CUCUMBER

Updated 1996

Cucumber Sub-Committee

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CUCUMBER

Cucumis sativus L.
(Updated January 1996)

I. INTRODUCTION

Cucumber is one of the 10 most important vegetable crops (in production area) grown in the U.S. Two distinct types of cucumbers are grown here, pickling (50 to 150 mm long with thin, mottled, warty skin) and slicing (200 to 230 mm long with smooth, uniform green, thick skin). A third type, the greenhouse slicer (very long fruited, parthenocarpic) is increasing in popularity with American consumers and greenhouse growers.

The leading states (in order of importance) in production of pickling cucumbers are Michigan, Ohio, North Carolina, California and Wisconsin. The leading states in production of slicing cucumbers are Florida, California, Texas, North Carolina and South Carolina. The U.S. has about 50,000 ha in production each year. Of the pickling cucumbers harvested, 40% are brined, 30% are refrigerated pack (raw cucumbers packed with flavorings into jars), and the remainder is pasteurized (processed without brining). Among the processing vegetables, 11% of the total U.S. market value comes from pickling cucumbers.

The U.S. farm value of pickling cucumber was $120.8 million in 1994 ($1.45 billion pickled), and cucumber is among the top 10 vegetable crops in value. Consumption of cucumbers is about 4 kg per capita. Of the 750,000 Mg of cucumbers used in the U.S. 50,000 Mg (7.6%) is imported from Mexico and the remainder is produced domestically.

II. PRESENT GERMPLASM ACTIVITIES

The public and private research programs that are actively involved in germplasm activities are listed below under the groupings of public and private research.

<u>PUBLIC RESEARCH</u>

COLORADO

National Seed Storage Lab., Fort Collins

Investigator: Eric E. Roos
National Seed Storage Lab.
Fort Collins, CO 80523
303-484-0402

Activities: Maintenance of the base collection

IOWA

Regional Plant Intro. Sta., Ames

Investigator: Charlie Block
North Central Regional Plant Intro. Sta.
Iowa State Univ.
Ames, IA 50011
515-294-3255

Activities: Maintenance of the working collection of *Cucumis*; evaluation of the PI accessions for disease resistance, yield and earliness.

Investigator: Kathy Reitsma
North Central Regional Plant Intro. Sta.
Iowa State Univ.
Ames, IA 50011
515-292-6502
Activities: Maintenance of the working collection of *Cucumis*; evaluation of the PI accessions for disease resistance, yield and earliness.

MICHIGAN

Michigan State Univ., E. Lansing

Investigator: Rebeca Grumet
Dept. Horticulture
Michigan State Univ.
E. Lansing, MI 48824
517-353-5568
Activities: Biotechnology, root type, breeding of cucumber.

NEW YORK

Cornell University, Ithaca

Investigator: Henry M. Munger
410 Bradfield Hall
Cornell University
Ithaca, NY 14853
607-255-3236
Activities: Breeding; enhancement of cucumber germplasm for disease resistance, gynoecy.

New York Agricultural Experiment Station, Geneva

Investigator: Richard W. Robinson
Dept. Of Horticultural Sciences
N. Y. Agr. Exp. Sta., Hedrick Hall
Geneva, NY 14456
315-787-2237
Activities: Genetics studies of *Cucumis* species; new gene mutants.

NORTH CAROLINA

North Carolina State University, Raleigh

Investigator: Todd C. Wehner
Dept. Hort. Sci., Box 7609
North Carolina State Univ.
Raleigh, NC 27695-7609
919-515-5363
Activities: Breeding of pickling and fresh-market cucumbers for the southeast U.S.; evaluation of cucumber germplasm for disease and nematode resistance, yield, earliness, fruit quality, insect resistance, and cold tolerance. Gene linkage.

TEXAS

Texas A & M University, College Station

Investigator: Leonard M. Pike
Dept. Horticulture
Texas A & M University
College Station, TX 77843
409-845-7012

Activities: Breeding pickling cucumbers; evaluation of germplasm for arthenocarpy, and disease and salt resistance. Gene linkage studies.

WISCONSIN

USDA, Madison

Investigator: Michael Havey
Dept. Horticulture
University of Wisconsin
Madison, WI 53706
608-262-1830

Activities: Breeding; evaluation of cucumber germplasm for disease resistance; restriction fragment length polymorphisms.

Investigator: Philipp Simon
Dept. Horticulture
University of Wisconsin
Madison, WI 53706
608-264-5406

Activities: Improvement of vitamin A and C content of cucumber; inheritance and linkage of morphological gene mutants.

Investigator: Jack E. Staub
Dept. Horticulture
University of Wisconsin
Madison, WI 53706
608-262-0028

Activities: Breeding; evaluation of cucumber germplasm for genetic diversity, disease resistance, drought, heat, cold, and other stresses; isozymes for inheritance studies; *Cucumis* species relationships;
gene linkage studies in cucumber.

PRIVATE RESEARCH

CALIFORNIA

Harris-Moran, El Macero

Investigator: Bill Copes and Brenda Lanini
Harris-Moran Seeds
P. O. Box 2508
El Macero, CA 95618
916-756-1382

Activities: Cucumber breeding; germplasm evaluation.

Petoseed (ELM), Woodland

Investigator: Ken W. Owens and Stephen King
Petoseed
Rt. 4, Box 1255
Woodland, CA 95695
916-666-0931

Activities: Cucumber breeding; germplasm evaluation.

GEORGIA

Asgrow Seed (ELM), Tifton

Investigator: Greg Tolla and David Groff
Asgrow Seed Co.
R. R. 1, Box 1907
Tifton, GA 31794
609-455-0716

Activities: Cucumber breeding; germplasm evaluation.

OREGON

SunSeeds, Brooks

Investigator: August Gabert
SunSeeds
8850 59th Ave, NE
Brooks, OR 97305-0008
503-393-3243

Activities: Cucumber breeding; germplasm evaluation.

WISCONSIN

Ferry-Morse, Sun Prairie

Investigator: Gary Taurick
Ferry-Morse Seed Co.
P. O. Box 392
Sun Prairie, WI 53590
608-837-6574

Activities: Cucumber breeding; germplasm evaluation.

III. VULNERABILITY

A. Status and Risks

The level of diversity of available cultivars has been surveyed. Data indicate that many cucumber cultivars grown in the U.S. are similar in parentage. Many of the pickling cucumber hybrids have Gy 14 as a significant source of germplasm in the seed parent. There is also much usage of 'Sumter' and M 21 in the germplasm of the pollen parent. The same is true of fresh-market cucumbers, where much use is made of 'Marketmore' and 'Poinsett', either directly or as a component of a hybrid.

The uniformity of cucumber cultivars represents a risk to the country if new, virulent diseases or insects appear in the production areas. The same is true if new, or existing environmental stresses become more important. For example, many cucumber cultivars have disease resistance which comes from the same genetic source as other cultivars. New races that can overcome resistance in one cultivar would then cause the loss of all similar cultivars. However, resistance to some diseases (e.g., scab, CMV and powdery mildew) has held up for decades.

B. Future Outlook and Needs to Reduce Genetic Vulnerability

Growers, buyers and processors all demand uniformity in plant type, fruit type, and maturity, so it is necessary that cultivars developed for sale in the U.S. meet commercial standards. It is also necessary to have resistance to the major disease problems in each production area. Those resistances are usually obtained from a single source, making the resulting cultivars identical for the gene(s) involved.

So far, few problems due to uniformity have arisen, but there are a few cases where new pathogens require new germplasm sources to stay ahead of production problems. Several races of anthracnose make it difficult to use single-gene resistance in the southeast. Zucchini yellow mosaic, curly top yellow, and silver leaf have become problems in the past few years. In some cases, resistance has been found and incorporated into adapted lines. Other viruses are known to cause problems in cucumber in other countries (for example, the Morocco strain of WMV), and may become a problem in the U.S. as well.

Solutions to the problem of uniformity involve using different sources of genes for the simply-inherited traits such as anthracnose resistance (combined or in multilines), or changing from qualitative to quantitative sources for those traits where it is practical (for example, quantitative resistance to anthracnose is available).

IV. GERMPLASM NEEDS (listed below in order of importance)

Cucumber is one of the most important cucurbits in the U.S. The 3 other commercially-used cucurbits of significant value are muskmelon (1 species), watermelon (1 species) and squash (4 species). The order of priority should probably be related to U.S. production value ($/year). That would make the priority: cucumber = muskmelon >watermelon > squash.

Cucumber, muskmelon, and related species of *Cucumis* are kept at the regional plant introduction station at Ames, Iowa. Muskmelon was maintained at the southern region station, but was moved to Ames in 1987. Of those species, muskmelon and cucumber are both important, and should receive the funding necessary for an adequate program of maintenance, collection and evaluation. There are more PI accessions of muskmelon than cucumber, so it is reasonable that muskmelon should receive more funds for maintenance, and cucumber should receive more funds for collection.

A. Acquisition

The germplasm collection of cucumber consists of 1361 plant introduction (PI) accessions (961 PI and 400 Ames numbers) at Ames, Iowa, plus 212 old cultivars in the base collection in Fort Collins, Colorado (Table 1). The accessions represent many countries of the world. Those include countries such as India where land races are found, and The Netherlands which has many highly-specialized cultivars (Table 2). The 1361 accessions, cultivars, and breeding lines in the USDA collection should be expanded to include representative germplasm available from collections in other countries, and from the collections of plant breeders in the U.S. Priority should be given to obtaining germplasm having traits not already represented in the USDA collection. The collection is important to the U.S. and other countries. It has distributed 4,994 accessions in the U.S. and 10,002 accessions internationally since 1987 (Table 3).

Researchers have screened the collection for accessions that have resistance to pickleworm, cucumber beetle and southern root-knot nematode, and have found none. Problems such as leafminer and Alternaria leafspot could be solved by identifying resistance, but no published reports of such research are known. We need accessions with higher levels of resistance to gummy stem blight and anthracnose, as well as accessions to use as sources for higher yield and earliness, better cold, heat and drought tolerance, and new plant types (branching, dwarfing, leaf size). Nutritional value in current cultivars is low, however, research by Simon indicated that the content of vitamins A and C can be improved significantly using genes for yellow and orange internal fruit color.

Exchange with other countries should be continued and reemphasized, especially where we are able to obtain germplasm with unique traits. A first step would be to send seeds of the old cultivars held in the base collection in Fort Collins to the working collection at Ames. Plant breeders in the U.S. should be encouraged to contribute any materials they have to the collection in case there are lines they have that are not in the PI collection. Care must be taken to avoid duplication.

Major expeditions should be sent out over the next 10 years to sample areas that have not received much attention. Collection efforts should be concentrated in India, Africa, China and neighboring countries. India and China represent the centers of diversity for the species. Africa is the center of diversity for the *melo* group (24-chromosome species) of *Cucumis*. Much was accomplished in the two recent expeditions to India in 1992 and China in 1993.

The goal for the USDA collection should be increased diversity, perhaps using restriction fragment length polymorphism or isozyme pattern as the index of diversity. While numbers of accessions is not the objective *per se*, the collection could easily include 2000 accessions once we begin to fill in the obvious gaps. That would include the present 1361 PI accessions, the 212 old cultivars from the base collection, and new accessions obtained from plant breeders, by exploration, and by exchange with other countries.

B. Maintenance and preservation

The accessions in the working collection were obtained from 58 countries around the world (Table 1). Currently, all *Cucumis sativus* accessions are kept in the working collection at the North Central Plant Introduction Station, Ames, Iowa. The base collection is at the National Seed Storage Laboratory, Fort Collins, Colorado. Due to a backlog in increasing and transferring newly-collected accessions, not all of the accessions are in the base collection yet.

Plant breeders in the USDA, state universities, and seed companies all maintain collections of accessions. However, it is not known how many they have, nor the conditions of storage. It is probable that those breeder collections include breeding lines not represented elsewhere.

The present size of the collection provides an adequate representation of germplasm from most of the important areas of the world (Table 2). The size of the collection is not large relative to that for *Cucumis melo*, but has provided some useful traits for plant breeding efforts in the last few decades. Some traits that are needed are not available in the collection (for example, pickleworm resistance). The collection might be doubled in size without excessive effort (expeditions) simply by obtaining cultigens (cultivars, populations, inbreds, breeding lines) from germplasm collections presently maintained in other countries and in U.S. breeding programs.

Those making foreign collection trips should send samples to the regional plant introduction (PI) station. In addition, plant breeders who release cultivars and germplasm should be requested by the journal publishing the release to send a sample to the PI station. Many plant breeders are not aware that they should send new cultivars to the germplasm collection. It is the responsibility of the PI station curator to send samples of all the PI accessions to the NSSL for backup. Presently, that has been done well. Seeds of each PI accession are kept in tightly-capped glass jars. Jars are kept in rooms maintained at 5°C with 30% relative humidity.

Accessions are intercrossed (sib- and self-pollinated) in isolation using bee hives in field cages with one accession per cage. Accessions are increased when supplies drop below 1000 seeds, or when germination falls below 70%. This has generally been every 15 to 20 years for the working collection. The original diversity has not been evaluated against the present level, but the techniques used are sound in theory. See Appendix 1 for specific seed increase procedures.

C. Evaluation

Researchers are more likely to make use of the PI collection after evaluations of horticultural performance have been conducted. After germplasm has been evaluated, a search can then be made to identify a group of accessions that will be useful in achieving a certain objective. For example, a plant breeder might want to identify the 10 most anthracnose resistant accessions that have long fruits suitable for fresh-market use. Several horticultural traits have been evaluated in the cucumber PI collection. Comprehensive evaluation resulting from germplasm evaluation would allow efficient identification of accessions. The list of traits collected by personnel at the PI station for basic identification of the accession (descriptors) should be changed to a list that is easier to measure. A reference list is shown in Table 4.

The germplasm resources information network version 3 (GRIN3) is in place, and much data collected by researchers involved in evaluating the PI accessions has been added to the basic list of descriptors. Emphasis by PI station personnel should be on collection, maintenance, and recording of descriptors. Additional emphasis is needed on the noting of novel traits. Evaluation of other traits should be done by researchers who have expertise in that area. Evaluation data should include the traits listed in Table 5. If funds become available to support evaluation of the germplasm collection, then traits should be done in the order listed.

D. Enhancement

The resources available to the regional plant introduction station do not permit much work to be done in the area of enhancement of the cucumber PI accessions. Only if PI station funding were increased significantly at the PI station, and if collection and preservation activities were being done exceptionally well, should the PI station personnel consider doing enhancement work.

Funds should be made available to public and private cucumber breeders for doing enhancement work on traits of interest to incorporate them into adapted pickling and slicing cucumber inbreds.

V. RECOMMENDATIONS

A. Priority of Actions

1. Provide additional funds for improved germplasm maintenance at the Ames, Iowa PI station to provide adequate maintenance of the *Cucumis* accessions.

2. Obtain available accessions from U.S. and world collections through exchange.

3. Encourage plant breeders to send samples of the populations, inbreds and hybrids that they release to the PI station (hybrids would probably be maintained as populations if they were accepted into the collection).

4. Provide grants for evaluation of the PI accessions already in the collection using priorities set forth in this report.

5. Fund expeditions to Africa to obtain other materials while they are still available.

B. Level of Support

1. Increase funds for the Ames, Iowa PI station by $100,000/year for improvement of the accession maintenance program.

2. Provide grants of at least $15,000/year each to at least 3 research programs every year for use in evaluating the collection.

VI. REFLECTIONS

Collection should be encouraged by providing grants for expeditions to world centers of diversity, especially the countries of China and India and their neighbors. Also countries in Africa should be explored for wild relatives of cucumber. Germplasm exchange should be emphasized constantly. There are opportunities to exchange accessions with institutions in the Russian Federation, China, India, and countries in Europe such as The Netherlands. High priority should be given to exchanging cucumber germplasm with the Vavilov Institute of Plant Industry, Leningrad, Russia, which has an extensive collection. The USDA should also look into exchange of germplasm with Warsaw Agricultural University where the cucumber collection of B. Kubicki was maintained. Useful OP cultivars and inbred lines should be placed in the PI collection using a suggested list to be determined by the CCGC membership.

A list of germplasm that has been useful to scientists and growers should be developed to indicate both the cultigens that should be added to the PI collection, and the PI accessions that have been valuable to the users of the collection. The accessions, cultivars and breeding lines below have useful genes or quantitative traits for horticultural research or production:

- 058049 (bitterfree)
- 173889 (Bt gene and disease resistance)
- 175111 (anthracnose, CMV, DM, PM, northern root-knot resistance)
- 175120 (anthracnose, CMV, DM, PM, northern root-knot resistance)

• 175120 (disease resistance)

• 175686 (low soluble solids in fruits)
• 179260 (ALS, CMV, PM, scab resistance)
• 179676 (ALS, anthracnose, DM, PM, northern root-knot resistance)
• 181755 (cold germination)
• 188749 (triazine tolerance)

• 188807 (ALS, BW DM, PM resistance)
• 197087 (anthracnose, ALS, CMV, GMMV, DM, PM, scab, red spider mite, belly rot resistance)
• 197088 (Anthracnose, PM, scab, belly rot resistance
• 200818 (bacterial wilt resistance)
• 200819 (bacterial wilt resistance)

• 211984 (amiben tolerance)
• 212233 (PM resistance)
• 220860 (gynoecious),
• 227208 (ALS, BW, CMV, DM, PM, scab, TRSV resistance)
• 234517 (ALS, anthracnose, DM, PM, belly rot, Verticillium wilt, melon fly resistance)

• 321011 (virus resistance)
• 351139 (hermaphroditic)
• 372893 (bitterfree)
• 390244 (atrazine tolerance)
• 432860 (variation for biochemical markers)

• Chinese Long (CMV resistance)
• Chipper (cold germination)
• H-19 (little leaf, multibranched, multiple fruited)
• Homegreen #2 (gummy stem blight resistance)
• Lemon (m, l, yg genes)

• LJ 90430 (little leaf, multibranched, multiple fruited)
• Natsufushinari
• Slice (anthracnose resistance)
• Tiny Dill (de gene)
• TMG-1 (CMV, PRsV, WMV-2, ZYMV resistance)
• Zeppelin (high fruit weight)

Table 1. Summary of the status of seed stocks of *Cucumis sativus* accessions at the U.S. Regional Plant Introduction Station, Ames, Iowa (as of November 1995).

	Number of accessions			
Location	Total	Available	Unavailable	NSSL*
PI numbers	961	840	121	743
Ames numbers	400	143	257	0
Total	**1361**	**983**	**378**	**743**

* Accessions that have been backed up by sending them to NSSL.

Table 2. Origin of the 744 *Cucumis sativus* L. accessions at the U.S. Regional Plant Introduction Station, Ames, Iowa.

No.	Botanical variety	Country	Number of accessions
1	sativus	Afghanistan	16
2	sativus	Albania	1
3	sativus	Australia	3
4	sativus	Bhutan	7
5	sativus	Brazil	2
6	sativus	Bulgaria	1
7	sativus	Canada	6
8	sativus	China	189
9	sativus	Czech Republic	31
10	sativus	Denmark	3
11	sativus	Egypt	21
12	sativus	Ethiopia	2
13	sativus	Former Soviet Union	44
14	sativus	France	6
15	sativus	Georgia	1
16	sativus	Germany	5
17	sativus	Greece	1
18	sativus	Hong Kong	4
19	sativus	Hungary	23
20	sativus	India	238
21	sativus	Indonesia	1
22	sativus	Iran	65
23	sativus	Iraq	1
24	sativus	Israel	8
25	sativus	Italy	6
26	sativus	Japan	60
27	sativus	Kazakhstan	2
28	sativus	Kenya	1
29	sativus	Korea, South	16
30	sativus	Lebanon	4
31	sativus	Malaysia	2
32	sativus	Maldives	1
33	sativus	Mauritius	1
34	sativus	Moldova	1
35	sativus	Myanmar	2
36	sativus	Nepal	11
37	sativus	Netherlands	35
38	sativus	New Zealand	2
39	sativus	Norway	1
40	sativus	Oman	5

(continued)

Table 2 Continued

No.	Botanical variety	Country	Number of accessions
41	sativus	Pakistan	7
42	sativus	Philippines	5
43	sativus	Poland	13
44	sativus	Puerto Rico	5
45	sativus	Russian Federation	14
46	sativus	Spain	76
47	sativus	Sweden	4
48	sativus	Syria	16
49	sativus	Taiwan	12
50	sativus	Thailand	2
51	sativus	Turkey	174
52	sativus	Ukraine	6
53	sativus	United Kingdom	7
54	sativus	United States	69
55	sativus	Uzbekistan	5
56	sativus	Yugoslavia	67
57	sativus	Zambia	5
58	sativus	Zimbabwe	2
59	sativus	Uncertain	23
60	anatolicus	Former Soviet Union	1
61	anglicus	Former Soviet Union	1
62	cilicicus	Former Soviet Union	1
63	europaeus	Former Soviet Union	1
64	falcatus	Japan	1
65	hardwickii	India	3
66	hardwickii	Nepal	1
67	indo-europaeus	Former Soviet Union	1
68	irano-turanicus	Former Soviet Union	1
69	izmir	Former Soviet Union	1
70	sikkimensis	India	1
71	squamosus	India	2
72	testudaceus	United States	1
73	tuberculatus	China	1
74	vulgatus	India	1
75	xishuangbannanesis	China	2
	Total		**1361**

Table 3. Packet distributions for 1987 through 1995 of *Cucumis sativus* L. germplasm*.

Year	Domestic	Foreign	Total
1987	289	2336	2625
1988	874	325	1199
1989	88	2620	2708
1990	2030	121	2151
1991	289	1743	2032
1992	155	536	691
1993	44	2136	2180
1994	26	92	118
1995	1199	93	1292
Total	**4994**	**10002**	**14996**

* Distribution data before 1987 and for December 1995 not available on GRIN.

Table 4. Cucumber descriptors developed and currently used by the U.S. Plant Introduction Station, Ames, Iowa, and the set proposed by the Cucurbit Crop Advisory Committee in 1986 for future use.

	Current (11)	Future (14)
1	-	Accession type (inbred, hybrid, F_2, population)
2	-	Branching habit (single, normal, multiple)
3	Internode length	Vine length (tall, dwarf, compact)
4	Plant vigor	-
5	-	Nodes to first female flower
6	Sex type	-
7	Predominant sex	Sex expression (androecious, monoecious, gynoecious, etc.)
8	Fruit shape	Fruit type (pickle, slicer, round)
9	Fruit length (cm)	Mature fruit length (mm)
10	Fruit diameter (cm)	Mature fruit diameter (mm)
11	Mature fruit color	-
12	-	Fruit mottling (uniform, mottled)
13	Spine color	Spine color (white, brown, black)
14	-	Spine size (warty, smooth)
15	Fruit skin texture	Skin texture (netted, clean)
16	100-seed wt (g)	100-seed weight
17	-	Isozyme profile
18	-	Unique character (not presently on trait list)

Table 5. Rank order for traits in the plant introduction collection of cucumber that 17 breeders would like evaluated (listed in priority order by 2 surveys).

Rank order			
1987	1985	Status	Trait
1	7	C	Gummy stem blight resistance
2	5	C	Root knot nematode resistance
3	15		Alternaria leaf blight resistance
4	3	C	Rhizoctonia fruit rot resistance
-	-		Rhizoctonia seedling damping-off resistance
5	12	C	Heat tolerance
6	2	C	Anthracnose resistance
7	26		Pythium cottony leak resistance
8	1	C	Fruits/plant (combining ability)
9	8	C	Downy mildew resistance
10	6		Fruit seedcell size
11	14	C	Chilling resistance
12	11	C	Pickleworm resistance
13	17		CMV resistance
14	18		PRsV resistance
15	19		WMV2 resistance
-	-		Beet Pseudo-yellows virus (cucumber yellows)
16	16		ZYMV resistance
17	23	C	Drought resistance
18	25	C	Earliness (no. oversized fruit in single harvest trial)
19	20	C	Angular leafspot resistance
20	22	P	Cold germination
21	21	C	Target leafspot resistance
22	13	P	Salt tolerance
23	4		Fruit shape (appearance, not L/D)
24	9	C	Powdery mildew resistance
25	10	P	Fruits/plant (actual)
26	28	C	Days to first flower
27	24		Branching habit
-	-		Air pollution resistance
28	27		Cucumber beetle resistance
29	29		Daylength response
30	-	I	Unique character
31	33	C	Scab resistance
32	-		Spider mite resistance
33	31		Fusarium wilt resistance
34	32		Bacterial wilt resistance
35	30		Verticillium wilt resistance
36	-	C	Nutritional value (vitamins A and C)
37	-		Parthenocarpic tendency
38	-		Cool growth speed

39	-	Brinestock quality
40	-	Sex expression

C = evaluation of trait completed; I = evaluation of trait in progress; P = evaluation of trait partially done.

- Prioritized recently by the Cucurbit CGC, but not originally on trait list for survey.

Appendix 1. Procedures for seed increase of *Cucumis*.

Planting
Seed is started in mid-May in the greenhouse. Direct seed 1 to 8 seeds in eight 3" peat pots, in the small, wood flats that will hold 8 pots. A greater number of plants could fit into one cage for increase, but 24 plants (thin pots to 3 plants each) have given us plenty of increase in the past*. Plants are transplanted into the field in early June only as fast as cages can be erected. A spray of "Cloud Cover" and Orthene increases the success rate of transplants. Cages are 5 x 20' and have 10' alleys between.

Plants in cages are mulched to help preserve moisture but they may need supplemental watering in a dry year. Wilted plants are an indication of water need.

Pollination
Place nucs of bees in isolation cages.

Harvest
Harvest fruit in "part harvests" as the fruit turns to mature color. Harvest time starts in August and goes through October, or until a strong freeze.

Seed cleaning
Hand-extract seeds and wash them clean in a screened tray. Float seeds to remove light, immature seeds and debris in a bushel tub. After seed has been dried, rub between your hands wearing gloves to separate the seeds and then clean in clipper to remove light, immature seed.

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*Exceptions are the accessions with long, thin, yellow fruits which have few seeds/fruit.