U.S.; there were 20 new members in 1989 as of July. In addition to individual memberships, there were 26 library subscriptions.

Cucurbitaceae '89 - Evaluation & Enhancement of Cucurbit Germplasm - was announced to be scheduled for Charleston, South Carolina, from 29 November to 2 December 1989. A new CGC Coordinating Committee member for watermelon was needed due to the expiration of Warren Henderson's term. The Nominations Committee chaired by Henderson and including C.E. Thomas and Gary Elmstrom nominated Dennis Ray (Univ. Arizona) for the position. There were no nominations from the floor and Ray was elected unanimously.

The Call for Papers for CGC Report No. 13 was scheduled to be sent in late August 1989. Submissions in electronic form on floppy disk (in addition to hard copy) would be solicited. The updated gene list for muskmelon (*Cucumis melo*) was scheduled for Report 13, and gene listings will henceforth carry notations as to which genes are available from CGC Gene Curators. Also scheduled in the near future is an expansion of the membership listings to include phone numbers and cucurbit interests.

Laura Merrick (Univ. Maine) queried the membership concerning information on the state of public sector plant breeding programs. With the recent decrease in the number of public plant breeding programs, many working collections of breeding materials are currently in "limbo." Merrick, who is compiling a mailing list of discontinued breeding programs, cited the examples of the currently inactive *Cucurbita* working collection compiled at the USDA Brawley station by T. Whitaker, who retired in 1970, and also the still active *Lycopersicon* germplasm collection compiled at U.C. Davis by C. Rick, who recently retired. R. Lower mentioned that there were several efforts underway in this area. NPBGR, under the direction of C. Hess (USDA), has set up a subcommittee headed by W. Collins (N.C. St.) to collect information on public sector breeding programs; questionnaires have already been sent out by the subcommittee. Also, the NAS Germplasm Committee conducts a biennial survey; 1986 data from this survey is currently available.

Jules Janick asked (1) whether anyone who worked with hull-less seed types in pumpkin had any success concerning problems with seed production, seed emergence and consumer acceptance, and (2) whether CGC would be interested in publishing a combined cucurbit gene list in Plant Breeding Reviews, which Janick edits. The latter issue will be considered by the CGC Coordinating Committee, Gene List Committee and Gene Curators during the coming year.

1989 CGC Fall Meeting

2 December 1989, Charleston, South Carolina USA

A special meeting of CGC was held in December 1989 in conjunction with Cucurbitaceae '89: Evaluation and Enhancement of Cucurbit Germplasm (see report elsewhere in this section). This was probably the largest gathering of CGC members ever, with over 80 members and guests in attendance. A brief history of CGC was presented as well as an overview of its present activities.

A discussion, initiated earlier in the conference by R.W. Robinson, continued concerning the vulnerability of gene collections by curators and institutions. Placing the responsibility of sole gene curator for a given cucurbit species on one individual is risky should anything unforeseen happen to the curator or his/her program. For example, the CGC watermelon gene collection a decade ago had been destroyed in a fire. It was decided that CGC should seek "back-up" gene curators for each of the species collections. D. Ray questioned whether genes that were no longer available should continue to be listed in the gene list updates for the CGC report. R.W. Robinson suggested that we should maintain our current policy, since the old mutations might recur or become available again.

Another point raised was that, since gene curators were involved in collecting, increasing and disseminating gene stocks, should CGC curators be appointed to perform a similar duty with races of known cucurbit pathogens? R. Martyn mentioned that race collections of cucurbit diseases were already available through the American Type Culture Collection (ATCC, Rockville, MD) and that breeders/pathologists should be encouraged to deposit new races with ATCC.

The topic of whether loci identified or developed through new genetic techniques (e.g. RFLPs, transgenic plants) should be included in the gene lists was discussed. M. Havey cited that cDNAs may not be identical to genomic DNA, and that the Bean Improvement Cooperative had been wrestling with this issue for 3 years. A. Morgan testified as to the government procedural difficulties involved in the transport of transgenic lines to sites other than where they were originated.

US Cucurbit Crop Advisory Committee 1990 Update

J.D. McCreight, USDA-ARS, Salinas, CA USA

The Cucurbit Crop Advisory Committee (CCAC) met in Charleston, South Carolina, in conjunction with Cucurbitaceae '89 on 29 November 1989. The GRIN database has been updated and made more "user friendly" than before. Users can make queries, obtain output and submit seed orders directly through the user interface or through the GRIN staff. The "Core Concept" proposes creation of a carefully selected subset of the germplasm of a particular species for routine evaluation. NPGS concluded that Core Concept can be applied to some of the larger germplasm collections (wheat) but not to small or incompletely documented collections as exemplified by cucurbits. Rumors that NSSL is full and refusing new accessions are not true. NSSL does, however, have a space problem which the CCAC is helping to solve through elimination of duplicate accessions. Four germplasm evaluation proposals and one germplasm enhancement proposal were recommended for funding in 1990. The evaluation proposals included: Evaluation of the U.S. Plant Introduction Collection of *Cucumis melo* (muskmelon) for Resistance to *Pseudoperonospora cubensis* (downy mildew); Evaluation of the Status of *Cucurbita* Introductions in the National Plant Germplasm System; Evaluation of Disease (Gummy Stem Blight, Root-Knot Nematode, Anthracnose) Resistance in the Cucumber Germplasm Collection; and Evaluating *Cucurbita* Plant Introductions from Mexico, Latin American Countries,

and South America for Disease Resistance. The germplasm enhancement proposal was Germplasm Enhancement in Muskmelon for Resistance to Watermelon Mosaic Virus 2. The major concerns of the committee remained: integrity of the PI accessions, accurate information in GRIN, and acquisition of additional germplasm before Centers of Origin are lost to development. The next meeting of CCAC will be in Tucson, Arizona, on 4 November 1990 from 1 PM to 5 PM in conjunction with the ASHS meeting.

Cucurbitaceae '89: Evaluation and Enhancement of Cucurbit Germplasm

29 November - 2 December 1989, Charleston, South Carolina USA

Conceived by the Cucurbit Crop Advisory Committee (CCAC) two years previously, this conference represented the first time that scientists from each of the principal cucurbit commodity groups (i.e., cucumber, muskmelon, squash, watermelon) as well as CCAC and CGC had met together. Over 120 scientists representing 10 countries and 4 continents were in attendance.

The conference included 16 invited oral presentations and 34 contributed poster presentations. These dealt with topics as diverse as taxonomic considerations in cucurbits, evaluation and utilization of germplasm resources, vulnerability of cucurbit germplasm collections, status and potential for pest resistance, utilization of biochemical and molecular markers in breeding, and the manipulation of cell and tissue cultures. In addition, meetings of the following groups held: CCAC, the Cucumber Breeders, the National Muskmelon Research Group, the Watermelon Research Workers, the Squash Breeders, and CGC. Registrants also had the opportunity to partake in a Plantation Oyster Roast and Shrimp Boil at the Middleton Place Plantation in the wake of hurricane Hugo.

All in attendance received a copy of the proceedings from the conference [**Thomas, C.E. (ed.) 1989. Proceedings of Cucurbitaceae '89: Evaluation and Enhancement of Cucurbit Germplasm. 185 pp.**]. A very limited number of these Proceedings are still available at the cost of $10 (U.S.) payable to the Cucurbit Genetics Cooperative. Please direct your inquiries to Dr. C.E. Thomas, USDA-ARS, U.S. Vegetable Laboratory, 2875 Savannah Highway, Charleston, South Carolina 29414 USA.

1990 Watermelon Research Group Workshop

G.W. Elmstrom, Univ. Florida, Leesburg, Florida USA

The tenth annual meeting of the Watermelon Workshop was held in conjunction with the Southern Association of Agricultural Scientists Annual Meeting in Little Rock, Arkansas, on 5 February 1990, with almost 50 participants in attendance. R. Martyn discussed race 2 Fusarium wilt resistance in PI 296341. G. Dull provided an update on the development of non-destructive sugar determination in melons. D. Hopkins described a new watermelon disorder that occurred in Florida and other states in the southeast and midwest. J. Norton talked about the glabrous male sterile gene in watermelon. This was followed by group and individual discussion.

1990 National Cucumber Conference

T.C. Wehner, North Carolina St. Univ., Raleigh, NC USA

At the Cucurbitaceae '89 meeting, it was decided that there should be a national (with encouragement for international representation) meeting for cucumber researchers. T. Wehner was elected first chairman of the group, which is to be called the National Cucumber Conference (NCC), and which will meet in even years with the Pickling Cucumber Improvement Committee (PCIC). The usual routine will be for NCC to meet on the last half-day following PCIC meetings in even years. However, in 1990 NCC will meet in Tucson, Arizona, on 4 November (Sunday) from 8 AM to 12 PM. This will occur prior to the start of the ASHS meeting and will allow cucurbit researchers to qualify for super- saver airfare by arriving Saturday before the meetings. IN order to keep things informal and to encourage discussion at NCC '90, there will be 45 minute sessions followed by 15 minute breaks (for conversation or refreshments). Each session will probably cover one topic, such as plant architecture or greenhouse cucumber production.

Upcoming meetings of interest to CGC members:

Group	Date & Location	Contact Person
Pickling Cucumber Improvement Committee	17-18 October 1990 Michigan St. University East Lansing, Michigan	Todd C. Wehner Dept. Horticultural Science North Carolina St. University Raleigh, NC 27695-7609 USA
National Cucumber Committee	4 November 1990 8 AM - 12 PM Tucson, Arizona	Todd C. Wehner (see above)
Cucurbit Crop Advisory Comm.	4 November 1990 1 PM - 5 PM Tucson, Arizona	J.D. McCreight USDA-ARS, 1636 E. Alisal St. Salinas, CA 93915 USA
National Muskmelon Research Group	Early November 1990 Tucson, Arizona (time to be announced)	Perry E. Nugent USDA, U.S. Vegetable Lab. 2875 Savannah Highway Charleston, SC 29414 USA
Cucurbit Genetics Cooperative	Early November 1990 Tucson, Arizona (time to be announced)	Timothy J Ng 1122D Holzapfel Hall College Park, MD 20742-5611USA
Squash Breeders Group	Early November 1990 Tucson, Arizona (time to be announced)	Henry Munger Cornell Univ., 410 Bradford Hall Ithaca, NY 14853 USA
Watermelon Research Group	Early February 1991 Forth Worth, Texas (time to be announced)	Gary W. Elmstrom Univ. Fla., Central FL R&E Ctr 5336 University Avenue Leesburg, FL 34748 USA

Cucumber Cultivars and Breeding Lines for the U.S.D.A. Plant Introduction Collection

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

The U.S.D.A. cucumber (*Cucumis sativus* L.) germplasm collection includes cultivars and breeding lines that are useful to the American pickle and slicer industry as cultivars, pollenizers, and/or parents of hybrids. The working collection consists of approximately 800 accessions, and is stored at the Regional Plant Introduction Station at Ames, Iowa. The Cucurbit Crop Advisory Committee has been considering additional cultivars and breeding lines (referred to collectively as cultigens) to include in that germplasm collection. In order to determine which cultigens we might add, I have listed many of the important inbreds that are already part of the collection (Table 1). In addition, I have developed a list of cultigens that should be considered for inclusion in the germplasm collection (Table 2). The list was developed from my list of inbreds that are or have been useful in production or breeding, especially those that are no longer maintained commercially.

I hope this report will generate discussion on these cultigens. Is there agreement that they should be maintained in the germplasm collection, and are there any additions or deletions that should be made? Are there seed supplies available (many of them have already been obtained, evaluated and increased as part of the germplasm evaluation effort at NCSU)?

If the cultigens are included in the germplasm collection, they will serve several functions: 1) preservation of useful cultigens that are not being maintained currently, 2) availability of cultigens to plant breeders for cultivar improvement, and 3) provision of reference points for evaluation of the germplasm collection for specific traits. Many of the cultigens are already used as checks for earliness, chilling resistance, or disease resistance, so it would be useful to have those a permanent part of the germplasm collection.

Table 1. American type cucumber cultivars and breeding lines that are currently in the U.S.D.A. germplasm collection.

Cultivar	PI Number	Origin	Cultivar	PI Number	Origin
Alko Bush Cucumber	PI 267747	United States	Improved Long Green	PI 265887	Netherlands
Apple Shape	PI 135122	New Zealand	Kyoto Three Feet	PI 400270	Japan
Armour	PI 306785	Canada	L 2	PI 401732	Puerto Rico
Beit Alpha	PI 292010	Israel	L 27	PI 401733	Puerto Rico
Beth Alpha	PI 211117	Israel	London Long Green	PI 385968	Kenya
Boston Heyare	PI 344348	Turkey	M 1	PI 209064	United States
Boston	PI 344347	Turkey	M 14	PI 209065	United States
Butchers Disease Resister	PI 356833	United Kingdom	M 16	PI 209066	United States
Clark No. 156	PI 249896	Zambia	M 20	PI 209067	United States
Concorde	PI 373917	United Kingdom	M 24	PI 209068	United States
Cool And Crisp	PI 385967	Kenya	M-2	PI 466921	Soviet Union
Cornell Chinese Long	PI 267744	United States	M-2c	PI 466922	Soviet Union
Delcrow	PI 279807	Canada	Manchuko Wonder	PI 114339	Japan
Delilah	PI 376063	Israel	Monique	PI 372584	Netherlands
Esvier	PI 255934	Netherlands	Nagaoka Longfellow	PI 267741	Japan
Everyday	PI 274902	United Kingdom	Ottawa 41	PI 451975	Canada
Everyday	PI 374726	United Kingdom	P. R. 39	PI 401734	Puerto Rico
Favor II	PI 284699	Sweden	Spangberg Pickling	PI 342950	Denmark
Favor II	PI 324239	Sweden	Sporu S	PI 372893	Netherlands
Green Apple	PI 289698	Australia	Spotresisting	PI 356832	Netherlands
Green Spot	PI 372898	Netherlands	Washburn's Waxy	PI 304805	United States
Green Spot Super	PI 277741	Netherlands	Yates Crystal Apple	PI 135123	New Zealand

Table 2. Cucumber cultivars and breeding lines that should be added to the U.S.D.A. germplasm collection.

Cultivar	Origin	Cultivar	Origin
A & C	Niagara Seed	Grand Rapids Forcing	Wyoming USDA (NSSL)
Addis	N. C. State Univ.	Green Prolific	Wood & Sons (NSSL)
Alpha Green	NSSL	Green Thumb	Harris Seed
Ansansky	NSSL	Gy 2	N. C. State Univ.
Aodai-Nazare	Asgrow Seed	Gy 3	Clemson Univ.
Arlington White Spine	NSSL	Gy 3u	Cornell Univ.
Armstrong Early Cluster	-	Gy 4	N. C. State Univ.
Ashe	N. C. State Univ.	Gy 5	N. C. State Univ.
Ashley	Clemson Univ.	Gy 14	Clemson Univ.
Black Diamond	Hollar	Gy 14u	Cornell Univ.
Brice	Burrell Seed (NSSL)	Gy 54	Clemson Univ.
Burpee Pickler	Burpee Seed	Gy 57	Clemson Univ.
Burpee's Sunnybrook	Burpee Seed	Gy 57u	Cornell Univ.
Burpless 33	Hastings Co. (NSSL)	H 19	Univ. Arkansas
Carnimus	Royal Sluis	Hanover	-
Challenger	Niagara (NSSL)	Heinz Pickling	Burpee Seed (NSSL)
Chicago Pickling	NSSL	Highmoor	Maine AES
China	-	Homegreen #2	-
Chipper	Clemson Univ.	Ilima	Hawaii AES
Chipper u	Cornell Univ.	Improved Long Green	NSSL
Clinton	N. C. State Univ.	Improved White Spine	Hastings (NSSL)
Colonial	Harris (NSSL)	Indefatigable Of Konigsdorf	Wyoming USDA (NSSL)
Coolgreen	Asgrow Seed	Japanese Climbing	NSSL
Cracker Lee	NSSL	Japanese Long	NSSL
Crystal Apple	NSSL	Klondike	NSSL
Crystal Salad	-	Lemon	NSSL
Cubit	Associated Seed (NSSL)	Little John	Univ. Arkansas
Cumberland	NSSL	LJ 90430	USDA, La Jolla
Danish Common	Wyoming USDA (NSSL)	Long Green	Northrup King
Danish Mustard	Wyoming USDA (NSSL)	Long Marketer	Ferry-Morse
Davis Perfect	Niagara Seed	Long of Keschmet	Wyoming USDA (NSSL)
Delicatesse	NSSL	Longfellow	Farmer Seed (NSSL)
Double Yield	NSSL	M 21	N. C. State Univ.
Dual	Clemson Univ.	M 27	N. C. State Univ.
Dublin	Stokes Seed	M 41	N. C. State Univ.
Dwarf PSMR 18 WS	Cornell Univ.	Magnolia	Mississippi AES (NSSL)
Dwarf SMR 18 u	Cornell Univ.	Maine No. 2	Maine AES
Dwarf Tablegreen	-	Mandarin	Vaughan-Jacklin (NSSL)
Earliest of All	Ferry-Morse (NSSL)	Marketer	Associated Seed
Early Cluster	NSSL	Marketmore	Cornell Univ.
Early Fortune	NSSL	Marketmore 70	Cornell Univ.
Early Green Cluster	Wood & Sons (NSSL)	Marketmore 70F	Cornell Univ.
Early Michigan	Burgess Seed	Marketmore 72	Cornell Univ.
Early Russian	NSSL	Marketmore 72F	Cornell Univ.
Early White Spine	NSSL	Marketmore 76	Cornell Univ.
English Telegraph	-	Marketmore 76F	Cornell Univ.
Everbearing	Burpee Seed (NSSL)	Marketmore 80	Cornell Univ.
Eversweet	-	Marketmore 80F	Cornell Univ.
Extra Early Majestic	Wyoming USDA (NSSL)	Marketmore 80 Bw	Cornell Univ.
Fletcher	N. C. State Univ.	Marketmore 85	Cornell Univ.
Galaxy	Clemson Univ.	Marketmore 86	Cornell Univ.
Giant White Arnstadt	Wyoming USDA (NSSL)	Marketmore 87	Cornell Univ.
Golden State Pickle	Robinson Seed	Marketsett	Clemson Univ.

(continued next page)

Table 2. (continued).

Cultivar	Origin	Cultivar	Origin
Midget	Minnesota AES	Seifu	Takii (Wageningen)
Milo	Hawaii CTAHR	Seiran	Takii (Wageningen)
Mincu	Minnesota AES	Shamrock	Iowa AES
Minn. Dwarf Cuke XII	Minnesota AES	Shogoin	Cornell Univ. (NSSL)
Model	Associated Seed (NSSL)	Sieger	Wyoming USDA (NSSL)
Monopol	Wageningen	Slice	Clemson Univ.
Morden Early	Morden, Canada	Smoothie	N. C. State Univ.
MSU 713-5	Michigan State Univ.	Snake	Wyoming USDA (NSSL)
Muronium	Niagara (NSSL)	Snow's Perfection	Harris (NSSL)
Nappa 63	Asgrow Seed (NSSL)	Snow's Pickling	-
National Pickling	NSSL	Sour Pickling	-
Natsufushinari	-	Southern Pickler	Arkansas AES
Niagara	Cornell Univ.	Southernsett	Harris-Moran
Northern Pickling	Maine AES	Spacemaster	Cornell Univ.
Ohio MR 17	Heinz and Ohio AES	Spacemaster 80	-
Ohio MR 25	Heinz and Ohio AES	Spartan Salad	Michigan State Univ.
Ohio MR 200	Heinz and Ohio AES	SR 6	Wisconsin AES
Orig. Groene St.	Wageningen	SR 551	Cornell Univ.
P 51	Ferry-Morse	SR 551F	Cornell Univ.
P.R. 10	Puerto Rico AES	SR 551 Bw	Cornell Univ.
P.R. 27	Puerto Rico AES	Stays Green	NSSL
Packer	Associated Seed	Stono	Clemson Univ.
Palmetto	Clemson Univ.	Straight Eight	NSSL
Palomar	Ferry-Morse	Sumter	Clemson Univ.
Pick	Clemson Univ.	Sumter u	Cornell Univ.
Pickler's Special	Wyoming USDA (NSSL)	Sunny South	Wyoming USDA (NSSL)
Pixie	Clemson Univ.	Tablegreen	Cornell Univ.
Pixie u	Cornell Univ.	Tablegreen 65	Cornell Univ.
PMR 551	Cornell Univ.	Tablegreen 66	Cornell Univ.
PMR 551F	Cornell Univ.	Tablegreen 68	Cornell Univ.
PMR 551 Bw	Cornell Univ.	Tablegreen 72	Cornell Univ.
Poinmarket	Clemson Univ.	Tablegreen 72F	Cornell Univ.
Poinsett	Clemson Univ.	Tablegreen 72 Bw	Cornell Univ.
Poinsett 76	Cornell Univ.	Tachibana 1	Wageningen
Poinsett 83F	Cornell Univ.	Tachibana 2	Wageningen
Poinsett 83 bi	Cornell Univ.	Tagoods Her Majesty	Wageningen
Poinsett 87	Cornell Univ.	Telegraph Improved	NSSL
Polaris	Clemson Univ.	Tex Long	NSSL
Producer	Associated Seed, CT	Tiny Dill	New Hampshire AES
Prolific	Sakata Seed	TMG-1	China
PSMR 18 WS	Cornell Univ.	Vestervange	Wyoming USDA (NSSL)
PSMR 18 WSF	Cornell Univ.	Wautoma	USDA-Wis
Quick Grow	Vaughan-Jacklin (NSSL)	White Lemon	NSSL
Redlands Long White	New World Seeds	White Wonder	Northrup King
Rhinish Pickling	-	WI 2757	Wis-USDA
Rhinish Drue	-	Windermoor Wonder	Stokes Seed
Riesenschal	Royal Sluis	Wis. SMR 12	Wisconsin AES
Robin 50	Niagara (NSSL)	Wis. SMR 15	Wisconsin AES
Salad Ace 1	Wageningen	Wis. SMR 18	Wisconsin AES
Salad Ace 2	Wageningen	WS Royal Improved	Clemson Univ.
Santee	Clemson Univ.	Yomaki	Niagara (NSSL)
SC 10	Clemson Univ.	Yorkstate Pickling	Cornell Univ.
SC 19B	Clemson Univ.	Zeppelin	Van Der Ploeg

Screening of the U.S. Cucumber Germplasm Collection for Heat Stress Tolerance

Jack E. Staub
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Alina Krasowska
Research Institute of Vegetable Crops, Skierniewice, Poland

The size of the U.S. *Cucumis sativus* germplasm collection (approx. 800) is small compared to germplasm collections such as bean (approx. 6,000) and potato and its wild relatives (approx. 3,500). The size of our present germplasm collection allows for the possibility of a rather comprehensive description of individual accessions. This information could be used to characterize inherent genetic diversity and allow for an appraisal of the core concept as it might apply to maintenance of the collection.

In order to describe the genetic diversity of the U.S. cucumber collection, our laboratory has used biochemical markers (1) and disease resistance (2) to assess genetic diversity. We report here the methods developed and applied for the evaluation of the collection for tolerance to superoptimal temperatures.

Six seeds each of 751 accessions were planted into each of two 13 cm pots (3 seeds per pot). Plants were grown in greenhouse until the second true leaf stage. One pot was designed for examination at a control temperature (30^{o}C) and the other for evaluation at an elevated temperature (50^{o}C). Greenhouse soil media used was a combination of sand, peat moss, soil and compost (1:1:1:1 v/v). In the greenhouse, plants were watered daily by hand to saturation.

Approximately 12 days after sowing, plants had 2 mature leaves and were moved to the Biotron (a controlled-environment facility). Of the 6 plants per accession evaluated, 3 were transferred to an elevated cyclic (24 hr) temperature regime (min. 27^{o}C, max. 50^{o}C) and three were exposed to more normal temperatures (temp. min. 27^{o}C, temp. max. 30^{o}C) for 4 days. This constituted the heat stress period. The relative humidity was relatively constant at 55% RH in both rooms. Photoperiod was 16 hours light/8 hours dark with fluorescent light at 500 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (4000 Lux). Plants were watered using full strength Hoagland's solution by drip irrigation during light periods every 2 hours for 5 minutes. Plants thus received approximately 1200 ml of nutrient solution daily. After the heat stress, plants were moved to the greenhouse, and symptoms evaluated 24 hours later.

Plants under heat stress conditions (27^{o}C/50^{o}C) were darker when compared to control plants. Plants grown at the high temperature had shorter internodes. We rated the plants for dry leaves, yellowing, and leaf cell damage, as described below.

Dry leaves (Fig. 1A). Damaged plants had dry or yellow-dry spots on the leaves. Sometimes all leaves, including the cotyledons were dry. The rating was 1-5 as follows: 1 = 1% or less of total plant leaf surfaces dry, very small dry or yellow-dry lesions (spots) on the oldest leaves, or the edges of the cotyledons, sometimes a combination of the two symptoms; 2 = 1-30 % of total plant leaf surfaces dry, and up to half of the cotyledon surface, dry spots on 1-2 older leaves and sometimes one leaf completely dry; 3 = 30-60% of total plant leaf surfaces dry, usually cotyledons dry and often oldest leaves completely dry, large portion of older leaves having some dry or yellow-dry spots, younger leaves without symptoms or with very small dry or yellow/dry spots; 4 = 60-90% of total plant leaf surfaces dry, cotyledons and older leaves completely dry, youngest 2 leaves green

and without spots; 5 = 90% or more of plant leaf surfaces dry, or older leaves dry and smallest young leaves with dry edges and spots.

Yellowing of youngest leaves (Fig. 1B). Sometimes leaves which developed under high temperatures were yellow or partially yellow. The symptom was different from the natural yellow-green leaf color of some cultivars. This symptom did not disappear after plants were moved back to the greenhouse for evaluation. The yellow color was very bright. The rating was taken from the leaf having the most symptoms. The rating was 1-5 as follows: 1 = all leaves dark-green, without symptoms; 2 = 40% or less of leaf surface yellow, yellow zones usually close to veins or on base of the leaf; 3 = 40-70% of leaf surface yellow, symptoms starting from leaf base, or large yellow zones mixed with green zones on the entire leaf surface; 4 = 70-95% of leaf surface yellow, leaf mainly yellow with small green zones on different locations on surface of the same leaf; 5 = 95% or more of leaf surface yellow, all leaves yellow, but sometimes having small green spots.

Leaf cell damage. Damaged cells appeared occasionally on the youngest, smallest leaves of some accessions. They occurred mainly between veins as holes and breaks, or transparent sites. This was uncommon, with a 3% occurrence.

A series of experiments were conducted to determine if plant ratings were consistent. Accessions which were rated 1 to 5 in the initial screen were reevaluated in two recapitulative experiments (Table 1). Although differences in ratings occurred in all cases, the relative ranking of accessions remained the same. This indicated that the rating system used was consistent and reliable.

Researchers interested in receiving a complete analysis of the germplasm collection for heat stress tolerance can contact the senior author directly. Please send either a formatted 3.5 or 5.25" double density disk, or request information through the Germplasm Resources Information Network after May, 1990.

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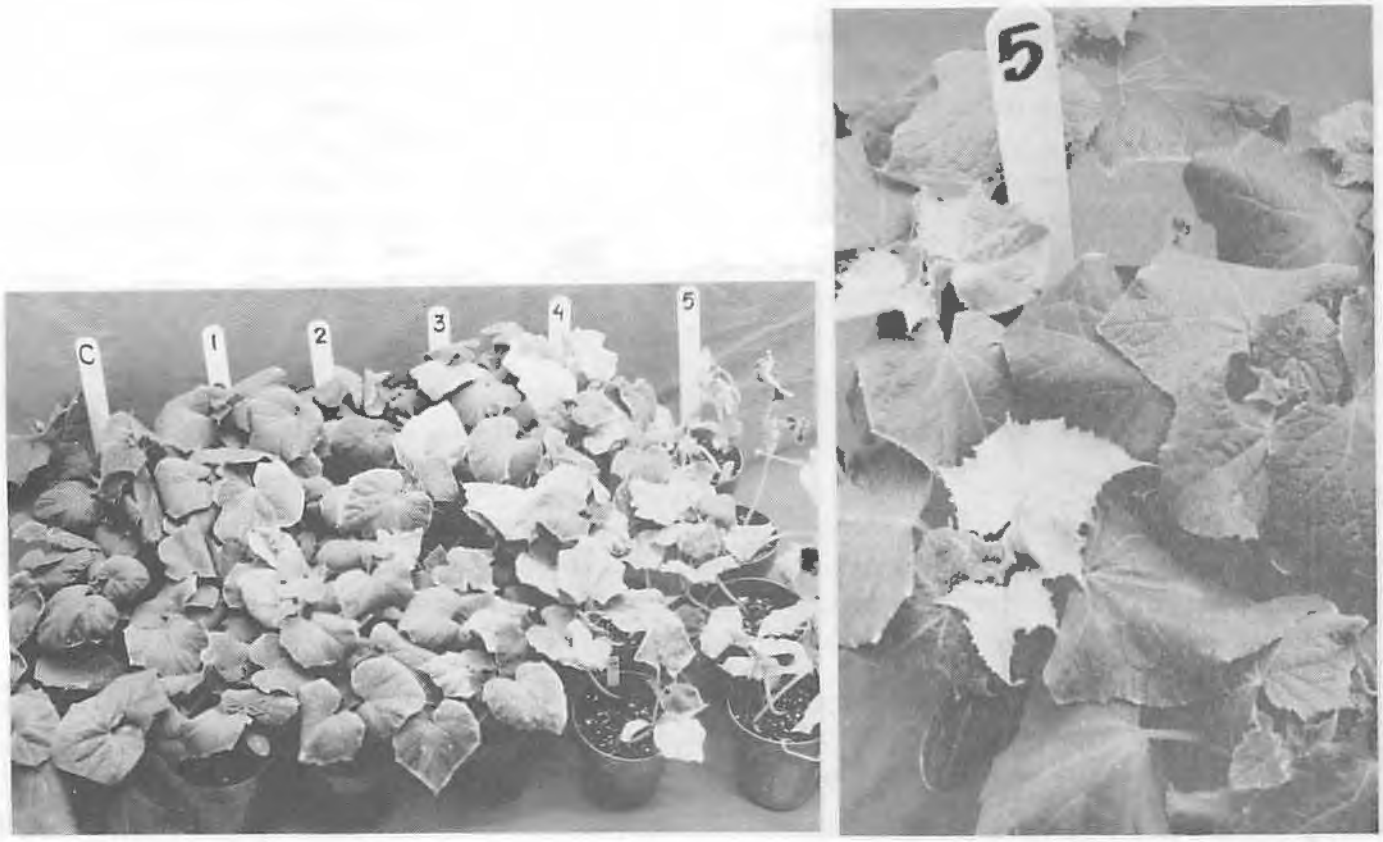

Fig. 1A. Cucumber plants grown at high temperature (27°C/50°C) for 4 days. C is control (optimal temperature of 27°C/30°C for 4 days); other rows show ratings of 1 to 5. Fig. 1B. Plants shown have a yellowing score of 5.

Table 1. Stress ratings (1 to 5) of leaf drying and yellowing of initial and recapitulative screening of cucumber accessions after growth at 27°C/50°C for 4 days, followed by greenhouse for 1 day.

			Initial screen						Recapitulative			
			1st exam				2nd exam		1st		2nd	
Rating group	PI no.	Origin	Drying $\bar{x}$	Drying s	Yellows $\bar{x}$	Yellows s	Drying $\bar{x}$	Drying s	Yellows $\bar{x}$	Yellows s	Yellows $\bar{x}$	Yellows s
1	164734	India	1.0	0.0	1.0	0.0	1.2	0.2				
	182190	Turkey	1.0	0.0	1.0	0.0	1.7	0.2				
	234517	USA	1.0	0.0	1.0	0.0	1.2	0.2				
	422200	Czechoslovakia	1.0	0.0	1.0	0.0	1.2	0.2				
	432864	Japan	1.0	0.0	1.0	0.0	1.2	0.2				
	163222	India							1.2	0.2	1.0	0.0
	267742	Hong Kong							1.0	0.0	1.0	0.0
	432873	China							1.0	0.0	1.0	0.0
	478367	China							1.0	0.0	1.0	0.0
	483344	Korea							1.0	0.0	1.0	0.0
	487424	China							1.0	0.0	1.0	0.0
Group Total			1.0	0.0	1.0	0.0	1.4	0.3	1.0	0.1	1.0	0.0

Table 1 (continued).

Rating group	PI no.	Origin	Initial screen 1st exam Drying $\bar{x}$	Initial screen 1st exam Drying s	Initial screen 1st exam Yellows $\bar{x}$	Initial screen 1st exam Yellows s	Initial screen 2nd exam Drying $\bar{x}$	Initial screen 2nd exam Drying s	Recapitulative 1st Yellows $\bar{x}$	Recapitulative 1st Yellows s	Recapitulative 2nd Yellows $\bar{x}$	Recapitulative 2nd Yellows s
2	169391	Turkey	1.6	0.5	2.0	0.0	2.3	0.4				
	292012	Israel	1.3	0.2	2.0	0.0	2.9	0.6				
	419214	Hong Kong	2.0	0.0	1.0	0.0	2.1	0.4				
	422184	Czechoslovakia	2.0	0.0	1.8	0.2	2.9	0.8				
	506462	Soviet Union	1.5	0.0	2.0	0.0	3.0	0.0				
	344348	Turkey	1.8	0.5	2.0	0.0	3.3	0.4	2.0	0.0	1.8	0.4
	169381	Turkey							2.0	0.0	2.2	0.4
	271331	India							2.0	0.0	1.3	0.5
	304803	USA							2.0	0.0	1.0	0.0
	357867	Yugoslavia							2.0	0.0	1.8	0.4
	390257	Japan							2.0	0.0	1.0	0.0
Group Total			1.8	0.4	1.8	0.4	2.8	0.7	2.0	0.0	1.5	0.6
3	171610	Turkey	1.0	0.0	3.0	0.0	1.2	0.2				
	285605	Poland	1.2	0.2	3.0	0.0	2.2	0.8				
	296121	Egypt	2.8	0.2	2.0	0.0	2.2	0.4				
	379282	Yugoslavia	3.5	0.0	1.0	0.0	2.5	0.5				
	390268	Japan	3.0	0.0	1.3	0.5	2.3	0.8				
	458845	Soviet Union	1.0	0.0	3.0	0.0	3.1	1.0				
	167197	Turkey							3.3	0.5	1.8	0.7
	176952	Turkey							3.5	0.5	1.7	0.5
	179676	India							3.0	0.0	1.0	0.0
	267088	Soviet Union							3.0	0.0	2.2	1.2
	288992	Hungary							3.2	0.2	1.7	0.7
	308915	Soviet Union							3.0	0.0	2.0	0.0
Group Total			2.1	1.1	2.2	0.8	2.2	0.9	3.2	0.3	1.7	0.7
4	211975	Iran	3.7	0.5	1.0	0.0	4.0	0.0				
	296387	Iran	4.0	0.0	2.7	0.5	3.5	0.8				
	436672	China	0.0	0.0	1.0	0.0	2.6	1.3				
	174170	Turkey	0.8	0.5	4.0	0.0	2.5	0.6	4.0	0.0	2.0	0.6
	209067	USA	1.5	0.0	4.0	0.0	3.7	0.2	4.0	0.0	2.7	0.5
	368550	Yugoslavia	1.0	0.0	4.3	0.5	2.6	0.8	4.3	0.5	2.8	1.1
	169350	Turkey							4.0	0.0	2.4	0.5
	175689	Turkey							3.5	0.5	2.5	0.8
	357844	Yugoslavia							3.7	0.5	2.0	0.6
Group Total			2.7	1.3	2.8	1.4	3.1	1.0	3.9	0.4	2.4	0.8
5	135345	Afghanistan	4.3	0.5	1.5	0.0	3.5	0.4				
	257286	Spain	1.0	0.0	4.3	0.5	3.6	0.3				
	288237	Egypt	5.0	0.0	-	-	4.5	0.4				
	390256	Japan	5.0	0.0	-	-	3.2	0.9				
	167052	Turkey	1.5	0.4	4.7	0.2	2.8	0.9	4.7	0.2	2.8	0.7
	169398	Turkey	1.5	0.0	4.5	0.5	4.1	0.5	4.5	0.5	2.0	0.0
	169386	Turkey							4.3	0.5	2.2	0.4
	169390	Turkey							5.0	0.0	1.2	0.4
	175681	Turkey							4.7	0.2	2.0	0.0
	175686	Turkey							4.7	0.5	2.5	1.1
Group Total			3.1	1.8	3.7	1.4	3.6	0.8	4.7	0.4	2.7	0.8
Experiment Total			2.1	0.7	2.3	0.9	2.6	0.8	3.0	1.3	1.9	0.6

Root Knot Nematode Egg Concentration for Inoculating *Cucumis* spp. Tests

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In determining resistance of plant cultigens to root knot nematodes (*Meloidogyne* spp.), eggs are often used as inoculum. It is important to know what level of inoculum to use on a given cultigen (accession, cultivar, breeding line, etc.) in determining resistance to root knot nematodes. If inoculum rate is too low, susceptible cultigens may have few root galls and appear to be resistant. On the other hand, if inoculum rate is too high, resistant cultigens may have root galls and appear to be susceptible (2).

Methods. A greenhouse study was conducted to determine the optimum egg concentration of root-knot nematodes to use when evaluating a species of *Cucumis* for resistance. Five egg concentrations (0, 500, 2000, 8000 and 16000 eggs/pot) of two root knot nematodes (*M. incognita* r. 3 and *M. javanica*) were used to determine optimum egg concentration for evaluating *C. sativus* 'Sumter' and *C. metuliferus* PI 482452 for resistance.

Plants were grown from seed, with two plants per 100-mm clay pot. The test was replicated three times. Plants contained within a pot were inoculated 2 weeks after planting with 1 of the 5 egg concentrations. Inoculum was prepared using the technique developed by Hussey and Barker (3).

Plants were rated 8 weeks after planting (6 weeks after inoculation) using the gall index system. The gall index system ranges from 0 to 100 and indicates the percentage of a root system that is galled by root knot nematodes (1).

Results. The range of gall index between the 2 cucumber lines was measured for each egg concentration and root knot nematode species. This range was then divided by the LSD and converted to a percentage (Table 1). These percentages are linear for each root knot nematode tested (Fig. 1). The optimum concentration to use would be that concentration just before the curve reaches a plateau. However, in our experiment we did not include an egg concentration high enough to show the optimum.

In conclusion, a short duration test (such as this 8-week test) should use at least 16000 eggs/pot. A long duration test (such as the 12-week tests we use now), the 16000 eggs/pot level would probably be excessive. We have settled on a concentration of 8000 eggs/pot for the long duration test.

Table 1. Gall index range/LSD (as %) between cucumber cultigens for 2 nematodes and 5 egg concentration.[z]

Egg concentration	Sumter		PI 482452		(%)Range/LSD	
	Mi3	Mj	Mi3	Mj	Mi3	Mj
0	2	2	1	1	10	10
500	6	11	3	6	30	50
2000	17	26	8	9	90	170
8000	38	53	20	26	180	270
16000	59	73	28	23	310	500
LSD (5%) for row-column comparisons of means				10		

[z]Data are means of 3 replications of 2 plants each. Mi3 = *M. incognita* r. 3 and Mj = *M. javanica*. Gall index represents percentage of root system that is galled by root knot nematodes.

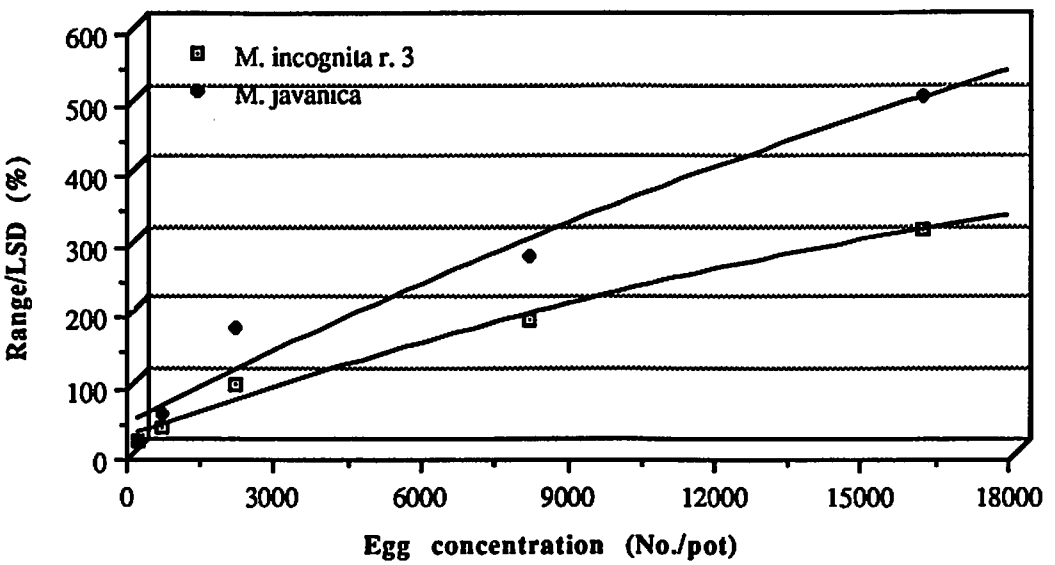

Figure 1. Range/LSD (in %) for 2 cucumber cultigens and 2 root knot nematodes tested against 5 egg concentrations.

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Resistance of Cucumber to the Root-knot Nematode, *Meloidogyne hapla*

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Cucumber (*Cucumis sativus* L.) is one of the most susceptible crops to root-knot nematode (*Meloidogyne* spp.) (2). There are four major pathogenic species of root-knot nematodes, *M. incognita, M. arenaria, M. javanica* and *M. hapla*. In North Carolina, cucumbers were reported to be resistant to *M. hapla* (5). However, others have reported that some cultivars of cucumber were susceptible to *M. hapla* (3, 6, 7). The objective of this study was to screen the cucumber germplasm collection for resistance to *M. hapla* to determine which cultigens had the most resistance.

Methods. Nine hundred cultigens of *Cucumis sativus* (728 accessions, 36 breeding lines and 136 cultivars), and 24 cultigens of *Cucumis metuliferus* (24 accessions) were evaluated in a greenhouse study for resistance to the root-knot nematode, *M. hapla*. Plants were grown from seed, with one plant per 150-mm-diameter clay pot. One replication of 924 plants was grown. (The experiment was not repeated since all cultigens were found to be resistant.)

'Rutgers' tomato was used to grow root-knot nematodes for inoculum. Three plants were grown in 150-mm-diameter pots, and inoculated at the seven-leaf stage with 5000 eggs of *M. hapla*. The same inoculum was used the same day to inoculate the 924 cultigens of *Cucumis*. These three plants were grown as checks for both temperature and inoculum.

Two weeks after planting each pot was inoculated with 5000 eggs of *M. hapla* using the technique developed by Hussey and Barker (4). Eleven weeks after planting (9 weeks after inoculation) plants were rated using the gall index system. This system determines the percentage of a given root system that is galled by a root-knot nematode. The gall index system ranges from 0 to 100, indicating percentage of roots injured (1).

Results. The 3 tomato plants that were grown as checks had an average gall index of 65. We were worried that high temperatures in the greenhouse would reduce the amount of gall development. However, the high GI for 'Rutgers' indicated that temperature was not a problem, and that the inoculum of *M. hapla* was virulent.

All cultigens evaluated were resistant to *M. hapla*, indicating that cucumber was a poor host. That conclusion supports the findings of Winstead and Sasser (5). Most cultigens (82.4%) had a gall index below 2 (Table 1). Cultigens that had a gall index of 0 included 'Marketmore 76' and Wisconsin SMR 18. The least resistant cultigen was 'Armstrong Early Cluster'. No susceptibility to *M. hapla* was found in the 870 *Cucumis* cultigens evaluated.

Table 1. Cucumber resistance (gall index) to *Meloidogyne hapla*.[z]

Gall index	Example Cultigens	No. of Cultigens	% of Cultigens
0	Gy 4, 'Poinsett', 'Sumter'	308	33.3
1	'Coolgreen', 'Magnolia'	453	49.1
2	'Chipper', 'Cubit', PI 321006	95	10.3
3	'Dual', PI 220860, PI 222986	10	1.1
4	'Sieger'	1	0.1
5	PI 267746	1	0.1
6	-	0	0.0
7	PI 432856	1	0.1
8	'Armstrong Early Cluster'	1	0.1
65	'Rutgers' tomato	-	-
Missing	-	54	5.8
Total	-	924	100.0

[z]Data are means of 1 replication of 1 plant each. Gall index represents percentage of root system damaged by nematode galls.

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Breeding Cucumbers for Fresh-market Production in Egypt

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One major cultivar of cucumber is grown for field production in Egypt, 'Beta Alpha' (referred to as 'Beit Alpha' in the U.S.). The cultivar is preferred for its fruit characteristics. Both the monoecious and gynoecious hybrids are grown, as well as the monoecious open-pollinated type. The U.S., Netherlands, Denmark, and England are the major suppliers of seed. The cultivated area is 18,730 ha/year, with an average yield of 9.5 Mg/ha.

In the last 3 years downy mildew (*Pseudoperonospora cubensis*) eliminated most of the crop, with losses of 80 to 100%. New mildew-resistant cultivars have been introduced in the last few years, i.e. 'Amra II' from U.S. (PetoSeed) and 'Sweet Crunch' from Japan. These hybrids are moderately resistant to downy mildew, and have the proper fruit type. For plastic tunnels (small greenhouses), many hybrids are available with the usual higher cost for seed.

Disease and insect problems. The major diseases of cucumber are (in order of importance) downy mildew, cucumber mosaic virus, powdery mildew (*Sphaerotheca fuliginea*), fusarium wilt (*Fusarium oxysporum* f. sp. *cucumerinum*), and gummy stem blight (*Didymella bryoniae*). Downy mildew is by far the major disease, and is capable of eliminating the crop, even with a weekly spray program. Cucumbers are affected by many insects, but aphid (*Aphis gossypii*) is the most important. Breeding for resistance to Egyptian disease problems is urgently needed in order to reduce the pesticide requirement for cucumber production.

Cultural practices. Cucumber is grown in 2 seasons, summer (sown 20 February to 7 April) and fall (sown 10 to 20 July). In plastic houses, cucumber is sown from 1 September to 7 October. Row spacing is 1 m with spacing of 20 to 30 cm between hills, with 4 seeds per hill. Seeds are sown by hand, at a rate of 3.6 kg/ha. Two weeks after sowing, hills are thinned to 2 plants. Cucumber is intercropped in the summer with tomato or cowpea. In the fall season, cucumber is intercropped with tomato.

Fruits are harvested every two days (about 15 harvests) 60 to 70 days after sowing. The ideal fruit has light-green skin color, uniform green (*u* gene) and wartless (*tu* gene). Fruit dimensions at harvest are 12 to 15 cm long and 30 to 35 mm diamter, with a weight of 100 to 120 g.

Table 1. Monthly mean air temperature and relative humidity (%) in 1989[z].

Season	Month	Temperature (°C)			R.H. (%)		
		Max.	Min.	Aver.	Max.	Min.	Aver.
Winter	Dec.	18.9	7.9	13.4	78.1	74.9	76.5
	Jan.	20.6	8.9	14.8	73.0	71.0	72.0
	Feb.	19.7	6.0	12.9	76.0	72.0	74.0
Spring	March	22.0	9.4	15.7	73.8	73.6	73.7
	April	30.0	12.1	21.5	70.0	65.1	67.6
	May	31.5	14.3	22.9	64.5	57.8	61.2
Summer	June	34.3	19.0	26.7	58.7	61.7	60.2
	July	34.4	21.5	28.0	74.6	72.8	73.6
	August	32.8	20.5	26.7	75.3	73.9	74.6
Autumn	Sept.	31.8	18.6	25.2	78.0	76.3	77.2
	Oct.	28.2	14.5	21.4	72.1	76.7	73.4
	Nov.	23.1	9.5	16.3	69.6	67.4	68.5

[z]Source: SAKHA Agriculture Research Station, KAFR EL-SHEIKH Governorate.

Effect of Explant Age and Growth Regulator Concentration on Adventitious Shoot Formation from Cucumber Cotyledonary Tissue

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Much of the work on organogenesis of cucumber (*Cucumis sativus* L.) has been difficult to repeat, and results have often been unpredictable. Maciejewska-Potapczykowa et al. (5) were the first to report organogenesis from callus produced by stem pieces of cucumber, but they did not describe the methods for obtaining shoots. Alsop et al. (1) obtained only callus from several organ explants with various concentrations of NAA (1-naphthaleneacetic acid) and BA (6-benzylamino purine). However, some bud-like knobs were observed in callus grown at 0.1 mg/l NAA and 0.1 mg/l BA. Aziz et al. (2) also described bud-like nodules on callus derived from internode pieces of cucumber, but they could induce only root formation.

Others working with cucumber have been able to produce adventitious buds and/or shoots from either hypocotyls or cotyledons (5, 9, 10, 11). Cotyledons appear to be the better explant for use in organogenesis experiments (4, 7, 11). However, callus from cotyledons is characterized by proliferation of fibrous roots whereas callus derived from hypocotyls is not (9, 10). Other organs have also been used as explants.

The main objective of this research was to increase the efficiency of shoot production from cotyledonary explants by manipulating growth regulator concentrations in the medium and determining the optimum cotyledon age for regeneration.

Explant source. For the time course study, seeds of two cultivars of cucumber ('Straight 8' and 'Sumter') were surface sterilized on a gyratory shaker at 100 rpm. Seeds were soaked in a 50% Clorox (2.6% NaOCl) solution for 30 minutes followed by 5 rinses in sterile distilled water. Ten seeds each were placed in 100 X 15 mm plastic petri plates containing 1% Bactoagar that had been autoclaved at 121°C for 15 minutes. Plates were sealed with Parafilm and placed in darkness at 30°C for seed germination.

For the secondary media study, seeds of the breeding line Gy 14A were surface sterilized in the same manner as described previously. After placing the sterilized seeds on water agar as described above they were germinated in the dark at 30°C for 5 days.

Regeneration procedure. For the time course study, cotyledons were excised from each seedling at 2, 4, 6, 8 or 10 days of age. Five 2 X 2 mm explants from the same cotyledon were placed adaxial side down in 100 X 15 mm plastic petri plates containing 20 ml of a Murashige-Skoog (MS) (8) medium with 1% agar and supplemented with 3% sucrose, 1 mg/l NAA and 1 mg/l BA. The medium (designated ORG) was adjusted to pH 5.8 prior to autoclaving. Five plates were used for each temperature, day and cultigen (cultivar or breeding line) combination.

Cultures were maintained at 22°C under a 24 hour photoperiod of fluorescent and incandescent lamps. Cultures were transferred to the same medium after 4 weeks. Data on callus diameter and numbers of roots and shoots were recorded after 4 and 8 weeks. The experiment was a split-plot treatment arrangement in a randomized complete block design with two replications. Data were taken as means of 5 petri plates.

For the secondary media study, cotyledons from 5-day-old seedlings were excised and divided into six 2 X 2 mm pieces. Explants were placed adaxial side down into 100 X 15 mm plastic petri plates containing 20 ml of ORG and placed under the same environmental conditions outlined above. After 4 weeks, all of the new growth was removed from the explants and transferred to ORG where the cultures remained for 4 additional weeks. The 8-week-old tissue was then placed onto MS medium containing 16 combinations of NAA and BA (concentrations were 0, 0.1, 0.3, and 1 ppm each of NAA and BA in a factorial design) where it remained for two 4-week subcultures.

Ratings on regeneration, and number of roots and shoots per plate were recorded after 4 weeks and again after 8 weeks on the 16 NAA-BA treatment combinations. The regeneration rating, based on color and differentiation of the tissue was as follows: 0=brown, 3=undifferentiated green tissue, 5=green nodular tissue, 7=green nodular tissue with leaves, 9=green tissue with shoots. The experiment was a split-plot treatment arrangement (with cultigen as whole plot and NAA-BA combination as subplot) in a randomized complete block design with 2 replications. Data were taken as means of 5 petri plates.

Time course study. Seeds began germinating after 2 days on water agar. Cotyledons emerged from the seed coats after 4 days for 'Sumter' and 5 days for 'Straight 8'. A hard, green, nodular tissue began forming around the cut edges of the cotyledon pieces after about 1 week, and adventitious shoots began forming from this tissue after 3 to 4 weeks on the culture medium. The number of days from germination to explanting (seedling age) affected callus growth, and root and shoot regeneration. Shoot production decreased for the 8 and 10 day treatments and was highest (60%) from 6-day-old tissue.

It appears that 4 to 6 days is the optimum germination period for shoot regeneration from cotyledon tissue at a germination temperature of 30°C. After 2 days, the cotyledons had not yet emerged from the seed coat, making it difficult to excise the explants. After 8 to 10 days in culture, the cotyledons lost their regenerative ability.

Secondary Media Study. Shoot formation occurred infrequently for all secondary media treatments and did not occur until 6 to 8 weeks after the explants had been on the secondary medium. One reason for the poor regeneration may have been a slight browning of the tissue which occurred after 8 weeks. The cultures probably needed to be transferred more frequently than every 4 weeks.

Total number of shoots per plate was influenced mainly by the concentration of NAA in the secondary medium (Table 2). When NAA was absent, Gy 14A developed shoots at all BA concentrations except 3 mg/l. A medium with 0.3 mg/l BA and no NAA produced the greatest number of shoots. The best regeneration ratings were also on secondary media lacking NAA (Table 2).

Root production was also influenced by NAA and BA levels. Numerous, short, callus-covered roots developed on all media having NAA but lacking BA (Table 2). BA tended to depress total root production, especially at the higher NAA concentrations. BA also appeared to promote root elongation.

One piece of tissue on a medium with 0.0 mg/l NAA and 0.3 mg/l BA produced a number of abnormal bipolar structures that began to differentiate shoots and roots. All of the embryoids were abnormal and none grew into plantlets. These results were promising since previous studies had never yielded more than 2 shoots from a single explant. The structures also appeared to have arisen indirectly from a friable yellow tissue which is typical of embryogenesis. It is also possible that some of the shoots observed on other plates may have actually been embryos that remained attached to maternal tissues. This would partially explain why shoots developed after 12 to 16 weeks instead of the 4 to 8 weeks described in the previous experiment. These possibilities led us to change our focus to regeneration through embryogenesis which had been reported previously in cucumber (6).

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Table 1. Root and shoot production of cotyledons excised at 2 day intervals over a 10-day period from 2 cultigens of cucumber[z].

Day	Cultigen	Cotyledon growth (mm)	No. per plate: Shoots	No. per plate: Roots	% explants with: Shoots	% explants with: Roots
2	Straight 8	17.7	1.3	3.0	26.7	60.0
	Sumter	15.3	1.0	2.0	20.0	43.3
4	Straight 8	15.8	0.4	1.6	8.0	32.0
	Sumter	17.0	0.8	2.0	15.0	40.0
6	Straight 8	14.3	3.0	0.3	60.0	6.7
	Sumter	13.5	1.0	0.5	20.0	10.0
8	Straight 8	15.5	0.5	0.5	10.0	10.0
	Sumter	15.8	0.0	0.2	0.0	4.0
10	Straight 8	13.3	0.0	0.0	0.0	0.0
	Sumter	12.0	0.0	0.0	0.0	0.0
LSD (5%)		2.1	1.0	1.4	21.5	28.5
$\bar{x}$		15.2	0.7	1.1	15.1	22.7
CV (%)		14	111	102	112	99

[z]Data are means of 5 plates taken after 8 weeks on MS media with 1 mg/l each of NAA and BA.

Table 2. Shoot and root numbers from Gy 14A cucumber 8 weeks after being subcultured from MS with 1 mg/l each of NAA and BA to 16 media with different combinations of NAA and BA[z].

NAA concn.	BA concn.	Friability rating[y]	Regeneration rating[x]	No. per plate: Shoots	No. per plate: Roots
0.0	0.0	3.2	3.3	0.3	3.5
	0.3	4.3	6.7	4.0	4.5
	1.0	5.3	3.8	0.5	2.2
	3.0	5.0	4.0	0.0	1.5
0.3	0.0	7.3	3.0	0.0	2.8
	0.3	6.0	3.2	0.0	2.2
	1.0	6.0	3.6	0.9	0.8
	3.0	5.7	4.3	0.0	3.7
1.0	0.0	8.9	4.2	0.4	18.8
	0.3	6.9	4.3	0.0	4.4
	1.0	7.3	4.0	0.0	2.2
	3.0	5.6	2.6	0.0	4.2
3.0	0.0	9.0	3.0	0.0	24.1
	0.3	8.0	3.5	0.0	0.5
	1.0	7.7	3.4	0.0	1.3
	3.0	6.8	3.4	0.0	3.4
LSD (5%)		1.1	2.5	1.1	1.6
$\bar{x}$		5.8	3.6	0.2	5.7
CV (%)		14	35	394	75

[z]Concentrations were 0.0, 0.3, 1.0, and 3.0 mg/l each of NAA and BA in a factorial design.

[y]Friability was rated 1 to 9 (1=hard, 5=moderately friable, 9=very friable).

[x]Regeneration was rated 1 to 9 (1=brown tissue, 3=undifferentiated green tissue, 5=tissue with buds, 7=tissue with leafy structures, 9=tissue with shoots).

Screening Wild *Cucumis* spp. in the Field and with Artificial Seed Inoculation against *Fusarium oxysporum* sp. *melonis*

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Wilt disease caused by *Fusarium* spp. is a serious problem of muskmelon (*Cucumis melo* L.) in the river beds of North India and other production areas (1,2,5). The Jamuna river bed showed a higher prevalence of *F. solani* compared to *F. oxysporum*, but isolates of the latter were more virulent (3). The performance of wild *Cucumis* spp. in field screening and with artificial inoculation (5×10^6 spores/ml) against *F. oxysporum* f. sp. *melonis* are furnished in Table 1. All the wild *Cucumis* spp. used in this study, except *C. melo* var. *callosus* (25% mortality) showed high resistance under field conditions. In the artificial inoculation study, *C. dipsaceus*, *C. meeusii* and *C. anguria* var. *longipes* failed to germinate in the inoculated and uninoculated tests and among the others, only *C. melo* var. *callosus* showed good germination. *C. figarei*, *C. zeyheri* 1 and 2 and *C. anguria* var. *longipes*, exhibited high resistance (no mortality), while *C. melo* var. *callosus* and the susceptible check M3 showed 41.7 and 90.0% mortality, respectively, at 5 weeks after inoculation. The slight mortality observed in *C. myriocarpus* 1 and 2 and *C. anguria* were not definitely due to *Fusarium* infection since mortality was confined to weak plants and was observed in check plants as well.

At the 5 weeks stage, a second inoculation was done by drenching the soil mixture to saturation with freshly prepared spore suspension (5×10^6 spores/ml). Watering was suspended for two days before and after the second inoculation. A fresh set of 3 week old seedlings of M3 was similarly drenched in spore suspension and used as susceptible check. No further mortality was observed (5 weeks after second inoculation) in any of the wild species.

Identification of resistance in wild species opens the possibility of their utilization in breeding program. This opens the prospect for developing multiple disease resistant lines, incorporating CGMMV resistance (4) and *Fusarium* resistance of *C. figarei*. This project is underway.

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Table 1. Performance of wild *Cucumis* spp. in field and with seed inoculation against *F. oxysporum* f. sp. *melonis*.

	FIELD		SEED INOCULATION		
Species	No. of Hills	% Mortality	No. of Plants	% Mortality 5 weeks	% Mortality *10 weeks
C. myriocarpus 1 (GBNR[a]-1676)	9	0	9	12.5	12.5
C. myriocarpus 2 (GBNR-1051)	7	0	5	20.0	20.0
C. figarei (GBNR-1804)	6	0	26	0	0
C. meeusii (GBNR-1800)	6	0	-	-	-
C. dipsaceus (GBNR-1774)	7	0	-	-	-
C. zeyheri 1 (73252 H 9)	6	0	2	0	0
C. zeyheri 2 (GBNR-1053) (Tetraploid)	6	0	13	0	0
C. anguria (GBNR-1970)	6	0	6	16.7	16.7
C. anguria var. *longipes* (GBNR-1735)	6	0	-	-	-
C. melo var. *callosus* (Acc. No. 566)[b]	8	25.0	24	41.7	41.7
C. melo M 3	-	-	12	90.0	-

* - 5 weeks after a second inoculation
a - Source: Wageningen, The Netherlands
b - Source: Tamil Nadu, India

Evolution of muskmelon virus infection on field crops in the Ebro Valley (Spain).

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About 15 different viruses have been reported infecting muskmelon (6). Mainly 10 of those viruses have some economic incidence (5), and among those five have been reported in Spain: Cucumber mosaic virus (CMV), watermelon mosaic virus-2 (WMV-2), squash mosaic virus (SqMV), muskmelon necrotic spot virus (MNSV), and Zucchini yellow mosaic virus (ZYMV) (1, 2, 3, 7, 8).

In 1984 a study aimed to assess the importance, identity, and evolution of virus infection on open-field grown muskmelon was started in experimental plots located in the Central Ebro Valley (Spain).

A total number of 633, 574, 590 and 125 plants from different local cultivars were examined during 1985, 86, 87 and 88, respectively.

Plants were sown in pots and transplanted to the field when the seedlings reached the 2-3 leaf stage (3rd June 1985, 28th May 1986, 1st June 1987, and 24th May 1988). All plants were individually observed at least once a week and the presence of foliar virus symptoms was recorded. For virus identification some samples were taken, at random, from plants that showed virus like symptoms; in this way 81, 75, 50 and 49 samples were studied in 1985, 86, 87 and 88 respectively.

Virus identification was done through biological (9) and serological (4) tests. The serological tests were done with CMV, WMV-2, ZYMV and PRSV-w antisera from INRA, Montfavet (France).

Virus symptoms were first observed as foliar mosaics 17 days after transplant in 1985, 18 days in 1986, 24 in 1987, and 28 in 1988. Virus infection reached 100% of the plants 70, 66, and 49 days after transplant in 1986, 87, and 88 respectively (Fig.1). In 1985 the infection had reached 95% of the plants 71 days after transplant, but an important powdery mildew infestation made difficult further observations.

The reactions of the diagnostic species and the serological tests showed that CMV and WMV-2 were the most important, and practically the only viruses present during 1985, 86, and 87. MNSV appeared in a few plants in 1986 (Table 1).

In 1985 both viruses (CMV and WMV-2) appeared simultaneously, but later WMV-2 became the most frequent (Fig. 2A). However, in 1986 CMV appeared first and was much more frequent

Table 1. Viruses detected and their frequency (%)in muskmelon foliar samples in 1985, 1986 and 1987.

Year	Number of Samples	VIRUSES				
		CMV	WMV-2	CMV+WMV-2	MNSV	CMV+MNSV
1985	81	17	72	11		
1986	75	48	5.3	42.7	2,7	1,3
1987	50	24	40	36		

than WMV-2 (Fg. 2B). In 1987 both viruses appeared almost simultaneously and none of them was clearly more frequent than the other (Fig. 2C).

In 1988 symptoms differed from those observed in previous years. Plants started showing vein clearing followed by leaf decoloration, yellowing, and sometimes necrotic spots on leaves and stems, and death of some of the plants. Plant growth became highly affected, and many flowers aborted before anthesis. Delays in fruit set and development were also observed, most of the fruits showed deformations and/or star-shaped cracking similar to those observed by other authors in ZYMV natural infections (4, 10).

From 17 samples taken from 21st June, when the first symptoms were observed, until 20th July, only ZYMV was found. CMV was detected later, but always mixed with ZYMV. From samples taken from 14th September, on the same plants that the above ones, a mixed infection of CMV and ZYMV was found, and in three plants WMV-2 was also found.

Varietal differences were observed in plant mortality and flower abortion during 1988 (Table 2), that could be attributed to vigor differences between cultivars or to varietal differences in the reaction to the virus (4).

Causes of this sudden upright of ZYMV incidence in the area are unknown but most probably they are related with an unusual mild spring and summer during 1988. A rainy autumn and mild temperatures during winter and spring could hasten weed development, that acted as virus source, and presence of high aphid populations during transplant and first stages of plant development. At the same time muskmelon plants grew weaker and slower that under normal climatic conditions.

Table 2.- Average percentage of surviving and pistillate flower producing plants.

CULTIVAR	% of surviving plants	%of plants producing pistillate flowers
Ariso	72 ab	26.6 a
Tendral Verde	60 a	64.0 b
Rochet	76 ab	71.3 bc
Piel de Sapo	92 b	55.0 b
Negro	96 b	92.0 c

Analysis of variance were performed after angular transformation of data. Mean comparisons were done according to Duncan's multiple range test ($p \leq 0.05$).

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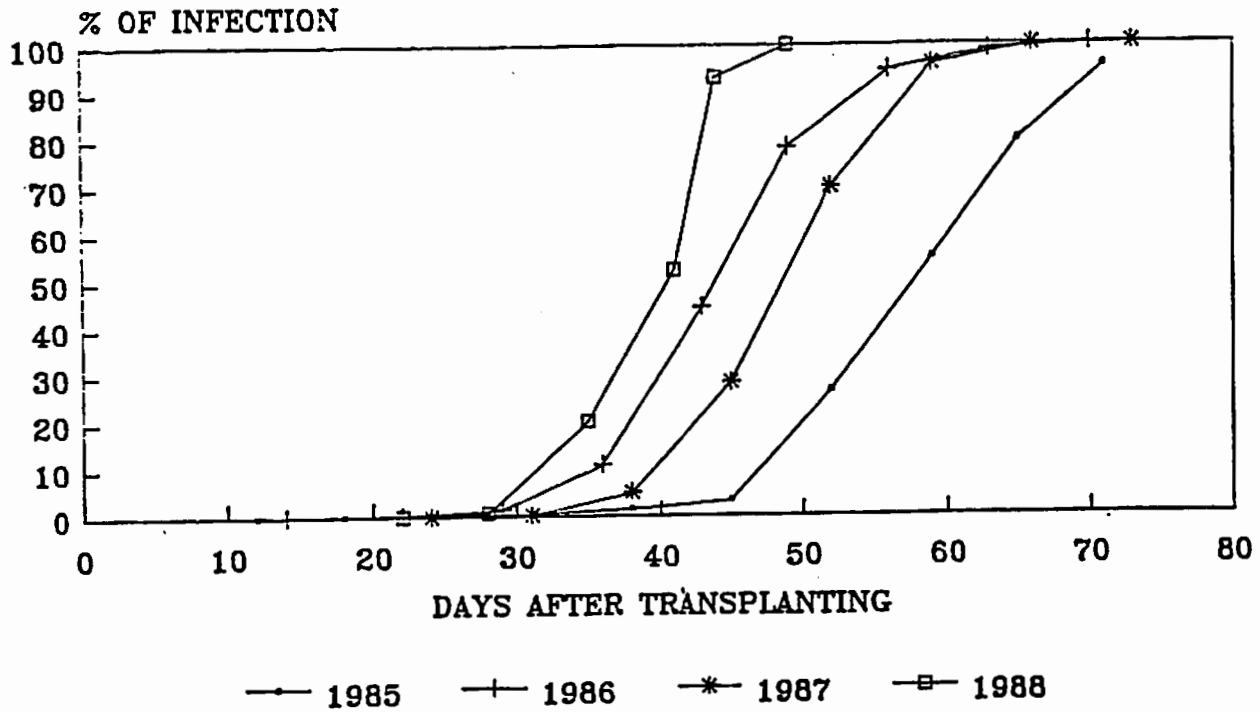

Figure 1. Virus infection evolution on open-field muskmelon grown during 1985, 1986, 1987 and 1988

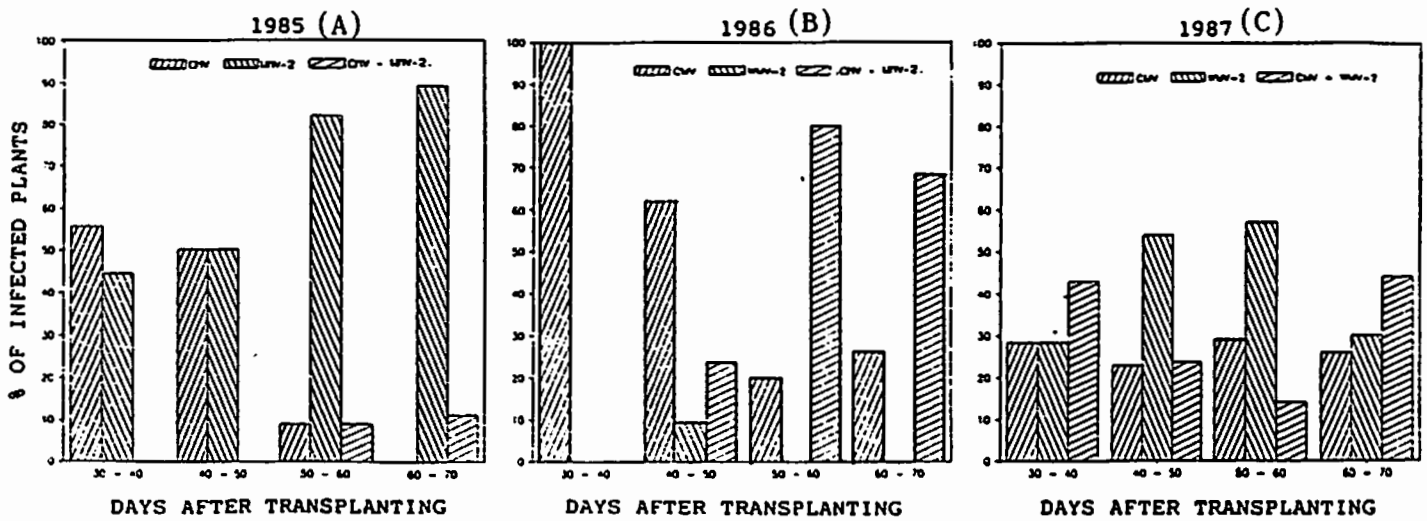

Figure . Evolution of CMV and WMV-2 infection on open-field muskmelon grown in 1985 (A), 1986 (B) and 1987 (C).

Further Sources of Resistance to ZYMV in *Cucumis melo* L

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Losses of *Cucumis melo* to zucchini yellow mosaic virus (ZYMV) have increased in Queensland where there are at least two distinct isolates of the virus (1). Resistance available in PI 414723 has been overcome by some variants (2). We are therefore seeking other sources of resistance which may be more stable. In early tests we found that line 91213, which has a low rate of multiplication of WMV-2 (3), was also resistant to ZYMV. This was not surprising as 91213 and PI 414723, which have similar reactions, are derived from PI 371795.

The results of an initial survey of a sample of PIs from U.S.D.A. Ames are reported here. Plants were manually inoculated twice on the cotyledons with ZYMV in phosphate buffer (pH 7.0). 'Doublon', PI 414723 and 'Planters Jumbo' were included as controls.

PI lines with infection percentages less than about 70% (Table 1), PI 390451 and PI 470252 warrant further evaluation and may provide sources of ZYMV resistance or tolerance. Fifteen of the 60 lines tested reacted with symptoms similar to those on 'Doublon'.

Lines PI 321005 and PI 164825 also showed a high degree of resistance to natural infections by powdery mildew (*Sphaerotheca fuliginea*) while PI 381803 showed a moderate level of resistance.

We are attempting to produce self-pollinated seed from survivors of the ZYMV evaluations to allow further testing and inheritance studies. PI 207662 is particularly interesting with a mild reaction and low frequency of infection. Some of the lines identified should provide additional sources of resistance to ZYMV.

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Table 1. Percentage of *Cucumis melo* plants infected following inoculation with ZYMV[z].

Cultivar (PI)				Percent of plants infected
136173 (10/10)[y]	390452 (8/8)	435992 (10/10)[w]	446930 (8/8)	
255478 (8/8)	401704 (2/2)[w]	476337 (9/9)[w]	470252(8/8)[u]	100%
255479 (1/1)	426627 (10/10)[w]	Doublon (5/5)[w]	476336 (10/10)	
381803 (10/10)	435086 (10/10)[w]	438684 (7/7)	Planters Jumbo	
390451 (8/8)[v]	435087 (10/10)[w]	438685 (10/10)	(14/14)	
102077 (3/3)	126099 (1/1)[w]	255953 (3/3)	357824 (3/3)	
124100 (3/3)	251516 (3/3)[w]	266934 (1/1)	385965 (3/3)	
	266943 (3/3)[w]	268227 (2/2)	439745 (3/3)	
	280548 (2/2)[w]	269368 (2/2)	500362 (3/3)	
	288236 (1/1)[w]	277283 (3/3)	502328 (3/3)	
	296119 (3/3)[w]	279366 (3/3)	502329 (3/3)	
	344411 (3/3)[w]	357800 (3/3)	504526 (3/3)	
161375 (5/6)	249560 (8/9)	435289 (8/9)	470253 (11/12)	71-99%
200819 (7/9)	321005 (5/6)	435941 (8/9)	PI414723 (10/13)[y]	
355056 (5/9)[w]	296345 (1/2)	164796 (2/3)	164825 (3/5)	41-70%
224786 (1/2)[w]	505936 (1/2)		266935 (2/3)	
503325 (2/3)[w]	357827 (2/3)[x]			
	164797 (1/3)	207662 (3/10)[x]		11-40%
	289876 (0/1)	436533 (0/2)		0-10%

[z] Sown 18 September 1989; inoculated with G4 strain of ZYMV 26 September and 11 October. Final assessment was on 20 November. Lines with more than five plants were from duplicated pots.

[y] Parenthesis indicates the number of plants showing symptoms/number inoculated.

[x] Mild reaction.

[w] Necrosis as in Doublon.

[v] Partial recovery; slow symptom development.

[u] Partial recovery; tolerant cucumber present in seed lot.

[t] Hypersensitive spotting as PI414723, stem necrosis.

Relationship between the Causal Agent of Melon Yellowing Disease in the South-East of Spain and its Vector

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The impossibility of mechanically transmitting melon yellowing disease to melon plants (*Cucumis melo* L.) (3) stimulated the design and development of a technique of artificial inoculation that uses the vector of the causal agent, the greenhouse whitefly *Trialeurodes vaporariorum* Westwood, to give 100% infection of susceptible plants. This technique effectively eliminates the problems of variability and escapes that can occur when working under natural infection conditions and it also allows the investigator to select genotypes with genetic resistance to the disease.

Several parameters of the interrelationship between causal agent of the disease and its vector had to be studied to develop the technique.

In experiments similar to those of Duffus (1) with Beet Pseudo Yellows Virus (BPYV), and of Hristova and Natskova (2), the following parameters of the relationship between the causal agent and its vector were studied: Relationship of numbers of insects to transmission, infection feeding period, and persistence of the causal agent in the vector.

The plant material consisted of healthy plants of *C. melo* cv. 'Piel de Sapo' at the one to two true-leaf stage that had been cultivated in a whitefly-free greenhouse.

Greenhouse whiteflies came from colonies bred on healthy melon plants.

Infected melon plants with definite symptoms of yellowing disease were the infection source.

To study the parameters of the causal agent-vector relationships, whiteflies had been allowed to feed for 48 h. on the yellowing disease source.

Persistence: Transfers of 40 disease bearing whiteflies to healthy melon plants at the 1-2 true-leaf stage were carried out daily for 7 days. Ten replicates were employed.

Relationship of numbers of insects to causal agent transmission: Disease carrying whiteflies were transferred individually, and also in groups of 5, 10, 20, 30 and 40, to healthy melon plants on which they were allowed to feed for 72 h.

Infection feeding period: Groups of 40 disease carrying whiteflies were placed on healthy melon plants and were permitted to feed for 6, 12, 24, 48 and 72 h.

All the plants were placed in a whitefly-free greenhouse to record symptoms development.

Persistence: *T. vaporariorum* lost its capacity to transmit the causal agent of melon yellowing disease after the 4th day of feeding on healthy plants. A semi-persistent relationship was observed between the causal agent and the vector.

Relationship of numbers of insects to causal agent transmission: One disease carrying whitefly was capable of transmitting the disease to a susceptible host. The transmission efficiency increased with the number of insects employed. Maximum transmission (100 %) was obtained with groups of 30 or more whiteflies. When 40 individuals of *T. vaporariorum* were employed, symptoms appeared sooner and 100% transmission was recorded 24 days after inoculation which was 3 days earlier than in the experiment in which 30 whiteflies were employed.

Infection feeding period: *T. vaporariorum* transmitted the disease to non-infected susceptible plants after six hours of feeding on them. Transmission of 100% effectiveness was obtained in periods of 72 h. The symptoms appeared between the 16th and 24th day after inoculation.

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Host Range of the Causal Agent of Melon Yellowing disease

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Breeding melon (*Cucumis melo* L.) plants with genetic resistance to melon yellowing disease is a long-term objective of extended research. Therefore, there is a serious need for short- or medium-term solutions that will permit the control of the disease or reduce its incidence. One approach to the problem is to seek and identify those wild or cultivated species that could act as reservoirs of the causal agent in the periods between consecutive melon crops. Once these other host plants are known, growers can carry out selective destruction of weeds in and around the greenhouse and to use cultivation strategies to avoid identified periods of growth.

The following are the plant species examined to date: *Tropaeolum majus* L., *Cucurbita* spp., *Cucumis sativus* L., *Phaseolus vulgaris* L., *Cichorium endivia* L., *Lactuca sativa* L., *Pisum sativum* L., *Lycopersicon esculentum* Mill., *Taraxacum officinale* Weber, and *Capsella bursa-pastoris* (L); the disease symptoms in the last two species have already been described and the species have been used as indicators of the presence of disease in experiments with *Cucumis melo* (3,4).

In the first experiment, non disease-carrying whitefly (*Trialeurodes vaporariorum* Westwood) were allowed to feed for 48 h on melon plants showing clear symptoms of yellowing. Then, these whiteflies were transferred in groups of 40 flies to 10 seedlings of each species and allowed to feed for 72 h. Five melon seedlings were used as indicators.

In the second experiment, numerous specimens of *T. vaporariorum* were allowed to feed for 48 h on plant species showing clear or suspected symptoms of disease. Then, for each species to be tested, groups of 40 flies were transferred to 10 seedlings of the same species and 10 melon seedlings, and left to feed for 72 h. In both experiments, whiteflies were then destroyed and the plants were transferred to an insect-proof and fly-free greenhouse to await the development of symptoms.

Table 1 shows that *Cucurbita* spp., *C. sativus*, *Ch. endivia* and *L. sativa* are hosts of the causal agent of melon yellowing disease and also efficient infection sources of nearby melon crops. These four species develop a mosaic yellowing that, in *Cucurbita* spp. and *C. sativus*, starts with a spotting which progresses until all the leaf, except the veins, is yellow.

Ph. vulgaris develops a slight chlorotic staining of the leaves, but in attempts to transmit the infection to other seedling of the same specie, this symptomology could not be reproduced, nor was melon yellowing produced in the melon plants and thus, *Ph. vulgaris* cannot be considered an infection source. *T. majus* showed a progressive yellowing of the leaves in some plants, but these symptoms could not be reproduced in plants of the same specie nor did melon yellowing appear in the melon plants infected with whiteflies that had previously been allowed to feed on symptom-showing leaves of *T. majus*.

P. sativum and *L. esculentum* never showed any symptoms.

Table 1. Possible range of hosts of the causal agent of melon yellowing disease. A = incidence of yellowing in plants inoculated by whitefly previously allowed to feed on melon plants with clear symptoms of disease. B = incidence of yellowing in plants of each species inoculated by whitefly previously allowed to feed on plants of the same species showing symptoms. C = incidence of yellowing in melon plants inoculated by whitefly previously allowed to feed on plants of each species showing symptoms.

	A	B	C
Cucurbita spp.	2/10[z]	4/10	7/10
Cucumis sativus	8/10	8/10	8/10
Phaseolus vulgaris	9/10	0/10	0/10
Cichorium endivia	3/10	3/10	9/10
Lactuca sativa	5/10	8/10	7/10
Tropaeolum majus	4/10	0/10	0/10
Pisum sativum	0/10	-	-
Lycopersicon esculentum	0/10	-	-
Taraxacum officinale	6/10	-	-
Capsella bursa-pastoris	9/10	-	-

[z] a/b; a = no. of plants with symptoms, b = total of plants inoculated.

These results suggest that the causal agent of melon yellowing disease observed in the greenhouses of S.E. Spain could be the beet pseudo yellows virus (BPYV) whose range of hosts has been described dy Duffus (1). The symptomology of the hosts described by Van Dorst et al. (5) and Hristova and Natskova (2) also coincides with our results. Yamashita et al. (6) describe the cucumber yellowing virus (CuYV) that produces the same yellowing symptoms in melon, but which can only be transmitted to Cucurbitaceae.

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Ten Interspecific Crosses in the Genus *Cucumis*: A Preparatory Study to Seek Crosses Resistant to Melon Yellowing Disease.

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Some wild species of the *Cucumis* genus show resistance to different plant pests and diseases, and consequently they may be useful experimental material for studies that seek to transfer this resistance to cultivated species.

The aim of this work was to determine the true potential of several wild species of the genus for improving melon plants *Cucumis melo* L. by carrying out interspecific crossing experiments. The species used in this work were selected taking into account their known resistance to melon yellowing disease shown in previous work (3,6) and also published material on this subject (1,2,4).

Four species were selected because of their resistance to melon yellowing disease in conditions of natural infection shown by several studies (3,6). They were: *Cucumis anguria* var. *longipes*, *C. zeyheri*, *C. africanus*, and *C. myriocarpus*. The last two species were tested against melon yellowing disease in controlled conditions to compare the results with those obtained in conditions of natural infection.

According to the literature (2,4), *C. metuliferus* is cross-compatible with the *C. africanus* wild species and also with the cultivated species *C. melo*. This cross-compatibility suggests that *C. metuliferus* could be used as a genetic bridge between these species to transfer the genes of yellowing resistance from *C. africanus* to the cultivated muskmelon, *C. melo*.

Manual cross-pollinations were carried out by using female flowers before anthesis. The plants were kept in a polyethylene greenhouse at a mean temperature of 27.4 ºC max. and 13.7 ºC min. with relative humidities ranging from 70 % max. and 30 % min.; they were cultivated in sandy soil with drip irrigation.

The following 10 interspecific crosses were studied: *C. myriocarpus* x *C. africanus*; *C. africanus* x *C. myriocarpus*; *C. africanus* x C. zeyheri; C. africanus x C. anguria var. *longipes*; *C. africanus* x *C. metuliferus*; *C. zeyheri* x *C. africanus*; *C. anguria* var. *longipes* x *C. africanus*; *C. metuliferus* x *C. africanus*; *C. melo* cv.'Piel de Sapo' x *C. metuliferus* and *C. melo* cv.'Bola de Oro' x *C. metuliferus*.

The numbers of flowers pollinated, the percentages of fruits against numbers of pollinations, and the mean numbers of embryos per fruit for the different crosses, are shown in Table 1.

Table 1. Numbers of pollinations, percentages of fruits against numbers of pollinations, and numbers of embryos.

Crosses	Nº Pollinations	% Fruits	Nº Embryos
C.myriocarpus x C.africanus	128	0.78	70
C.africanus x C.myriocarpus	45	86.67	131
C.africanus x C.zeyheri	23	39.13	16
C.africanus x C.anguria L[z]	91	15.38	57
C.africanus x C.metuliferus	44	0.00	-
C.zeyheri x C.africanus	87	43.68	7
C.anguria L x C.africanus	85	23.53	26
C.metuliferus x C.africanus	66	21.21	415
C.melo PS[y] x C.metuliferus	67	7.46	0
C.melo BO[x] x C.metuliferus	97	7.22	3

[z]L: *longipes* variety

[y]PS: 'Piel de Sapo' cultivar

[x]BO: 'Bola de Oro' cultivar

C. myriocarpus as the female parent crossed with *C. africanus*, although the percentage success was very low (0.78%), and the fruits showed viable F1 seeds, but few germinated and then only with difficulty.

As the female parent, *C. africanus* crossed with *C. myriocarpus* and gave 86.67% success; with *C. zeyheri*, it gave 39.13%; and with *C. anguria* var. *longipes* it gave 15.38%. The fruits of these three crosses produced viable F1 seeds.

The *C. africanus* x *C. metuliferus* crosses were fruitless, but only 44 pollinations were carried out and this was less than were carried out in most of the other interspecific crosses.

C. zeyheri as the female parent crossed with *C. africanus* and the pollination success was 43.68%, but the viability of the F1 seeds was very small; only two seeds could be germinated in Murashige and Skoog cultivation medium (5).

C. anguria var. *longipes* as the female parent crossed with *C. africanus* to give a 23.53% success, but the F1 seed viability has not yet been tested.

C. metuliferus as female parent crossed with *C. africanus* to give 21.21% success. The fruits contained viable F1 seeds.

The 'Piel de Sapo' and 'Bola de Oro' cultivars as female parents crossed with *C. metuliferus* to give respective success rates of 7.46 and 7.22%. The first cross was fruitless. The viability of the F1 seeds of the second cross has not yet been determined.

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A Fifth Gene for Male Sterility in *Cucumis melo*

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Four genes of male sterility have been described in muskmelon (1,2,3,4). A fifth gene has been observed and used for a long time for F1 hybrid seeds production by Clause Seed Company but its description and inheritance have never been published.

This mutation was first observed in 1966 in a breeding program for introducing the powdery mildew resistance of PMR 45 in the Charentais muskmelon type.

On male-sterile plants the number of male flowers blooming is fewer than in male-fertile plants because of abortion at the bud stage. On the male or hermaphroditic flowers, the anthers are of reduced size and empty. The pollen begins to degenerate at the meiotic stage.

Inheritance of male sterility. F1 hybrids between male-sterile and male-fertile plants belonging to different types (Charentais, American Cantaloupes, Indian lines as MR-1...) are fertile and in F2 progenies we have always observed about 25% of male sterile plants (1784 male-fertile vs 560 male-sterile, X^2 = 1.5381, Prob = 21%). These results support the hypothesis of a recessive monogenic control of the male sterility.

Allelism tests. Allelism tests have been made with the four genes of male-sterility which have been described (Table 1). As all the observed plants are fertile, it appears that the allele under study is not allelic of the already known genes. We propose to name it *male sterile-5* (symbol *ms-5*). This gene has been used for commercial F1 hybrid production for instance '68-02' and 'Jivaro' in the Charentais type or 'Fox' in the netted type.

Table 1. Allelism tests between the new male-sterile mutant (ms-5) and the four male sterile mutants already described.

Genotype female parent	Genotype male parent	Number of sterile plants	Number of fertile plants
ms-1 ms-1	*ms-5 ms-5*$^+$	0	49
ms-5 ms-5	*ms-1 ms-1*$^+$	0	30
ms-2 ms-2	*ms-5 ms-5*$^+$	0	44
ms-5 ms-5	*ms-2 ms-2*$^+$	0	25
ms-5 ms-5	*ms-3 ms-3*$^+$	0	92
ms-5 ms-5	*ms-4 ms-4*$^+$	0	90

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Somatic Hybridization of Muskmelon (*Cucumis melo* L.) with Kiwano (*Cucumis metuliferus* Naud.) and Squash (*Cucurbita pepo* L.) by Protoplast Electrofusion

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The introduction of disease and pest resistances and the increase in cold tolerance are two important objectives of muskmelon (*Cucumis melo* L.) improvement programs.

Considerable progress has already been assessed in these areas through conventional breeding techniques. However the resistances to Squash Mosaic Virus (SqMV) and root-knot nematode (*Meloidogyne incognita*) still remain to be introgressed into the cultivated muskmelon. *Cucumis metuliferus* Naud. (African horned cucumber or kiwano) was found to contain genes that confer resistance or tolerance to these major plagues (4,12). But its cross-incompatibility with *Cucumis melo* L. is very severe, hampering the formation of hybrid progenies (5,10).

Grafting on *Cucurbita* sp. is generally used to improve muskmelon growth at low temperature; however, this method is costly and time-consuming. Sexual crossings would be another way to combine the two genera *Cucumis* and *Cucurbita* but all attempts failed, due to strong incompatibility barriers (9).

Consequently, somatic hybridization by protoplast fusion appears to be a judicious approach to overcome this sexual incompatibility. Several studies already reported somatic hybridization in Cucurbits at the interspecific (3,7,13,14,17) and intergeneric (1,3,13) levels.

In this report, we describe results concerning the isolation and culture of muskmelon protoplasts and their electrofusion with kiwano or squash protoplasts. Our aim is to obtain somatic hybrids with the agronomically valuable traits mentioned above.

Plant material: Cotyledons and leaves of axenic cultures of muskmelon, squash and kiwano (leaves only) were used in our experiments. *Cucurbita pepo* L. cv. Diamant F1 and *Cucumis melo* L. cv. Preco F1 were provided by Dr. Mounier Mirabel, Nunehms Zaden, Valence-France. *Cucumis melo* L. cv. Charentais T, *Cucumis metuliferus* (originally from Fassuliotis), and *Cucurbita moschata* L. were provided by Drs. Risser and Pitrat, INRA, Avignon-France.

Muskmelon seeds were sterilized in 2% calcium hypochlorite (70% active Chloride, Prolabo) for 3 min. followed by 3 rinses in sterile bidistilled water. Squash and Kiwano seeds were placed in 4% calcium hypochlorite for 15 min. and then soaked for 24 h in bidistilled water. After seed coat removal they were placed in 2% calcium hypochlorite for 3 min. followed by 3 rinses in sterile bidistilled water (7).

Fully expanded cotyledons were cut off as apical buds were aseptically planted into 250 ml bottles containing 50 ml of MEL (7) modified medium with 3% sucrose and 0.7% agar. Table 1 gives culture duration on MG and MEL media.

Table 1. Culture duration of mother plants on MG and MEL media for the obtention of cotyledon and leaf mesophylls as source of protoplasts.

Plant	Cotyledon (MG)	Mesophyll (MEL)
muskmelon	12 days	18-21 days
squash	7 days	11-13 days
kiwano	-	clonal propagation

The first to fourth expanded leaves were used as a source of mesophyll protoplasts. The incubation was carried out in a culture room at 27±1°C (day) and 21±1°C (night). The photoperiod was 16 h under 50 $\mu Em^{-2}.s^{-1}$ provided by cool white fluorescent tubes GRO-LUX Sylvania.

Protoplast isolation: Leaves and cotyledons were cut in 1 mm wide strips and preplasmolysed during one hour in SB solution consisting of CPW salts (6), 0.1M glycine, 0.1M glucose and 3mM MES. The osmotic pressure was adjusted to 600 mosmol/kg with mannitol. The pH was adjusted to 5.7 with KOH. Enzymatic digestion was performed in SB completed with 1.5% cellulase onozuka R-10 (Yakult, Tokyo) and 0.3% macerozyme R-10 (Yakult, Tokyo); tissues were incubated overnight (15-16 h) in the dark at 27±1°C. The enzyme-protoplast mixture was then filtered on a 63 μm stainless steel mesh. Protoplasts were pelleted (100 g, 5 min.), resuspended in CPW solution with 21% w/v sucrose and centrifuged (120 g, 10 min.). Intact floating protoplasts were rinsed in SB solution (100 g, 5 min.) and finally transferred to culture medium.

Protoplast fusion: Electrofusion was carried out using the electric apparatus described by Sihachakr et al. (15). The movable multi-electrodes were connected to both a function generator (Enertec 4415) and a DC square pulse generator (self-constructed unit). They were placed in a Petri dish containing 0.6 ml of a mixture (1:1) of protoplasts of both parents at a density of 3.10^5/ml of a 0.5 M mannitol solution. Following the application of 15 s AC field at 125 V/cm and 1 Mhz for aligning protoplasts, 6 square pulses developing 1150 V/cm for 60 μs each were applied for protoplast fusion.

Protoplast culture: Immediately after the fusion process, 0.4 ml LCM culture medium (16) was progressively added to the fused protoplast mixture, completed with 1 ml 1.2% agarose-containing medium 24 h later. This gave a final concentration of 10^5 protoplasts/ml. After 2 weeks culture in darkness, plating efficiency (number of dividing protoplasts/total number of protoplasts) was established and agarose blocks transferred on solid LCM medium with 0.75 mg/l BAP. When microcalli have reached the size of about 1-2 mm they were isolated and cultured according to the protocol of Branchard and Chateau (2), for initiation and development of somatic embryos.

Protoplast isolation: The same isolation procedure was applied to all our genotypes with satisfactory yield of intact protoplasts. That is $0.5\text{-}1.5.10^6$ prot./g cotyledon tissue and $1.5\text{-}5.10^6$ prot./g mesophyll tissue.

Protoplast fusion and culture: Without any fusion treatment, muskmelon protoplasts began to divide on the third day of culture; the plating

efficiency determined 14 days after isolation was on average 25% in LCM medium, whatever genotype and organ source. But until now plant regeneration was obtained only from 'Charentais T' cotyledons, with 3 months being necessary from protoplast isolation to development of embryos into plantlets. Kiwano and squash protoplasts underwent divisions but at a lower rate than muskmelon ones, with plating efficiencies being respectively 9% and 7%. Kiwano calli showed vigorous and sustained division on the contrary of squash calli whose growth was very slow and which tended to turn brown with time. None of these calli were able to differentiate embryogenic structures in our conditions.

The fusion treatment did not seem to significantly affect plating efficiency compared with control. The number of binary fused protoplasts varied between 18 and 28% according to the parental species and the origin of protoplasts (results assessed thanks to a DAPI (4'-6'diaminido-2-phenylindole) coloration of protoplast nuclei). No regeneration was observed after fusion experiments yet.

We do not have any early markers to select our heterocaryons or hybrid microcalli. So the fact that squash and kiwano protoplasts divide with low frequency and that they are unable to regenerate into plants appears to be a great advantage. Moreover, our fusion procedure is quite efficient and then increases the probability for heterofusions to occur. Both these facts will help considerably the recovery of hybrid products.

But the main problem encountered was the bad regeneration efficiency of muskmelon protoplast-derived calli. Some experiments are underway to improve the regeneration rate.

From now on, isozyme studies will be undertaken to confirm hybridity at the callus and plant levels; we focus our attention on malate dehydrogenase and acid phosphatase systems.

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Edible Seed Watermelons (Citrullus lanatus (Thunb.) Matsum.& Nakai) in Northwest China

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Northwest China is a major production area for melons (Cucumis melo L.) and fleshy watermelons, due to the high temperatures, intensive sunlight, and the extremely dry summer climate. In addition, this is a very important production area for watermelon grown for edible seeds. Early edible seed watermelon production and varieties were described in the "Gaolan County Record" of 1774 (1), thus there has been production in Northwest China for over 200 years. Presently, edible seed watermelon is an important economic crop in this region. In 1988, the edible seed watermelon production area and total seed yield in Gansu province were 266,000 mu (6 mu = 1 acre) and 22,636 tons, respectively (data provided by the Gansu Melon & Fruit Company).

Edible Seed Watermelon Varieties in Northwest China

Edible seed watermelons can be divided into two types based on seed coat color. Varieties with red seed coats are distributed mainly in other areas of China, especially South China. Edible seed watermelons in Northwest China, for the most part, have seeds with a black margin and a white or yellowish center (Fig. 1). There are four common varieties of white-black seeded, edible seed watermelons in Northwest China. All of these varieties have good storage and shipping quality, and have good adaptability throughout the area.

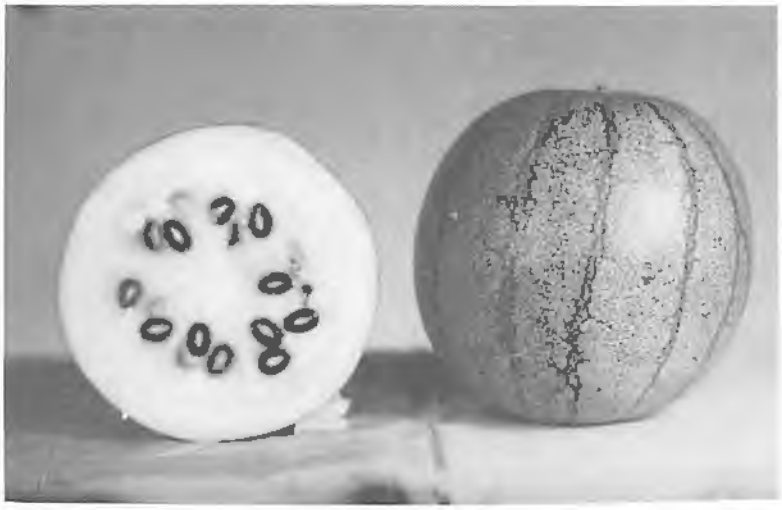

Figure 1. Fruit of edible seed watermelon.

1. 'Hetaopi' is a late maturing, popular variety which produces round fruits of about 3 kg. The light green skin is ornamented by 10 or more wide pencilled line-type bands, with a rind thickness of 0.9 cm. The yellowish sour flesh is of poor quality with a soluble solids content (SSC) of 4%. Fruits ripen 55 days after pollination, with the total developmental period more than 120 days. There are 250 or more seeds per fruit with a 1000-seed weight of 260 g. The seeds are 1.65 cm in length and 1.1 cm in width.

2. 'Green Skin' is a late maturing variety in which the fruit ripens 55 days after pollination, and total plant development takes over 120 days. The fruit is round and weighs about 3 kg, with light green skin and 8 to 10 narrow pencilled line-type bands. The rind is 1 cm thick, and the slightly sweet white flesh contains 4.8% soluble solids. There are 300 seeds per fruit, with a 1000-seed weight of 210 g or more. Seed length and width are 1.6 cm and 0.95 cm, respectively.

3. 'Dark Skin' is a late maturing variety with fruit development and plant maturity of 55 days and 120 days, respectively. Fruits are round and weigh about 2.5 kg, with sour tasting white flesh of poor quality (SSC=4.5%). There are about 250 seeds per fruit, with lengths and widths of 1.5 cm and 0.95 cm, respectively, and a 1000-seed weight of 230 g.

4. 'Striped Skin' is a late maturing variety with the same developmental periods as the above described varieties. The fruits are round and weigh about 3.5 kg. The skin is green and smooth with 10 dark green stripes. The flesh is white and somewhat sweet, with a SSC of 4%. There are 320 or more seeds per fruit, with a 1000-seed weight of 210 g, and a seed length of 1.65 cm and a seed width of 1.1 cm.

Production Practices for Edible Seed Watermelon

Traditional cultural practices are very simple. Farmers sow seed after the last frost and wait until senescence to harvest fruits. There is almost no management throughout the season, and seed are collected when farmers have free time.

Only recently has research begun on cultural practices, and seed yield has been shown to be affected by horticultural management. Higher seed yields (202.3 kg/mu) were obtained by using a plastic film for mulching, adding 10 to 15 kg/mu phosphorus (P_2O_5), and increasing the plant density (3000 to 4000 plants/mu) (2,3,4).

Potential for Edible Seed Watermelon Improvement

Existing varieties are highly heterogeneous and express great diversity for seed size and other horticultural characteristics. It appears that the most important economic character, 1000-seed weight, can be greatly improved by using simple selection. Lines with 1000-seed weight as high as 340 g have been produced and placed in commercial production (3), verifying the potential for genetic improvement of seed yield. Development and utilization of F1 hybrids might also accelerate commercial edible seed watermelon production in Northwest China.

Edible seed watermelon breeding projects have been initiated at the Melon Research Center of Gansu Agricultural University and the Lanzhou Agriculture Research Institute. In addition to seed yield, resistances to Fusaarium wilt, anthracnose, and gummy stem blight are being sought. A few desirable breeding lines have been developed.

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Nutrients in Seeds of Edible Watermelon (*Citrullus lanatus* (Thunb.) Matsum. and Nakai)

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Although there are other processed products from the flesh of edible seed watermelons in China, the main purpose is seed production. The seeds are roasted and eaten, with or without salting. Therefore, the economic value of these watermelons is dependent upon seed yields and nutrient values. A clear understanding of the nutrient make-up of seeds and their diversity among accessions are of practical importance for improvement of seed quality.

In 1987, dry seeds, with the seed coats removed, from three edible watermelon seed accessions (SW-1 and SW-2 with white-black seed coats, and SW-3 with red seed coats) were tested for nutrient content. Seeds were evaluated for amount of crude protein and fat, 17 amino acids, and fatty acid composition. Determinations were performed at the Center Laboratory at Northwestern Agricultural University. Analyses of crude protein and fat, amino acids, and fatty acids were determined on a MRK MR-150 KJEL auto nitrogen and protein analyzer, a MRK FATEX-P fat extractor, a BEKMAN 121MB amino acid analyzer, and a HITACHI 663-30 gas chromatograph, respectively.

The results of the crude protein and fat analyses are shown in Table 1. Similar analyses were previously reported for African and common watermelon accessions (1). The crude protein content of the edible seed lines in this test were much lower than were found in the seeds of the African lines (33.9 to 43.6%). However, the crude fat content in the edible seeds is similar to the African accessions (37.7 to 46.8%). Fatty acid composition of the edible seed revealed a very high proportion of the essential fatty acid, linoleic acid (C18:2) (Table 2). The proportion of linoleic acid in accessions SW-2 and SW-3 is much higher than the high quality plant oils from soybean (52.2%) and sesame (43.7%) (2). The very high proportion of the unsaturated linoleic acid in edible watermelon seed could provide a nutritious new source of the fatty acid used in the reduction of cholesterol and the prevention of arteriosclerosis in humans. In addition, edible watermelon seeds contain significant amounts of the essential amino acids (Table 3).

Even though the number of accessions of edible watermelon seed studied were limited, diversity in nutritive characters was observed. The greatest diversity was found in total fat content (38.6 to 47.9%) and the proportion of linoleic acid (31.17 to 72.98%). This shows us there is a high potential for genetic improvement of nutrients in edible watermelon seed.

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Table 1. The crude protein and crude fat contents (%) of seed of edible seed watermelon.

Accessions	Crude Protein	Crude Fat
SW-1	26.77	38.69
SW-2	28.15	44.39
SW-3	27.69	47.93

Table 2. The fatty acid components and their proportions (%) of edible seed water melon seeds.

Accessions	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2*	C18:3*
SW-1	0.6	33.28	0.98	14.90	15.32	31.17	2.07
SW-2	trace	10.03	trace	3.18	9.46	77.33	none
SW-3	0.22	10.56	trace	4.19	12.44	72.98	none

* Essential fatty acids.

Table 3. The amino acid content of edible seed watermelon seeds (g/100g).[z]

Amino Acids	SW-1	SW-1	SW-3
Asp	3.334	3.211	3.003
Thr*	1.826	1.724	1.641
Ser	1.736	1.430	1.398
Glu	6.646	6.442	6.278
Pro	3.005	1.665	1.751
Gly	1.803	1.761	1.677
Ala	1.904	1.499	1.502
Cys	0.299	0.296	0.286
Val*	1.904	1.759	1.616
Met*	0.337	0.249	0.343
Ileu*	1.439	1.486	1.333
Leu*	2.530	2.164	2.036
Tyr	0.733	0.899	0.894
Phe	1.508	1.696	1.627
Lys*	1.142	1.088	0.960
His*	1.080	0.843	0.679
Arg*	6.662	4.980	4.796

* Essential amino acids.

[z] Amino acid grams in 100 grams of sample.

A Genetic Male-Sterile (ms) Watermelon from China

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In 1983, Xitong Xia and his colleagues found two male-sterile watermelon plants with small, shrunken anthers and aborted pollen, from among selfed progeny of cv. Nongmi No. 100. They pollinated each male-sterile plant separately with pollen from two fertile sibs, which were also self-pollinated. The four F1 hybrids and progeny from the four fertile sibs were planted and scored for male-fertility in 1984. Three of the four F1 hybrids segregated 1:1 (fertile:sterile), and the progeny of the self-pollinated fertile sibs segregated 3:1 (fertile:sterile). Testing and selections were made over three subsequent generations. A male-sterile line, G17AB, with a well-behaved single recessive gene, designated ms, was reported in 1986 (Chinese reference not cited). The ms gene has been introduced into two of their breeding lines.

The Chinese ms watermelon line, G17AB, came into our breeding program in 1988. In contrast to the gms trait described by Watts (4), the Chinese ms watermelon line contains no gross morphological differences between sterile and fertile plants. However, there are similarities in male flower morphology. Male flowers of a gms line (provided by B. B. Rhodes, Clemson University) and the Chinese ms line are both very small and usually do not open early in the season. When they do open later in the season, the pollen is shrunken and non-viable.

G17AB is a medium round melon with dark green stripes (similar to the striping in 'Sugarlee'). Fruit matures about 100 days after sowing and 32 days after flowering. Under our conditions, G17AB fruit mature before 'Sugarbaby'. Flesh is red, with small, dark brown seed. The number of seed per male-sterile fruit is nearly normal or slightly less than fruit on male-fertile plants. The soluble solids content is about 10 per cent.

This ms line has been used as a maternal parent for F1 seed production in China. This system of F1 seed production was suggested by Rhodes and coworkers (1,2,3). In 1988, Rhodes (personal communication) suggested that a new male-sterile combination might be obtained by crossing lines containing the Chinese ms and the gms traits. These crosses are being made by Rhodes at Clemson University and Zhang at Northwestern Agricultural University. Through this collaborative research we hope to develop commercial watermelon lines with this new male-sterile combination.

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Male-Sterile (ms) from China Apparently Non-Allelic to Glabrous-Male Sterile (gms) Watermelon

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Controlled pollinations were made in the summer of 1989 between different watermelon lines containing the single recessive genes male-sterile (ms) and glabrous-male sterile (gms). F_1 plants grown in the greenhouse in winter of 1989-90 revealed no segregation for sterility in genotypes [(ms ms) x (Gms gms)] and [(gms gms) x (Ms ms)]. These data suggest that ms and gms are non-allelic.

Staining Procedure for Watermelon Somatic Chromosomes

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The application of polyploidy in watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) breeding, and the development of aneuploid stocks for future genome mapping and chromosome engineering, requires the characterization of the watermelon chromosome karyotype. This report presents methodology which can be used routinely for chromosome screening. The procedure allows for the arresting of chromosome divisions at metaphase, which is very suitable for chromosome counting. P-dichlorobenzene (PDB) is used as a pretreatment factor. PDB causes straightening of the chromosome arms, prevents excesssive clumping, and stimulates contraction. It has been employed successfully as a pretreatment reagent in karyotype studies on a number of plants, particularly legumes. A root-tip squash technique which applied paradichlorobenzene was used for soybean. Forty, uniformly shaped, small chromosomes were described (2). Skorupska and Palmer (1) using PDB treatment were able to identify soybean monosomics (2n-1 = 39 chromosomes).

The seed of three cultivars, 'Sugar Baby', 'Charleston Gray', and 'Southern Bell Hybrid', were germinated and positive chromosome staining was obtained. Chromosomes were stained dark purple and the cytoplasm was clear enough to provide a good contrast for more detailed analyses of chromosome morphology.

Root-tip Squash Preparation

1) Germinate scarified seeds for 72 to 96 hours at 27 to 28°C on 10 x 15 regular weight germination paper.
2) Harvest root-tips at 8:30 a.m., excise 1 cm and partly slit tips with a razor blade for better chemical penetration.
3) Prefix root-tips in covered vials in saturated PDB at 12.5°C for 2-1/2 hours.
4) Transplant seedlings into peat-pots.
5) Wash root-tips in distilled water, transfer to 3:1 fixative (95% ethanol:glacial acetic acid) for 24 to 48 hours in covered vials at 28 to 30°C.
6) Wash root-tips in distilled water hydrolyze in 1N HC1 for 8 to 10 minutes, at 60°C.
7) Place root-tips in Feulgen's stain, in covered vials 45 to 60 minutes in the dark, at room temperature.
8) Place root-tips in ice cold water and allow to set 20 minutes.
9) Place root-tips in a porcelain spot plate in pectinase. Cover plate with parafilm and incubate for 1-1/4 hours at 30°C.

10) Transfer root-tips to 70% ethanol and store in refrigerator.

11) Put treated root-tip on a slide and with a razor blade remove and discard the unstained root cap. Place 1/2 to 1 mm of the root-tip in a drop of 0.5% aceto-carmine stain. Tap gently but thoroughly with a glass rod. Apply a cover slip and press firmly under filter paper, or a pellet press.

PDB Preparation

750 mg PDB, 50 ml distilled water, in stoppered 125 ml Erlenmeyer flask, corked, incubate overnight at 60°C. Cool, then shake vigorously before using.

Leuco-basic Fuchsin (Feulgen Stain) Preparation*

1) Put 1 g basic fuchsin in a 500 ml Erlenmeyer flask.
2) Pour 200 ml boiling water into flask, shake well.
3) Cool to 50°C check temperature frequently with a thermometer (further cooling may cause precipitation).
4) In a Buchner funnel, vacuum filter through 2 layers #1 filter paper.
5) Add: 30 ml 1N HC1
   3 g potassium metabisulfite ($K_2S_2O_5$)
6) Shake well, pour into a well-stoppered bottle, store in the dark at room temperature for 24 to 48 hours.
7) Add 1 g powdered decolorizing charcoal, shake well. Vacuum filter in a Buchner funnel through 2 layers of #1 filter paper. If solution is still slightly colored, you may add another 1 g charcoal, and refilter.
8) Store in a well-stoppered amber bottle, or bottle wrapped in foil, in the refrigerator. Allow stain to "mature" 1 to 2 days before using.

*Adapted from "The Handling of Chromosomes." 1970. C. D. Darlington and L. F. LaCour. Hafner Publishing Company, Inc., Darien, Conn.

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Availability and Use of Interspecific Populations Involving *Cucurbita moschata* and *C. pepo*.

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In view of increasing interest in the transfer of traits between species of *Cucurbita*, it may be relevant to call attention to the existence of interspecific populations that we have maintained and found useful. These are derived from the work of Wall and York (1960) and have been maintained by periodic increases in isolated plantings which allow natural intercrossing within each population. All populations started with several F_1 plants obtained through embryo culture from 'Yankee Hybrid' (YH, a yellow straightneck summer squash, *C. pepo*) pollinated by 'Butternut' (BN, *C. moschata*). Wall and York (2) created the following three populations:

1. YH X BN F_2 obtained by selfing the F_1. Increases in 1960, 1973, 1979, and 1989 consisted of isolated plantings of 50-75 plants each.

2. (YH X BN) X BN. Four increases were made as for the F_2. Plants most closely approaching bush habit were backcrossed several times to Butternut to get 'Butternut 77'. This has not so far been useful as a variety because of a strong tendency to produce dimorphic crookneck plants. With correction of this defect nearly accomplished, it may be possible to take advantage of the slightly earlier maturity, more concentrated fruit set, and shorter vines derived from *C. pepo*.

3. (YH X BN) X *C. pepo*. This population is highly variable because backcrosses to several summer squash varieties were combined for increases in 1960. Three additional increases have been made. It was used as a bridge for the transfer of resistance to powdery mildew and cucumber mosaic from *C. martinezii* to *C. pepo*. Contin (1) obtained several viable seeds after pollinating this backcross population with the F_1 of Butternut X *C. martinezii*. The resulting plants were selected for PMR and were readily crossable with various *C. pepo* varieties. We have also found in this population plants with resistance to the squash vine borer, *Melittia cucurbitae* (Harris) and have used them to start incorporating this insect resistance into *C. pepo*.

Some of the recent increases of these 3 populations will be sent to the National Seed Storage Laboratory. For the near future, seeds may be obtained from the author.

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Relationship Between the B Genes of Two Cucurbita Species, III.

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The main subject of this series of reports is the relationship between the gene for precocious depletion of chlorophyll in ovaries of C. pepo and the gene for precocious depletion of chlorophyll in stems and ovaries of C. maxima. Precocious depletion of chlorophyll is associated with white, yellow, or golden color, singly or in combination, depending upon other genes.

The "precocious" gene of C. pepo was formally designated by symbol B for potential bicolor fruit variation. And the "precocious" gene of C. maxima was tentatively designated by the same symbol because it too is potentially associated with bicolor fruit variation. Over 20 years ago, in the absence of a breeding test for allelomorphism, I treated the two genes as different alleles at the same locus. This was done for sake of temporary convenience in nomenclature, but not without misgivings.

The absence of a breeding test for allelomorphism was due to the fact that the two species are isolated from one another by strong genetic barriers. These barriers were circumvented through interspecific transfers of the two "precocious" genes to C. moschata. As a result, two new inbreds of C. moschata were established: NJ-B and IL-B. NJ-B carries the "precocious" gene of C. pepo, and IL-B carries the "precocious" gene of C. maxima (Ref. 1; see also Table 1 in the present report.)

Now that we have a breeding test for allelomorphism, through the cross NJ-B x IL-B, it seems that my early assumption that the two genes are alleles was false, and that these genes are non-linked (Refs 1 and 2; see also additional data in the following report, IV). But one cannot yet exclude the possibility that the two genes belong to the same "gene family".

Although the evidence for non-linked relationship is fairly convincing, some mysteries remain. The mysteries are largely due to epigenetic and external factors that profoundly modify the expression of the "precocious" genes during plant development. And these factors indirectly introduce difficulties in classification. The objective of this report is to present data on the breeding behavior of a single plant, 123-66, whose phenotype was difficult to classify with certainty.

Plant 123-66. Two F_2 segregates of the cross NJ-B x IL-B were described in the 1989 report as "having precociously pigmented stems, green ovaries and green leaves". The two plants were listed in a group of nine unclassified F_2 individuals (see last paragraph in reference 2), and one of the two was 123-66. This plant was lightly pigmented overall. It produced small, oblate fruits (4.5 x 7 cm) that turned from green to tan at maturity. Apart from fruit size and shape, its fruit color development was similar to that of 'Butterbush' (Table 1). Precocious depletion of chlorophyll in stems was mainly confined to the base of the plant.

The reason for listing 123-66 among the unclassified plants was that I had some reservation of its true phenotype. Specifically, I observed only six ovaries in this plant and indeed all were green. Experience has shown, however, that some B plants produce in sequence as many as ten green ovaries before they produce precociously pigmented bicolor ovaries. Furthermore, certain virus infections can transform potentially yellow ovaries into green ones. Since 123-66 with green ovaries and precociously pigmented stems posed a challenging question, I decided to study its breeding behavior. The question was this: Is plant 123-66 a cross-over product?

Key to phenotypic symbols used in classification. For each plant, the pigmentation of ovaries, stems, petioles and leaf blades was represented by a combination of letters. The key to these phenotypic symbols was as follows: B = leaf blade; G = green; L = low level of expressivity, implying that precocious depletion of chlorophyll was not extensive; O = ovary; P = petiole; PDC = precocious depletion of chlorophyll; S = stem; T = turn, implying that ovaries turned from green to another color at anthesis or about 2 days after anthesis, i.e., chlorophyll depletion occurred early in fruit development, but not at very early pre-anthesis stages; U = uniform pigmentation over the entire surface of the ovary or fruit. Thus: the combination GO, GS, GP, GB refers to all-green plants; GO, PDC-SL, GP, GB describes plants in which the ovaries are green, the stems exhibit a low level of expressivity with respect to precocious depletion of chlorophyll and the petioles and blades are green; GOT, PDC-S, GP, GB refers to plants in which ovaries turn early in fruit development from green to another color, the stems exhibit a high level of expressivity of precocious depletion of chlorophyll (extensive pigmentation) and the petioles and leaves are green; and PDC-UO, PDC-S, PDC-P, GB describes plants whose ovaries are precociously and uniformly pigmented, stems and petioles are also precociously pigmented and blades are green. In this latter phenotype, the leaf blades are often partially PDC, i.e., fluctuating from GB to PDC-BL.

Results and discussion. The results are presented in Table 2. The proportion of phenotypes in the offspring of 123-66 does not disagree with a monhybrid ratio of 1:2:1 (test #1, n=49, X^2=1.16,df=2, P=0.50-0.70; note that I excluded from the total a single deviant plant to which I'll refer later), suggesting that 123-66 was heterozygous for the "precocious" gene of C. maxima, and that in heterozygotes the effect of this gene on ovaries appears as a recessive trait whereas its effect on stems appears as a partially dominant trait. This suggestion is supported by test #3 (n=256, deviation X^2=0.09, df=2, P=0.95-0.98; heterogeneity X^2=3.74, df=6, P=0.70-0.80) as well as by all other relevant tests.

Conclusion: 123-66 did not originate as a cross-over product. Reason: In the offspring of 123-66, plants homozygous for the "precocious" gene exhibited the dual effects of this gene rather than one exclusively, the effect on stems.

It is important to point out that I observed 15 F1 plants of each of the crosses IL-B x Black Line and IL-B x 'Butterbush' (see Table 1; note that both Black Line and 'Butterbush' are standards), and all 30 plants exhibited precociously pigmented stems and fruits. In these hybrids, the "precocious" gene of C. maxima is partially dominant with respect to its dual effects. Question: Does the F2 of NJ-B x IL-B segregate for elements that selectively switch one of the dual effects of this gene from dominant to recessive expression?

As to the deviant plant (123-66-26) found in the offspring of 123-66 (test #1), it is clear (test #7) that this is a mutant whose phenotype is intermediate between the "precocious" homozygote and the heterozygote. This is perhaps another example supporting the suggestion made years ago that "precocious" loci are labile.

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Table 1 - Description of some breeding materials in *C. moschata*

Breeding Materials	Description
Black Line	A vine breeding line homozygous for genetic material conditioning normal synthesis of chlorophyll. It is considered as standard. Stems and fruits are green at early stages becoming darkgreen or "black" later in development. Fruits are similar to 'Butternut' in size and shape. Originated in an F_2 segregate (124-56) of the cross NJ-B x IL-B.
'Butterbush'	An inbred of 'Burpee Butterbush' homozygous for genetic material conditioning normal synthesis of chlorophyll. It is considered as another standard. But unlike Black Line, it exhibits an overall light green pigmentation. Fruits turn from green to tan 14-16 days following anthesis.
IL-B	A vine inbred that carries a gene for precocious depletion of chlorophyll in stems and fruits. This gene was transferred to *C. moschata* from P.I. 165558 of *C. maxima*[z] through innovative series of backcrosses. Stems and fruits are precociously yellow at early stages, becoming intensely golden late in development. Fruits are similar to 'Butternut' in size and shape. Leaf blades are green under field conditions in New Brunswick, NJ, and Naples, Florida.
MP	A clone derived from an F_1 plant, 7356-14, of the cross NJ-B x IL-B. Stems and fruits are precociously yellow gradually becoming light golden. Fruits are of medium size and bell-shaped. Leaf blades exhibit precocious yellow pigmentation along their midrib ("midrib pattern") in short days.
NJ-B	A bush inbred that carries gene *B* for precocious depletion of chlorophyll in fruits. This gene was transferred to *C. moschata* from 'Jersey Golden Acorn' (JGA) of *C. pepo* through the pedigree method of selection following the cross JGA x 'Butterbush'. Fruits are precociously yellow at early pre-anthesis stages, turning white and later tan at maturity. The fruits are small and oblate (3.5 x 7.0 cm). Stems and leaves are green.
NOMP	A clone derived from an F_1 plant, 7356-1, of the cross NJ-B x IL-B. It is similar to MP except that its leaf blades do not exhibit precocious yellow pigmentation along their midrib.

[z] This gene of *C. maxima* was tentatively designated by symbol *B*; but its physical and functional relationship to gene *B* of *C. pepo* is not known.

Table 2. Breeding tests of selection 123-66 and its offspring. This selection was an F_2 segregate of the cross NJ-B x IL-B (Table 1). The F_2 was grown in fall 1988; the offspring of 123-66 was grown in spring 1989 and all other progenies were grown in fall 1989. Field data, Naples, Florida.

Test	Parent: Pedigree, phenotype and mode of reproduction	Offspring: Phenotypic Classes[z] PDC-UO[y] PDC-S PDC-P GB	GOT PDC-S GP GB	GO PDC-SL GP GB	GO GS GP GB	Total
1	123-66:GO,PDC-SL,GP,GB[y],⊗	13	1[x]	21	15	50
2	123-66-1:GO,GS,GP,GB,⊗	0	0	0	10	10
3	123-66-8:GO,PDC-SL,GP,GB,⊗	9	0	25	16	50
	123-66-21:GO,PDC-SL,GP,GB,⊗	13	0	27	10	50
	123-66-30:GO,PDC-SL,GP,GB,⊗	12	0	17	8	37
	123-66-49:GO,PDC-SL,GP,GB,⊗	29	0	60	30	119
	Test 3 pooled	63	0	129	64	256
4	123-66-1x123-66-8	0	0	4	6	10
	123-66-1x123-66-21	0	0	7	3	10
	123-66-1x123-66-30	0	0	4	6	10
	Test 4 pooled	0	0	15	15	30
5	123-66-23:PDC-UO, PDC-S,PDC-P,GB,⊗	5	0	0	0	5
	123-66-32:PDC-UO, PDC-S,PDC-P,GB,⊗	5	0	0	0	5
	123-66-44:PDC-UO, PDC-S,PDC-P,GB,⊗	5	0	0	0	5
	Test 5 pooled	15	0	0	0	15
6	123-66-23x123-66-1	0	0	5	0	5
	123-66-44x123-66-1	0	0	5	0	5
	Test 6 pooled	0	0	10	0	10
7	123-66-26:GOT,PDC-S,GP,GB,⊗	0	106	0	0	106

[z] The fruits of all the plants of these classes were indistinguishable at maturity, being uniformly tan.

[y] The key to phenotypic symbols is given in the text.

[x] The pedigree of this plant was 123-66-26. See test 7 (above) for the breeding behavior.

Relationship Between the B Genes of Two Cucurbita Species, IV.

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This report provides data on the inheritance of precocious depletion of chlorophyll in C. moschata based on the cross NJ-B x IL-B (see Table 1 in the preceding report). The data were obtained in Naples, Florida, during the past three growing seasons. The spring and fall data of 1989 are presented in Tables 1 and 2 respectively. The combined data for the three seasons, including fall of 1988, are presented in Table 3.

The focus in classification is on the effects of two "precocious" genes on ovaries and stems. The genetic basis for the myriad effects of these genes on leaves, in response to environmental variations, requires a separate analysis.

With the exception of one baffling case (F2 from clone NOMP, Table 1; see also Table 3, test #5), the data agree with the hypothesis that the two "precocious" genes are non-linked (see Table 2 as well as Table 3, tests #4 and 6).

In addition to the total of 306 F2 plants in Table 2, there were 12 F_2 individuals of doubtful phenotypes. These were listed in our notebook as unclassified. Of the 12, one plant, 807-34, was tentatively described as having green stems and bicolor fruits. The bicolor fruits were of the type we usually associate with plants heterozygous for the "precocious" gene of C. maxima. Nevertheless, there was a lingering doubt about the genetic basis for the bicolor fruits.

Breeding tests of plant 807-34 (or tests of other similar plants) should reveal its genotype. Any one of the following three answers is conceivable. (a) Plant 807-34 was heterogygous for the "precocious" gene of C. pepo. (b) It was a cross-over product involving the "precocious" gene of C. maxima. (c) It was heterozygous for the "precocious" gene of C. maxima, but carried elements that selectively switch one of the dual effects of this gene from dominant to recessive expression. At present we incline to believe that the third answer (c) is the correct one.

Table 1 - Inheritance of chlorophyll depletion in C. moschata. Field data, spring 1989, Naples, Florida.

Breeding materials[z]	Phenotypic Classes: PDC-O or GOT[y] PDC-S PDC-P or GB PDC-B or GB	PDC-O GS GP GB	GO GS GP GB	Total	χ^2 F_2 12:3:1 Testcross 2:1:1	P
P_1, NJ-B	0	5	0	5	-	-
P_2, IL-B	5	0	0	5	-	-
F_1, P_1 x P_2	20	0	0	20	-	-
F_2						
from clone MP	167	37	15	219	0.5738	0.70-0.80
from clone NOMP	124	47	4	175	10.9353	0.001-0.01
Testcross						
F_1 x Black Line	74	27	49	150	6.4800	0.02-0.05
F_1 x 'Butterbush'	54	26	30	110	0.3273	0.80-0.90

[z] The description of the breeding materials is given in Table 1 of the preceding report.

[y] The key to phenotypic symbolsis given in the text of the preceding report.

Table 2. Inheritance of precocious depletion of chlorophyll in C. moschata. Field data. fall 1989. Naples. Florida

Breeding materials[z]	Phenotypic Classes: PDC-O or GOT[y] PDC-S PDC-P or GP PDC-B or GB	PDC-O GS GP GB	GO GS GP GB	Total	χ^2 F_2 12:3:1 Testcross 2:1:1	P
P_1, NJ-B	0	5	0	5	-	-
P_2, IL-B	5	0	0	5	-	-
F_1, P_1xP_2	10	0	0	10	-	-
F_2						
(a) from F_1 plant 153-2	88	18	9	115	1.0812	0.50-0.70
(b) from F_1 plant 153-8	75	15	8	98	1.2245	0.50-0.70
(c) from F_1 plant 154-1	65	19	9	93	2.2115	0.30-0.50
F_2 pooled	228	52	26	306	3.0729	0.20-0.30
			Heterogeneity		1.44	0.80-0.90
Testcrosses						
(a) 153-2x Black Line	24	9	15	48	1.5000	0.30-0.50
(b) 153-8x Black Line	31	9	9	49	3.4489	0.10-0.20
(c) 154-1x Black Line	27	14	9	50	1.3200	0.50-0.70
Testcrosses pooled	82	32	33	147	1.9796	0.30-0.50
			Heterogeneity		4.29	0.30-0.50

[z] The description of the breeding materials is given in Table 1 of the preceding report.

[y] The key to phenotypic symbols is given in the text of the preceding report.

Table 3. Inheritance of precocious chlorophyll depletion in C. moschata. Summary of field data from fall 1988 to fall 1989, Naples, Florida.

Test — Breeding materials[z] Generations & growing seasons	Phenotypic Classes: PDC-O or GOT[y] / PDC-S / PDC-P or GP / PDC-B or GB	PDC-O GS GP GB	GO GS GP GB	Total
1. P_1, NJ-B: Fall'88, Spring '89, Fall'89[x]	0	22	0	22
2. P_2, IL-B, Fall'88, Spring'89, Fall'89	22	0	0	22
3. F_1, $P_1 \times P_2$:Fall '88, Spring'89, Fall'89	48	0	0	48
4. F_2:				
(a) from clone MP, Fall '88	162	34	18	214
(b) from clone MP, Spring '89	167	37	15	219
(c) from new F_1 plants, Fall '89	228	52	26	306
F_2 of test 4 pooled	557	123	59	739
		X^2	df	P
Deviation (12:3:1)		5.32	2	0.05-0.10
Heterogeneity		1.00	4	0.90-0.95
5. F_2:				
(a) from clone NOMP, Fall '88	96	25	1	122
(b) from clone NOMP, Spring '89	124	47	4	175
F_2 of test 5 pooled	220	72	5	297
		X^2	df	P
Deviation (12:3:1)		14.72	2	<0.001
Heterogeneity		2.39	2	0.30-0.50
6. Testcrosses:				
(a) F_1 x Black Line, Spring '89	74	27	49	150
(b) F_1 x 'Butterbush', Spring '89	54	26	30	110
(c) F_1 x Black Line, Fall '89	82	32	33	147
Testcrosses pooled	210	85	112	407
		X^2	df	P
Deviation (2:1:1)		4.00	2	0.10-0.20
Heterogeneity		4.79	4	0.30-0.50
7. BC_1, $F_1 \times P_1$:				
(a) Clone MP x NJ-B, Fall'88	47	43	0	90
(b) Clone NOMP x NJ-B, Fall'88	50	52	0	102
BC_1 of test 7 pooled	97	95	0	192

[z] The description of the breeding materials is given in Table 1 of the preceding report. The F_1 seed was produced in small samples in New Brunswick, NJ, between 1983 and 1985. Most of the F_2 seed (test 4, a and b; test 5, a and b) and all the BC_1 seed (test 7) was also produced in New Brunswick, NJ. Other F_2 seed (test 4, c) and all testcross seed (test 6) was produced in Naples Florida.

[y] The key to phenotypic symbols is given in the text of the preceding report.

[x] The data for fall 1988 were taken from Table 1 in reference 2. The data for spring and fall 1989 are in Tables 1 and 2 of the present report.

Gene list for Cucumis melo L.

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Lists of the known genes for the melon have been published previously (13, 14, 15, 62). In order to update and collect information on the melon, the following represents the current list of described genes for *Cucumis melo* L. In **bold characters** are the genes which are maintained by the curators or which are very common in collections (like *andromonoecious* or *white testa*). In light characters are genes which either have been apparently lost, are not yet maintained by curators, or have uncertain descriptions.

It is hoped that scientists will consult the following list as well as the rules of gene nomenclature for the Cucurbitaceae (see appendix) before choosing a gene name and symbol. Thus inadvertent duplication will be prevented.

Gene symbol Prefer.	Synonym	Character	Reference
a	***M***	***andromonoecious*. Mostly staminate, fewer perfect flowers; on a^+_ plants, pistillate flowers have no stamens; epistatic to *g*.**	**57, 63, 70**
ab	-	*abrachiate*. Lacking lateral branches. Interacts with *a* and *g* (e.g. *abab aa* g^+_ plants produce only staminate flowers).	24
Ac	-	***Alternaria cucumerina* resistance (in MR-1).**	**67**
Af	-	*Aulacophora foveicollis* resistance. Resistance to the red pumpkin beetle.	68
Ag	-	***Aphis gossypii* tolerance. Freedom of leaf curling following aphid infestation (in PI 414723).**	**4**
Ala	-	*Acute leaf apex*. Dominant over obtuse apex, linked with *Lobed* leaf. (*Ala* in Maine Rock, Ala^+ in PV Green).	27
Al-1	Al_1	*Abscission layer-1*. One of two dominant genes for abscission layer formation. See *Al-2*. (*Al-1 Al-2* in C68, $Al\text{-}1^+$ $Al\text{-}2^+$ in Pearl).	65
Al-2	Al_2	*Abscission layer-2*. One of two dominant genes for abscission layer formation. See *Al-1*.	65
$Ap\text{-}1^1$	$APS\text{-}1^1$	*Acid phosphatase-*1^1. One of two codominant alleles, each regulating one band. The heterozygote has two bands. See $Ap\text{-}1^2$.	22

Gene symbol Prefer.	Synonym	Character	Reference
Ap-1^2	*APS-1*^{2}	*Acid phosphatase-1*^{2}. One of two codominant alleles, each regulating one band. The heterozygote has two bands. See *Ap-1*^{1}.	22
bd	-	*brittle dwarf*. Rosette growth with thick leaf. Male fertile, female sterile (in TAM-Perlita45).	10
Bi	-	*Bitter*. Bitter seedling (common in honeydew or in Charentais type while most American cantaloupes are *Bi*$^+$).	41
cb	*cb*$_1$	*cucumber beetle* resistance. Interacts with *Bi*, the nonbitter *Bi*$^+$_*cbcb* being the more resistant (in C922-174-B).	50
cl	-	*curled leaf*. Elongated leaves that curl upward and inward. Usually male and female sterile.	10
dc-1	-	*Dacus cucurbitae-1* resistance. One of two complementary recessive genes for resistance to the melon fruitfly. See *dc-2*.	64
dc-2	-	*Dacus cucurbitae-2* resistance. One of two complementary recessive genes for resistance to the melon fruitfly. See *dc-1*.	64
dl	-	*dissected leaf* (in URSS 4). Highly indented leaves.	18
dl^v	*cl*	*dissected leaf Velich*. First described as *cut leaf* in Cantaloup de Bellegarde. Allelic to *dl*.	69
dl-2	-	*dissected leaf-2*. First described as "hojas hendidas".	21
f	-	*flava*. Chlorophyl deficient mutant. Growth rate reduced (in K 2005).	53
fas	-	*fasciated* stem (in Vilmorin 104).	25
fe	-	*fe* (iron) inefficient mutant. Chlorotic leaves with green veins. Turns green when adding Fe in the nutrient solution.	49
Fn	-	*Flaccida necrosis*. Semi-dominant gene for wilting and necrosis with F pathotype of Zucchini Yellow Mosaic Virus (*Fn* in Doublon, *Fn*$^+$ in Védrantais).	61
Fom-1	*Fom*$_1$	*Fusarium oxysporum melonis* resistance. Resistance to races 0 and 2 and susceptibility to races 1 and 1,2 of Fusarium wilt (*Fom-1* in Doublon, *Fom-1*$^+$ in Charentais T).	60
Fom-2	*Fom*$_{1,2}$	*Fusarium oxysporum melonis* resistance. Resistance to races 0 and 1 and susceptibility to races 2 and 1,2 of Fusarium wilt. (*Fom-2* in CM 17187, *Fom-2*$^+$ in Charentais T).	60

Gene symbol Prefer.	Synonym	Character	Reference
Fom-3	-	***Fusarium oxysporum melonis* resistance. Same phenotype as *Fom-1* but segregates independently from *Fom-1*. (*Fom-3* in Perlita FR, *Fom-3*$^+$ in Charentais T).**	*75*
g	-	***gynomonoecious*. Mostly pistillate, fewer perfect flowers. Epistatic to *a*: a$^+$_*g*$^+$_ monoecious; *a*$^+$_*gg* gynomonoecious; *aa g*$^+$_ andromonoecious; *aa gg* hermaphrodite.**	57
gf	-	***green flesh* color. Recessive to salmon. (*gf* in honeydew, *gf*$^+$ in Smiths' Perfect cantaloupe).**	32
gl	-	***glabrous*. Trichomes lacking (in Arizona glA).**	23
gp	-	*green petals*. Corolla leaf like in color and venation.	47
Gs	-	*Gelatinous sheath* around the seeds. Dominant to absence of gelatinous sheath.	26
gyc	-	*greenish yellow corolla*.	74
gy	*N*	**gynoecious. Interacts with *a* and *g* to produce stable gynoecious plants (*a*$^+$_*gg gygy*) (in WI 998).**	37
h	-	***halo* cotyledons. Yellow halo on the cotyledons, later turning green.**	51
jf	-	*juicy flesh*. Segregates discretely in a monogenic ratio in segregating generations.	8
L	-	*lobed* leaf. Dominant on non lobed, linked with *Acute leaf apex*. (*L* in Maine Rock, *L*$^+$ in P.V. Green).	27
lmi	-	***long mainstem internode*. Affects internode length of the main stem but not of the lateral ones (in 48764).**	44
Mc	-	*Mycosphaerella citrullina* resistance. High degree of resistance to gummy stem blight (in PI 140471).	58
Mc-2	*Mc*^{1}	*Mycosphaerella citrullina* resistance. Moderate degree of resistance to gummy stem blight (in C-1 and C-8)	58
Me	-	*Mealy* flesh texture. Dominant to crisp flesh. (*Me* in *C. callosus*, *Me*$^+$ in makuwa).	26
ms-1	*ms*^{1}	***male sterile-1*. Indehiscent anthers with empty pollen walls in tetrad stage.**	6
ms-2	*ms2*	***male sterile-2*. Anthers indehiscent, containing mostly empty pollen walls, growth rate reduced.**	5
ms-3	*ms-L*	***male sterile-3*. Waxy and translucent indehiscent anthers, containing two types of empty pollen sacs.**	46

Gene symbol Prefer.	Synonym	Character	Reference
ms-4	-	***male sterile-4*. Small indehiscent anthers. First male flowers abort at bud stage (in Bulgaria 7).**	42
ms-5	-	***male sterile-5*. Small indehiscent anthers. Empty pollen (in Jivaro, Fox).**	40
Mt	-	*Mottled* rind pattern. Dominant to uniform color. Epistatic with *Y* (not expressed in Y^+y^+) and *st* (*Mt_ ststst* and *Mt_* st^+st^+ mottled; Mt^+Mt^+ *ststst* striped, Mt^+Mt^+ st^+st^+ uniform). (*Mt* in Annamalai, Mt^+ in makuwa).	26
Mu	-	*Musky* flavour (olfactory). Dominant on mild flavour (*Mu* in *C. melo callosus*, Mu^+ in makuwa or Annamalai).	26
n	-	***nectarless*. Nectaries lacking in all flowers (in 40099).**	2
Nm	-	***Necrosis* with *Morocco* strains of Papaya Ringspot Virus (formerly Watermelon Mosaic Virus Morocco) (*Nm* in Védrantais, Nm^+ in Ouzbèque).**	59
nsv	-	**Melon *necrotic spot virus* resistance (in Gulfstream, Planters Jumbo).**	12
O	-	*Oval* fruit shape. Dominant to round; associated with *a*.	70
p	-	*pentamerous*. Five carpels and stamens; recessive to trimerous (in Casaba).	63
Pa	-	***Pale* green foliage. *PaPa* plants are white (lethal); $PaPa^+$ are yellow (in 30567).**	45
Pc-1	-	***Pseudoperonospora cubensis* resistance. One of two complementary incompletelydominant genes for downy mildew resistance (in PI 124111). See *Pc-2*.**	9, 66
Pc-2	-	***Pseudoperonospora cubensis* resistance. One of two complementary incompletely dominant genes for downy mildew resistance (in PI 124111). See *Pc-1*.**	9, 66
Pc-3	-	***Pseudoperonospora cubensis* resistance. Partial resistance to downy mildew (in PI 414723).**	20
$Pgd\text{-}1^1$	*6-PGDH-2*^{1} $Pgd\text{-}2^1$	*Phosphoglucodehydrogenase-1*^{1}. One of two codominant alleles that regulates 6-phospho-glucodehydrogenase, each regulates one band.The heterozygote has one intermediate band. See $Pgd\text{-}1^2$.	22
$Pgd\text{-}1^2$	*6-PGDH-2*^{2} $Pgd\text{-}2^2$	*Phosphoglucodehydrogenase-1*^{2}. One of two codominant alleles that regulates 6-phospho-glucodehydrogenase, each regulates one band. The heterozygote has one intermediate band. See $Pgd\text{-}1^1$.	22

Gene symbol Prefer.	Synonym	Character	Reference
Pgi-1^1	*PGI-1*^{1}	*Phosphoglucoisomerase-1*^{1}. One of two dominant alleles, each regulating two bands. The heterozygote has three bands. See *Pgi-1*^{2}.	22
Pgi-1^2	*PGI-1*^{2}	*Phosphoglucoisomerase-1*^{2}. One of two dominant alleles, each regulating two bands. The heterozygote has three bands. See *Pgi-1*^{1}.	22
Pgi-2^1	*PGI-2*^{1}	*Phosphoglucoisomerase-2*^{1}. One of two dominant alleles, each regulating two bands. The heterozygote has three bands. See *Pgi-2*^{2}.	22
Pgi-2^2	*PGI-2*^{2}	*Phosphoglucoisomerase-2*^{2}. One of two dominant alleles, each regulating two bands. The heterozygote has three bands. See *Pgi-2*^{1}.	22
Pgm-1^1	*PGM-2*^{1} *Pgm-2*^{1}	*Phosphoglucomutase-1*^{1}. One of two codominant alleles, each regulating two bands. The heterozygotes has three bands. See *Pgm-1*^{2}.	22
Pgm-1^2	*PGM-2*^{2} *Pgm-2*^{2}	*Phosphoglucomutase-1*^{2}. One of two codominant alleles, each regulating two bands. The heterozygotes has three bands. See *Pgm-1*^{1}.	22
Pm-1	***Pm*^{1}**	***Powdery mildew* resistance-1. Resistance to race 1 of *Sphaerotheca fuliginea* (in PMR 45).**	**34, 35**
Pm-2	***Pm*^{2}**	***Powdery mildew* resistance-2. Interacts with *Pm-1*. Resistance to race 2 of *Sphaerotheca fuliginea* (in PMR 5 with *Pm-1*).**	**7**
Pm-3	***Pm*^{3}**	***Powdery mildew* resistance-3. Resistance to race 1 of *Sphaerotheca fuliginea* (in PI 124111).**	**29,30**
Pm-4	***Pm*^{4}**	***Powdery mildew* resistance-4. Resistance to *Sphaerotheca fuliginea* (in PI 124112).**	**29, 30**
Pm-5	***Pm*^{5}**	***Powdery mildew* resistance-5. Resistance to *Sphaerotheca fuliginea* (in PI 124112).**	**29, 30**
Pm-6	-	***Powdery mildew* resistance-6. Resistance to *Sphaerotheca fuliginea* race 2 (in PI 124111).**	**38**
Prv^1	*Wmv*	***Papaya Ringspot Virus* resistance. Resistance to W strain of Papaya ringspot Virus (formerly Watermelon Mosaic Virus 1) (in B 66-5, WMR 29, derived from PI 180280). Dominant to *Prv*^{2}.**	**55, 71**
Prv^2	-	***Papaya Ringspot Virus* resistance. Allele at the same locus as *Prv1* but different reaction with some strains of the virus (in 72-025 derived from PI 180283). Recessive to *Prv*^{1}, dominant to *Prv*$^+$.**	**36, 55**

Gene symbol Prefer.	Synonym	Character	Reference
Px-1^1	*PRX-1*^{1}	*Peroxidase-1*^{1}. One of two codominant alleles, each regulating a cluster of four adjacent peroxidase bands. The heterozygote has five bands. See *Px-1*^{2}.	22
Px-1^2	*PRX-1*^{2}	*Peroxidase-1*^{2}. One of two codominant alleles, each regulating a cluster of four adjacent peroxidase bands. The heterozygote has five bands. See *Px-1*^{1}.	22
Px-2^1	*Px2A*	*Peroxidase-2*^{1}. One of two codominant alleles, each regulating a cluster of three adjacent peroxidase bands. The heterozygote *Px-2*^{1} *Px-2*^{2} has 4 bands. See *Px-2*^{2}.	16
Px-2^2	*Px2B*	*Peroxidase-2*^{2}. One of two codominant alleles, each regulating a cluster of three adjacent peroxidase bands. See *Px-2*^{1}.	16
r	-	***red* stem. Red pigment under epidermis of stems, especially at nodes; tan seed color (in 30569).**	**3, 45**
ri	-	ridge. Ridged fruit surface, recessive to ridgeless. (*ri*$^+$ in Pearl, *ri* in C68).	65
s	-	*sutures*. Presence of vein tracts ("sutures"); recessive to ribless.	1
si-1	***b***	***short internode-1*. Extremely compact plant habit (bush type) (in UC Topmark bush).**	**17**
si-2	**-**	***short internode-2*. Short internodes from 'birdnest' melon (in Persia 202).**	**52**
So	-	*Sour* taste. Dominant to sweet.	39
sp	-	*spherical* fruit shape. Recessive to obtuse; dominance incomplete.	1, 43
st	-	*striped* epicarp. Recessive to non-striped.	28
v	**-**	***virescent*. Pale cream cotyledons and hypocotyls; yellow green foliage (mainly young leaves).**	**31**
v-2	-	*virescent-2*.	19
Vat	**-**	***Virus aphid transmission* resistance. Resistance to the transmission of all the viruses by *Aphis gossypii* (in PI 161375).**	**54**
w	**-**	***white* color of mature fruit. Recessive to dark green fruit skin. (*w* in honeydew, *w+* in Smiths' Perfect cantaloupe).**	**32**
wf	-	*white flesh*. Recessive to salmon.	33

Gene symbol Prefer.	Synonym	Character	Reference
Wi	-	White color of *immature* fruit. Dominant to green.	39
Wt	-	***White testa*. Dominant to yellow or tan seed coat color.**	**28**
Y	-	*Yellow* epicarp. Dominant to white fruit skin.	28
yg	*y*	***yellow green* leaves. Reduced chlorophyll content.**	**72**
yg^W	*lg*	*yellow green Weslaco*. First described as *light green* in in a cross Dulce x TAM-Uvalde. Allelic to *yg*.	11
yv	-	*yellow virescence*. Pale cotyledons; yellow green young leaves and tendrils; bright and yellow petals and yellow stigma; etiolated; older leaves becoming green.	73
Zym	-	***Zucchini Yellow Mosaic* Virus resistance. Resistance to pathotype 0 of this virus (in PI 414723).**	**56**

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Watermelon :	W. R. Henderson
***Cucurbita* spp. :**	R. W. Robinson
Other genera :	R. W. Robinson

Linkage groups in Cucumis melo L.

Eleven independent linkage groups have been described until now in muskmelon but no relation has been identified between a linkage group and a chromosome.

Group 1 : ***si-1*** (*short internode-1*) - ***yv*** (*yellow virescence*).

Group 2 : ***Vat*** (*Virus aphid transmission* resistance) - ***Pm-w*** (a gene for *powdery mildew* resistance in WMR 29, allelism tests have not been made with the 6 described powdery mildew resistance genes) - ***Fn*** (*Flaccida necrosis*).

Group 3 : ***ms-1*** (*male sterile-1*) - ***r*** (*red* stem) - ***gl*** (*glabrous*) - ***Pa*** (*Pale*).

Group 4 : ***a*** (*andromonoecious*) - ***O*** (*Oval* fruit shape) - ***h*** (*halo* cotyledons) - ***Pm-x*** (*Powdery mildew* resistance in PI 414723, allelism tests have not been made with the 6 described powdery mildew genes) - ***Zym*** (*Zucchini yellow mosaic* virus resistance). The order in this group is unknown.

Group 5 : ***Prv*** (*Papaya Ringspot virus* resistance) - ***Fom-1*** (*Fusarium oxysporum melonis* resistance *1)*

Group 6 : ***ms-2*** (*male sterile-2*) - ***yg*** (*yellow green* foliage) - ***Fom-2*** (*Fusarium oxysporum melonis* resistance *2*)

Group 7 : ***nsv*** (*necrotic spot virus* resistance) - ***Pm-3*** (*Powdery mildew* resistance *-3*)

Group 8 : ***flava*** (*flava*) - ***lmi*** (*long mainstem internode*)

Group 9 : ***ms-4*** (*male sterile-4*)

Group 10 : ***dl*** (*dissected leaf*)

Group 11 : ***v*** (*virescent*)

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Watermelon Gene Stocks
1989

Gene Symbol	Character(s)	Reference (CGC 10:107-110)
Ar-2	resistance to race 2 authracinose	25, 26, 32
dg/I-dg	delayed green/Inhibitor	21
dw-1	dwarf-1	10, 13
dw-2	dwarf-2	10, 14
Fo-1	resistance to race 1 *Fusarium oxysporum*	15
gms ·	glabrous male sterile	29, 30
nl	nonlobed leaves	12
Sp	spotted leaves, fruit	21
not assigned	4 mm seed	(CGC 3:38)
not assigned	first node fruit set	(Ma KeQi)
not assigned	Chinese male sterile	(Xia Xitong, et al.)

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Gene Nomenclature for the Cucurbitaceae

[From: Robinson, R.W., H.M. Munger, T.W. Whitaker and G.W. Bohn. 1976. Genes of the Cucurbitaceae. HortScience 11:554-568.]

1. Names of genes should describe a characteristic feature of the mutant type in a minimum of adjectives and/or nouns in English or Latin.
2. Genes are symbolized by italicized Roman letters, the first letter of the symbol being the same as that for the name. A minimum number of additional letters are added to distinguish each symbol.
3. The first letter of the symbol and name is capitalized if the mutant gene is dominant, and all letters of the symbol and name are in lower case if the mutant gene is recessive to the normal type. The normal allele of a mutant gene is represented by the symbol "+", or where it is needed for clarity, the symbol of the mutant gene followed by the superscript "+". The primitive form of each species shall represent the + allele for each gene, except where long usage has established a symbol named for the allele possessed by the normal type rather than the mutant.
4. A gene symbol shall not be assigned to a character unless supported by statistically valid segregation data for the gene.
5. Mimics, i.e. different mutants having similar phenotypes, may either have distinctive names and symbols or be assigned the same gene symbol, followed by a hyphen and distinguishing Arabic numeral or Roman letter printed at the same level as the symbol. The suffix-1 is used, or may be understood and not used, for the original gene in a mimic series. It is recommended that allelism tests be made with a mimic before a new gene symbol is assigned to it.
6. Multiple alleles have the same symbol, followed by a Roman letter or Arabic number superscript. Similarities in phenotype are insufficient to establish multiple alleles; the allelism test must be made.
7. Indistinguishable alleles, i.e. alleles at the same locus with identical phenotypes, preferably should be given the same symbol. If distinctive symbols are assigned to alleles that are apparent reoccurrences of the same mutation, however, they shall have the same symbol with distinguishing numbers or letters in parentheses as superscripts.
8. Modifying genes may have a symbol for an appropriate name, such as intensifier, suppressor, or inhibitor, followed by a hyphen and the symbol of the allele affected. Alternatively, they may be given a distinctive name unaccompanied by the symbol of the gene modified.
9. In cases of the same symbol being assigned to different genes, or more than one symbol designated for the same gene, priority in publication will be the primary criterion for establishing the preferred symbol. Incorrectly assigned symbols will be enclosed in parentheses on the gene lists.

[From: CGC Gene List Committee. 1982. Update of cucurbit gene list and nomenclature rules. CGC 5:62-66.]

The same symbol shall not be used for nonallelic genes of different *Cucurbita* species. Allelic genes of compatible species are designated with the same symbol for the locus.

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Biblioteca Inst. Valenciano de Invest. Agrarias Apartado Oficial, Moncada, Valencia, Spain.

British Library, Document Supply Center Accessions Department, Boston Spa, Yorks LS23 7BQ, England.

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

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Robson Seed Farms (Attn: W. Whitwood) One Seneca Circle, Hall, NY, 14463.

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

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Wyatt, Colen
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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* spp., 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.
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 provisions of the By-Laws or any 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.

Approvals:

W. Bemis

J. D. Norton

R. W. Robinson

W. R. Henderson

M. L. Robbins

R. L. Lower

Cucurbit Genetics Cooperative

FINANCIAL STATEMENT

31 December 1989

Balance on 31 December 1988		$3,639.44
Receipts		
Dues and Back Issue Orders	$1,968.00	
Interest	$ 183.79	
Total		+ $2,151.79
Expenditures		
CGC Report No. 12 (1989)[z]	$1,826.00	
Call for Papers, Report No. 13	$ 58.16	
Miscellaneous (postage, envelopes, supplies)	$ 160.67	
Federal Deposit Insurance Corp. Fees	$ 3.00	
Total		- $2,047.83
Balance on 31 December 1989		$3,743.40

[z]Publishing and mailing