Squash and Pumpkin

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I Introduction

Squash and pumpkins are unique in that they represent several species for the same crop. Summer squash is *Cucurbita pepo*, but winter squash may be *C. pepo* (e.g. 'Acorn'), *C. moschata* ('Butternut'), *C. mixta* ('Japanese Pie'), or *C. maxima* ('Hubbard', etc.). The Jack O' Lantern type of pumpkin is *C. pepo*, but commercially canned pumpkin pie mix is also made from *C. moschata* (e.g. 'Libby Select') or *C. maxima* ('NK 580'). *C. mixta* and *C. ficifolia* are used for food in Mexico and in Central and South American countries but are seldom grown in the U.S.

Squash and pumpkin are usually grown for their fruit, harvested immature for summer squash or mature for winter squash and pumpkin. When man first domesticated *Cucurbita*, however, it was for their edible seed because the fruit was bitter and poisonous. *Cucurbita* is still grown for seed today, particularly in Mexico. Efforts are being made to breed *C. pepo* for "naked" seed coats so the seed will be more palatable, and to domesticate *C. foetidissima* and other xerophytic species so they can be grown in arid lands for their oil and protein-rich seed. *Cucurbita* is also sometimes grown for ornamental purposes, such as pumpkins and the ornamental gourd, *C. pepo* var. *ovifera*, or for the enormous fruit of *C. maxima* (e.g. 'Atlantic Giant') grown for display purposes. In Latin American countries, flowers, leaves and vine tips of *Cucurbita* are consumed, and mature fruit are used for livestock fodder or as containers.

Summer squash is most often eaten fresh, but winter squash may be stored several months. Both summer and winter squash are canned and frozen commercially.

Reliable statistics on acreage and production of squash and pumpkin in the US are not readily available. The USDA does not include this information in their Agricultural Statistics. The IBPGR Report on Genetic Resources of the Cucurbitaceae reported that the world production of *Cucurbita* in 1979-81 was 5,256,000 metric tons from 539,000 acres annually.

Winter squash and pumpkins are a good source of vitamin A. Squash was an important component of the triumvirate of squash, maize, and beans in the diet of Indians in pre-Columbian times. It was valued then for its long storage life, and still is today.

II Present Germplasm Activities

Most recent squash and pumpkin cultivars have been released by private seed companies, but seed company breeders rely on the following state and USDA breeders for germplasm and information:

1. J. Baggett, Oregon State Univ., Corvallis. Squash has been selected for powdery mildew resistance, but the program may be discontinued due to the low level of resistance.
2. E. A. Borchers, Hampton Roads Agricultural Experiment Station, Virginia Beach, Va. Breeding *C. pepo* for vine borer resistance.
3. D. Coyne, Univ. Nebraska, Lincoln. Breeding *C.* moschata for resistance to powdery mildew and the herbicide, trifluralin. Investigating genetics of fruit color in *C. maxima*.
4. G. W. Elmstrom, Agricultural Research Center, Leesburg, Fla. Variety trials of *C. pepo*. Breeding summer squash for resistance to powdery mildew, watermelon mosaic viruses, and zucchini yellow mosaic virus.
5. K. Elsey, U.S. Vegetable Laboratory, Charleston, SC. Evaluations for insect resistance.

6. N. Holland, No. Dakota State Univ., Fargo. Breeding bush *C. maxima* for high soluble solids and specific gravity. Investigating genetics of bush habit and male:female flower ratio in *C. maxima*.
7. J. B. Loy, Univ. New Hampshire, Durham. Breeding bush *C. maxima* with good quality and adaptation to high density plantings. Breeding bush *C. pepo* pumpkin with naked seeds. Investigating genetics and biochemistry of the naked seed trait of *C. pepo*.
8. J. D. McCreight, USDA, Salinas, CA. Breeding for resistance to squash leaf curl virus in progeny of the crosses *C.* maxima x *C. ecuadorensis* and *C. maxima* x *C. lundelliana*.
9. H. Mohr, Univ. Kentucky, Lexington. Breeding bush *C.* maxima and naked seeded *C. pepo* squash and pumpkin.
10. H. M. Munger, Cornell Univ. Ithaca, N.Y. Breeding *C. pepo* and *C. moschata* for resistance to powdery mildew, cucumber mosaic virus, watermelon mosaic virus 2, papaya ring spot virus, and zucchini yellow mosaic virus.
11. R. Provvidenti, New York Agric. Expt. Station, Geneva. Locates sources and studies inheritance of virus resistance in *Cucurbita* species. Cooperates with the breeding programs at Ithaca (Munger) and Geneva (Robinson).
12. B. B. Rhodes, Edisto Research and Education Center, Edisto, S.C. Breeding for resistance to pickle worm, powdery mildew and downy mildew. Evaluates introductions of *C. pepo*, *maxima*, and *moschata.*
13. R. W. Robinson, New York Agric. Expt. Station, Geneva. Interspecific gene transfer and breeding *C.* maxima, *C. moschata* and *C. pepo* for resistance to cucumber mosaic, zucchini yellow mosaic, watermelon virus 2, papaya ring spot, and squash mosaic viruses. Investigations of genetics of *Cucurbita.*
14. O. Shifriss, Rutgers Univ., New Brunswick, N.J. Breeding and genetics of precocious fruit pigmentation in *C. pepo* and *C.* maxima. Evaluation of *C.* maxima x *C. moschata* lines. Gynoecy in *Cucurbita.*
15. C. E. Thomas, USDA, Vegetable Laboratory, Charleston, S.C. Pathology of downy and powdery mildews.

III Vulnerability and Risks

A. Status and Risks.

Until recently, less breeding for disease resistance was done with squash and pumpkins than with most other vegetable crops of equal importance. Even today, only disease susceptible cultivars are commonly grown. Squash cultivars resistant to powdery mildew and cucumber mosaic virus, derived from Cornell University germplasm, are expected to be released by seedsmen soon, but cultivars resistant to other diseases will take longer to develop.

An example of the vulnerability of present cultivars is zucchini yellow mosaic virus, which was unknown less than a decade ago but now is a major problem with all cultivars of the Cucurbitaceae throughout the US and many other countries. Although resistance to zucchini yellows, watermelon mosaic viruses, and other diseases has been found in *Cucurbita* species, a high level of resistance has not yet been transferred to a horticulturally acceptable cultivar.

Because of the difficulty in producing seeds of wild material, some of the most important *Cucurbita* introductions have not been increased by USDA Plant Introductions. Most land races and wild species of *Cucurbita* are tropical in origin, and may not be adapted to the climate and photoperiod of temperate areas. Accessions that flower readily are the ones most likely to be increased by USDA Plant Introductions, but they are often cultlvars or other highly developed germplasm that are not of major interest to breeders. The wild and primitive germplasm that represents the most likely sources of disease resistance and other traits needed by breeders are often late to flower and sometimes are not increased by USDA Plant Introductions. Thus, none of the 6 accessions of *C. andreana* at the Geneva, NY or the 35 accessions of *C. ficifolia* at the Experiment, GA Plant Introduction Stations have been increased.

Another problem of genetic vulnerability that has become apparent in recent years is the occurrence of unacceptably high frequencies of plants with bitter fruit grown from certain commercial seedlots. Seed companies need to take steps to prevent and to monitor the occurrence of cross pollination of *C. pepo* cultivars with bitter, ornamental gourds.

There is a very serious problem in regards to maintenance of *Cucurbita* stocks in the collections of recently retired researchers, notably

T. W. Whitaker, W. P. Bemis, and A. M. Rhoades. They need to be evaluated to determine which stocks should be preserved by the USDA Plant Germplasm System or another agency.

B. Future Outlook and Need to Reduce Genetic Vulnerability.

Resistance has been found to the major viruses of *Cucurbita*, but in most cases the resistance is in a wild, distantly related species. Additional sources of resistance, particularly in cultivated species, would be welcome since this would reduce the time needed to breed resistant cultivars and would guard against new pathotypes. Resistance is needed against storage rots, nematodes, squash vine borers and other insects, and to cold weather and other environmental stresses. Presently available plant introductions of *Cucurbita* have not been adequately evaluated for these traits.

Genetic vulnerability is probably the greatest for *C. moschata*, since much of the U.S. production is with only two cultivars, Butternut and Waltham Butternut. There is a need for more genetic and cytoplasmic diversity. The IBPGR Report on Genetic Resources of Cucurbitaceae (1983) rated the genetic vulnerability of *Cucurbita* species as being high or very high in many areas of Mexico, Latin America, and South America.

The genetic integrity of *Cucurbita* plant introductions is seriously threatened by the use of open pollination to increase introductions at some, but not all PI stations. The high rate of natural cross-pollination by insects will contaminate stocks increased by open pollination, and the next generation will be different from the genotype collected and evaluated. The importance of controlled pollination, preferably by sibbing to maintain the genetic diversity within an introduction, cannot be over emphasized.

The S-9 PI Station is commended for funding the increase by controlled pollination in 1984-1985 of 100 PI of *Cucurbita pepo*, *mixta*, *sororia*, *digitata*, *texana*, *lundelliana*, *martinezii*, *radicans*, *moschata*, *pedatifolia*, and *foetidissima*. This was done at the Univ. of California at Davis by Cornell University graduate student, Laura Merrick. There is a need to also use controlled pollination for the stocks increased at Experiment, Georgia and Pullman, Washington. Contracting by a regional PI Station to have *Cucurbita* introductions increased elsewhere should be primarily those introductions which do not produce fruit at the PI Station, due to photoperiod or other reasons.

At the NE-9 PI Station, all *Cucurbita* seed is produced by hand sib-pollinations. Pollination begins at 7:00 A.M., and is done seven days a week during the pollinating season. There is concern that, for the first time in many years, no *Cucurbita* introductions at all were increased at NE-9 in 1988. At NC-7, all *Cucurbita* introductions are now increased by sib-pollination. Male and female flowers are closed and marked on the afternoon before anthesis, and pollination begins at 7 am the next morning. Pollen from three male flowers is applied to each female flower; one male flower provides more than enough pollen, but three are used to increase genetic diversity. After pollination, the stigma i5 covered with cotton to exclude insect pollinator6. In the past, some PI of *C. pepo* were increased at NC-7 by open pollination, but they are now attempting to produce seed from the original seedlots by controlled pollination. Eight hills of three plants each are grown for each PI, and they attempt to obtain at least three hand-pollinated fruit per hill. Open pollination is used to increase cucurbits at the S-9 and W-6 PI Stations.

The Cucurbit CGC (CCGC) supports the proposal to add a horticulturist to the staff of the S-9 Plant Introduction Station at Experiment, GA. There is no need to wait, however, for funding of this position in order to use controlled pollination of *Cucurbita* pollinations at S-9. A Ph.D. horticulturist is not essential for this; it can be accomplished by temporary high school or college students during the summer at minimal cost if properly supervised. The transfer of responsibility for Cucumis introductions from S-9 to NC-7 and the recommendation to drastically reduce the number of descriptors that elaborate data are taken with *Cucurbita* introductions should make more time available for controlled pollinations of cucurbits at S-9. It is recommended that all seed increases of *Cucurbita* introductions are done by controlled pollination, beginning immediately.

One problem encountered at Geneva, N.Y. with *C. andreana*, and undoubtedly at each PI station with other primitive accessions and wild species, is that these introductions are very viny and late to flower. It is difficult to find the flowers to pollinate, and they may flower too late to produce mature seed before frost. There is no ideal solution to this problem, but several steps may help. In the squash breeding program at Geneva, N.Y., we have had earlier flowering of wild *Cucurbita* species when grown on black plastic, and row covers or hot caps also enhance earliness. Starting the plants in peat pots in the greenhouse and transplanting early in the season, as is done at the NE-9 and NC-7 PI Stations, also improves earliness.

Ray Clark, at the Ames, Iowa PI Station, is interested in using growth regulators to alter sex expression, and this is a good idea. Ethephon can be applied to some of the plants of an introduction to promote female flower production, and these plants can be pollinated with male flowers from adjoining untreated plants of the same line. The ethephon treatment also has the advantage of reducing vine length. It is not effective, however, for plants that have not begun floral initiation. Although it can be successfully applied to squash cultivars in the first true leaf stage of development, it needs to be applied later to wild species that are photoperiodic or for other reasons are late to initiate floral buds. The treatment alters sex expression in early stages of flower development, but does not initiate flowering.

Treatment with GA or Ag can be used to stimulate male flower production, but this should rarely be necessary with plant introductions. Grafting to summer squash will promote flowering of wild species. Consideration should be given to increasing *C. ficifolia*, which requires a short photoperiod for flowering, and other refractory introductions at a southern location, perhaps at the PI stations at Miami, Florida or Mayaguez, Puerto Rico.

Another problem sometimes encountered at PI Stations is poor fruit set. At the Geneva, NY PI Station, it is estimated that 140-150 pollinations are made per accession. Since 80 accessions are usually grown, approximately 12,000 pollinations are made each year, more than four pollinations for each plant. Fruit set can be improved, usually to better than 80-90%, by pollinating only the first female flowers to develop. It also helps to remove open pollinated fruit at an early stage of development. It should be possible to reduce the number of pollinations to no more than two per plant.

IV Germplasm Needs

A. Collection

In 1977 and 1978, R.W. Robinson submitted a proposal to the ~SDA for an exploration trip to Mexico by T.W. Whitaker to collect seed of *Cucurbita* species. It was pointed out that Plant Introductions had many PI of *Cucurbita* from Turkey, Yugoslavia and other distant countries but very few from Mexico, the most important area of all because it is the center of origin for the genus. Of the 435 plant introduction of *C. pepo* at that time, only four were from Mexico and only one was of a wild species of *Cucurbita*. It's not surprising that most previous surveys for disease resistance in *Cucurbita* plant introductions were largely unsuccessful, since few of the plant introductions were primitive land races or wild species subject to natural selection for disease resistance.

Another proposal for a collection trip in Mexico was made in 1978 by G. Sowell, and the USDA funded an exploration in 1979 by Whitaker and Knight. They collected seed of 183 *Cucurbita* introductions in Mexico and Guatemala, including:

Species	Number
C. *pepo*	49
C. *moschata*	47
C. *mixta*	41
C. *ficifolia*	11
C. *foetidissima*	13
C. unidentified spp.	22 (later most were identified by Laura Merrick as *C. sororia* or *C. pedatifolia*)

Additional *Cucurbita* introductions were collected in Mexico in 1980 by Clark and Winters. Subsequently, Cornell University graduate student Laura Merrick made a number of successful trips to Mexico for *Cucurbita* introductions. Recently, she sent to the USDA and the Mexican National Germplasm Collection (INIFAP) seed of the following *Cucurbita* accessions she collected in Mexico from 1981 to 1986:

Species	Number	Species	Number
C. ficifolia	8	*C. moschata*	73
C. foetidissima	6	*C. pepo*	28
C. martinezii	11	*C. sororia*	48
C. maxima		*C. radicans*	3
C. mixta	70		

The Merrick collection and seed increase represents a valuable addition to the genetic resources of *Cucurbita*. Particularly noteworthy are the *C. radicans* accessions, the first of this species to be included in PI stocks or any other gene bank collection.

Another Cornell University graduate student, Tom Andres, collected seed of species of the Cucurbitaceae from Mexico in 1986 and will provide seed of them to Plant Introductions. Included among the stocks will be seed of Cucurbita *fraterna*, valuable for its affinity to *C. pepo*, but not previously available from Plant Introductions or other sources. Other species of Cucurbita collected by Andres were *C. lundelliana*, *C. martinezii*, *C. sororia*, *C. radicans*, *C. pedatifolia*, and *C. ficifolia*.

Thanks to the collection trips to Mexico by Whitaker and Knight, Clark and Winters, Merrick, and Andres in the past 8 years, we now have a much better selection of *Cucurbita* germplasm from that important area than ever before. However, many important *Cucurbita* species are still not included in Plant Introduction stocks. Additional introductions from Mexico would be of value, especially of *C. pepo*. A disproportionate number of the introductions from Mexico are *C. mixta*, which is seldom cultivated in the US, and only 39 are of the much more important *C. pepo*. The Latin American countries of Guatemala, Nicaragua, El Salvador, Costa Rica, Honduras, Belize, and Panama are not well represented in Plant Introduction stocks of *Cucurbita*, and should be considered for future exploration trips.

C. maxima has a more southern origin than other cultivated species of *Cucurbita*, and thus it is important that the USDA Plant Germplasm System has a number of *C.* maxima introductions from Argentina. More Argentinean introductions of *C. maxima*, particularly primitive land races, would be of interest, and there is a need to obtain more introductions of *C.* maxima and *C. andreana* from Uruguay, Paraguay, Chile, Peru, and other South American countries.

C. texana is poorly represented in PI stocks. Since considerable genetic diversity is known in this species, which crosses readily with *C. pepo*, more accessions should be obtained. They could be collected in Texas, or possibly obtained from Hugh Wilson of Texas A ~ M University, who has already provided seed of some of his *C. texana* accessions to the USDA.

The ornamental gourd, *C. pepo* var. *ovifera*, has been cultivated for centuries and was portrayed in medieval herbals. It is the source of the precocious yellow (*B*) gene and may have other traits of breeding value. It is not now represented in USDA Plant Introductions, so acquisitions of this taxon are needed.

Particularly deserving of conservation is *C. okeechobeensis*, the most endangered species of Cucurbita. *C. okeechobeensis* is now nearly eradicated from its habitat near Lake Okeechobee, Florida. A survey by R. W. Robinson in 1987 indicated it has apparently been extirpated from the shoreline of the lake where it once flourished; only a single plant of C. *okeechobeensis*, on Torrey Island, could be found in a three-day search of sites where it previously grew. Although it is allied to *C. martinezii* of Mexico, and has been proposed to be the same species, there is some evidence of biochemical differences between the two taxa and more accessions of *C. okeechobeensis* are needed to preserve it and determine its relationship to *C. martinezii*.

The country of origin and number of accessions from each country for NPGS *Cucurbita* plant introductions follow.

Country	*pepo*	*maxima*	*moschata*	*mixta*	Total
Afghanistan	11	21	4	0	36
Argentina	3	58	2	7	70
Australia	1	4	1	0	6
Belize	0	0	6	4	10
Bhutan	0	7	0	0	7
Bolivia	1	6	0	0	6
Brazil	0	2	2	0	4
Bulgaria	1	1	1	0	3
Burma	0	0	3	o	3
Cameroon	0	1	0	0	1
Canada	1	3	1	0	5
Chile	0	1	0	0	1
China (PRC)	6	11	7	0	24
Colombia	0	0	1	0	1
Costa Rica	1	0	1	0	2
Ecuador	0	0	4	0	4
Egypt	3	0	1	0	4
El Salvador	0	0	2	0	2
England	3	1	0	0	4
Ethiopia	3	12	1	0	16
Germany	2	0	0	0	2
Greece	4	0	o	0	4
Guatemala	10	0	40	1	51
India	6	19	49	0	74
Iran	32	35	16	0	83
Iraq	1	0	0	0	1
Israel	1	0	0	0	1

Italy	0	0	1	0	1
Japan	1	1	3	0	5
Korea	7	1	0	0	8
Lebanon	2	0	1	0	3
Malaysia	0	0	1	0	1
Mexico	39	0	178	66	283
Nepal	0	0	1	0	1
Nigeria	0	3	0	0	3
Pakistan	2	3	2	0	7
Paraguay	0	6	1	0	7
Peru	0	3	o	0	3
Poland	2	0	0	0	2
Saudi Arabia	0	1	1	0	2
Sierra Leone	1	0	0	0	1
South Africa	0	4	3	0	7
Spain	2	1	0	0	3
Surinam	O	1	0	0	1
Syria	4	6	0	0	10
Thailand	0	0	1	0	2
Turkey	197	63	17	0	267
Upper Volta	0	6	0	0	6
USA	12	28	14	3	57
USSR	4	1	0	0	5
Venezuela	0	0	2	0	2
Yemen	1	0	0	0	1
Yugoslavia	104	93	7	0	204
Zambia	0	113	114	0	227
Zimbabwe	4	21	103	0	128
Totals	472	538	591	70	1671

The number of foreign plant introductions is less than the above table would seem to indicate. Some of the PI acquired in various countries are really American cultivars, e.g. PI 385969 from Kenya is actually the American Fl hybrid ‘Ambassador’ (which is *C. pepo* but is listed by Plant Introductions as *C.* maxima) and PI 381323 from Japan is ‘Vegetable Spaghetti'. There are also some duplications of the same cultivar given more than one PI number.

Species	Number	Species	Number
C. pepo	472	*C. ecu*adorensis	5
*C. max*ima	538	*C. foetidissima*	13
C. moschata	591	*C. lundelliana*	8
C. mixta	70	*C. martinezii*	3
C. ficifolia	36	*C. okeechobeensis*	
C. andreana	3	*C. pedatifolia*	1
C. digitata		*C. sororia*	

Responsibilities for *Cucurbita* introductions is divided among four of the RPIS:

PI Station	Responsibility
NC-7, Ames IA	*C. pepo* and *C. texana*
NE-9, Geneva, NY	*C.* maxima and *C. andreana*
W-6, Pullman, WA	*C. foetidissima*
S-9, Experiment, GA	All other *Cucurbita* spp., including *C. moschata* and *C. mixta*

It does not seem logical that the late maturing, xerophytic *C. foetidissima*, which is adapted to the desert southwest, should be grown at W-6 in the Pacific northwest, but the other species assignments seem reasonable. Because of the high labor requirements during the pollinating season, it is good that the *Cucurbita* introductions are divided among several PI stations. It is unfortunate, however, that most of the wild *Cucurbita* species are assigned to a PI Station that has not used controlled pollination to maintain them.

Very few introductions of *Cucurbita* or any other cucurbit from the USSR are included in USDA Plant Introduction stocks. A very extensive collection of cucurbit germplasm is at the N.I. Vavilov Institute of Plant Industry in Leningrad. In 1983, the IGPGR reported that there were 2640 *Cucurbita* accessions and even more of Cucumis at VIR in Leningrad. In 1986, V. V. Vitkovskis, Acting Director of that institute, visited the US. He expressed interest in exchange of germplasm, and since then has provided genetic stocks to R. W. Robinson. They maintain stocks collected or bred not only in the USSR but also from many other countries. An exchange of cucurbit germplasm between the US and the USSR would be of mutual benefit.

Another important resource for Cucurbita germplasm is CATIE at Turrialba, Costa Rica. Over 2,500 *Cucurbita* stocks are included in their collection. The IBPGR has sponsored expeditions to collect *Cucurbita* germplasm, and has recently acquired 60 additional stocks of *C. moschata* that Miguel Holle hopes to increase by controlled pollination. A *Cucurbita* gene bank is maintained at the Unidad de Recursos Geneticas at Celaya, Mexico. They have over 1,000 *Cucurbita* accessions, but many are duplications of USDA plant introductions. Additional accessions of *C.* maxima, *C. moschata*, *C. pepo*, and *C. ficifolia* are in the collection at Pairumani, Bolivia. There is a need for more information for American breeders on the availability and characteristics of the *Cucurbita* collections in Latin American countries. T. W. Whitaker and Laura Merrick have completed an IBPGR-sponsored project to evaluate the status of Latin American *Cucurbita* gene bank collections, but more information is needed.

Other sources of cucurbit germplasm are listed in the 1983 IBPGR Report on Genetic Resources of Cucurbitaceae. Among them is the Institute of Horticultural Research at Bangalore, India, which was reported to have 300 stocks of *C. maxima*.

One of the greatest collections in the world of *Cucurbita* germplasm is that of T. W. Whitaker, retired USDA geneticist. Included in his collection are not only plant introductions of *Cucurbita* and other genera of the Cucurbitaceae but also many stocks of species and interspecific *Cucurbita* hybrids not previously in the P.I. system. Most of the seed is very old and has been stored at less than ideal conditions (50 F and 50~ RH), but many accessions are still viable. Seed of the Whitaker collection was previously kept at Brawley, CA but now most of the seed is in storage at the University of California, Davis. The Whitaker collection was recently inventoried by Laura Merrick, and she also increased seed for 11 of the non-PI accessions. Her inventory revealed that the seed originated at Argentina, Bolivia, Mexico, USA, Ecuador, England, Guatemala, Nepal, Peru, Belize, Chile, Brazil, India, Japan, El Salvador, and Nicaragua, and thus includes countries not now adequately represented in P.I. stocks of *Cucurbita*. The Whitaker collection includes the following accessions that are not now included in USDA Plant Introductions:

Species	Number	Species	Number
C. *andreana*	6	*C. maxima*	18
C. *cordata*	2	*C. mixta*	14
C. *cylindrata*	5	*C. moschata*	22
C. *digitata*	8	*C. okeechobeensis*	4
C. *ecuadorensis*	4	*C. palmata*	16
C. *ficifolia*	17	*C. pedatifolia*	2
C. *foetidissima*	5	*C. pepo*	26
C. *lundelliana*	2	*C. sororia*	61
C. *martinezii*	1	*C. texana*	2

Plans are being made by the USDA and the California Genetic Resources Conservation Program to renew stocks in the Whitaker collection. It is recommended that the person selected for this assignment have expertise in identifying and growing wild species of the Cucurbitaceae. It was reported by L. Merrick that one-third of the accessions in the Whitaker collection, many of them obtained by him from others, were misidentified as to species. Their botanical identity needs to be verified when they are grown for seed increase. It would be disastrous to direct seed in the field, in the way customary for planting squash, many of the accessions that include only a few, very old seed that may be difficult to germinate. They should be planted on germination blotters, so that if germination is not prompt then the seed coats can be removed or the seed can be treated with hormones, fungicides, or special temperature regime to encourage germination. It has been proposed that different seed companies increase some of these stocks by open pollination in isolation plots. This may be satisfactory for some accessions that can be handled in the routine manner used by seedsmen for producing squash seed, but not for other accessions which are refractory and require special care for germination, growing, and pollination.

Another notable collection of *Cucurbita* is that of W. P. Bemis of the University of Arizona. Included in his collection are cytogenetic stocks, species, and interspecific hybrids. Particularly noteworthy is the greatest collection in the world of *C. foetidissima*, 145 stocks in 1983 according to the IBPGR Report. Dr. Bemis died this year, and the 15-year interdisciplinary program at the University of Arizona to domesticate *C. foetidissima* was recently terminated. The seed is being kept at poor storage conditions, in boxes on the floor, and in some cases does not have adequate passport data.

Still another collection of *Cucurbita* species and hybrids by a now retired researcher, that of A. M. Rhoades of the University of Illinois, is now in the care of J. A. Juvik. The pedigree of the seed stocks is reportedly not well documented.

Cucurbita is a member of the Cucurbitinae subfamily of the Cucurbitaceae family, tribe Cucurbiteae, subtribe Cucurbitinae. It would be of interest, for those interested in distant hybridization with *Cucurbita*, to collect species of other genera in the Cucurbitinae subtribe, including *Calycophysum*, *Cronosicyos*, *Edmondia*, *Penelopeia*, *Peponopsis*, *Pittiera*, *Roseanthus*, *Schizocarpon*, *Sicana*, and *Tecunumania*. All are indigenous to the New World, like *Cucurbita.* None of them is more available from USDA Plant Introductions.

B. Evaluation

Much time has been spent in the past by PI personnel in evaluating introductions for morphological traits, but the data are seldom used by squash and pumpkin breeders. In view of the dire need to increase *Cucurbita* PI by controlled pollination rather than by open pollination, it would be better for them to spend less time on evaluation and more on proper seed increase.

Descriptors that should be evaluated at PI stations include:

1. Plant habit: bush, intermediate or vine
2. Date of first male and female flowers
3. Fruit skin colors(s) at maturity and, for summer squash, at the edible stage
4. Skin color design (solid, striped, etc.)
5. Flesh color
6. Fruit length and width (cm)

7. Diameter of seed cavity (cm)
8. Mature fruit weight (gm)
9. 100 seed weight
10. Unique characteristics
11. Verify that the species designation is correct

If reliable data can be obtained at the PI Station for disease or insect resistance or for another natural occurrence of interest to breeders, that information should be noted as a unique characteristic. In general, however, controlled inoculations to test for resistance, and other specialized evaluation tests should be made by users at public institutions and seed companies so that Plant Introductions can concentrate on producing seed properly.

Information of value is often obtained by users and reported to the PI station that provided the seeds, but it may not be made available to other breeders. This information, as well as that obtained at the PI Station, should be included in the GRIN database.

Among the traits needed are the following, ranked in order of importance by participants in the 1987 squash breeders meeting:

1. Resistance to zucchini yellows mosaic virus, especially in *Cucurbita pepo*.
2. Resistance to watermelon mosaic virus-2 in *C. pepo*.
3. Resistance to papaya-ring spot virus (watermelon mosaic virus-l) in *C. pepo*.
4. Resistance to squash mosaic virus.
5. Gummy stem blight resistance.
6. Gynoecious sex expression.
7. Squash bug resistance.
8. Downy mildew resistance.
9. Cucumber beetle resistance.
10. Resistance to storage rots.
11. Pickleworm resistance.
12. Early development of male flowers in *C. pepo*.
13. Resistance to squash leaf curl virus.
14. A gene inhibiting biosynthesis of cucurbitacins that is epistatic to genes for bitter fruit.
15. Vine borer resistance.
16. *Fusarium* resistance.
17. Naked seed in *C. maxima* and *C. moschata.*
18. Cucumber mosaic virus resistance.
19. Powdery mildew resistance.
20. Leafminer resistance.

PI personnel should evaluate *Cucurbita* introductions to confirm that the species is correctly classified. In the past a number of *Cucurbita* introductions were misclassified or unidentified as to species, and Plant Introductions has sometimes sent out seed packets labeled incorrectly even after they were informed of the correct species for those introductions. It would be helpful if Plant Introductions could provide to interested researchers a list of corrected species names for *Cucurbita* introductions.

Recently, R.W. Robinson informed Plant Introductions of several taxonomic changes that should be made, and Laura Merrick corrected t-he species designation of 50 PI of *Cucurbita.* This improves the situation, but there is a continuing need for *Cucurbita* introductions to be verified for species identity because many seed collections received by Plant Introduction are not correctly classified. Many taxonomic errors can be detected by examination of the seed, and many errors in classification could be corrected before the seed is sent from Beltsville to the PI stations.

Personnel at PI stations have responsibilities for many crops, and cannot be expected to be experts on the taxonomy of all *Cucurbita* species. They should be, however, able to recognize whether a *Cucurbita* introduction is a member of the particular species assigned to their PI station or not. The USDA Systematic Botany, Mycology, and Nematode Lab should assist Plant Introductions in classifying *Cucurbita* P correctly.

C. Enhancement

The improvement of horticultural type of plant introductions should be done by public and seed company breeders, not at PI stations. Often, state or federal breeders will find and study the inheritance of useful traits of plant introductions and develop germplasm with improved type, then seed company breeders will complete the development of new cultivars.

D. Preservation

The policy at the NC-7 PI station is to renew seed lots when supplies fall below 500 seed or the germination below 65%. Germination tests are run every 5 years.

There appears to be good seed storage facilities, at controlled low temperature and humidity, at the PI stations and the National Seed Storage Laboratory (NSSL). Under these conditions, good quality *Cucurbita* seed should remain viable for two decades or more. Seed of many, but not all plant introductions are in storage at the NSSL as well as at a PI Station,

Seed of all plant introductions of *Cucurbita* should be kept at the NSSL, as well as at a PI Station, to guard against accidental loss.

Many of the *Cucurbita* seed stocks of the NSSL are now more than a quarter of a century old, but few seem to have been increased. Of the 1263 *Cucurbita* accessions at the NSSL, only 112 (less than l %) have been increased. Even though they may still have good viability now, there may be many that will need to be increased soon, and plans should be made for an orderly renewal of these stocks.

The National Seed Storage Laboratory (NSSL) in Fort Collins has the responsibility to obtain and maintain viable seed of plant introductions and cultivars of *Cucurbita* and other crop species. Although they have stocks of many older cultivars, there is a large number of more recently developed cultlvars that are not in the NSSL. Table 1 indicates the *Cucurbita* cultivars they now have, and Table 2 indicates cultivars not included in the NSSL inventory, although they are listed in ASHS Lists of Vegetable Varieties I to XXI. Additional *Cucurbita* cultivars that are commercially available now, but are not included in NSSL stocks, are listed in Table 3. Omitting the duplications in Tables 2 and 3, there are 125 *Cucurbita* cultivars listed in those tables that are not being preserved at the NSSL.

Plant breeders, both public and private, should send seed to the NSSL when they introduce a cultivar, but this is often not done. The Agronomy Society of America requires that seed be sent to the NSSL for all cultivars of field crop listed in Crop Science. The American Society for Horticultural Sciences does not, but should, have a similar requirement for seed to be sent to the NSSL for all new vegetable cultivars described in HortScience.

In addition to the need for the NSSL to acquire stocks of modern *Cucurbita* cultivars, including those listed in Tables 2 and 3, there is an even greater need to preserve seeds of heritage cultivars that are no longer listed in seed catalogs. The Seed Savers Exchange, Native Seeds/Search, and other sources should be contacted for seed of heritage cultivars not now in the NSSL collection.

There are probably many more *Cucurbita* cultivars that should be, but are not being maintained by the NSSL, since not all cultivars are included in the ASHS lists summarized in Table 2 and more were released since list XXI was published in 1980. The fault for this omission from NSSL seed stocks is partly due to plant breeders and seedsmen, who have not done an adequate job of providing the NSSL with seed of their new releases. However, the USDA should also be doing more. It is not sufficient for the NSSL to passively wait for breeders to send them seed; they should be actively seeking seed of new releases and of older cultivars they don't have. They should try to obtain seed of cultivars listed in HortScience and in previous ASHS Lists of Vegetable Varieties, in the ‘Seed Savers Exchange’ and the ‘Garden Seed Inventory', and those that are awarded plant patents. The CCGC should periodically review the NSSL inventory and make recommendations for additional accessions to obtain.

There are a number of duplications in the NSSL stocks of *Cucurbita* cultivars. They have as many as eight accessions of the same squash cultivar (Table 1). It is recommended that the duplications already in storage be kept there until they lose viability, but then seed be increased for only one accession for each cultivar. Plant Introductions and the NSSL should not maintain seed of F_1 hybrids unless the hybrid has unique characteristics. An example of a unique hybrid that deserves to be preserved is ‘Yankee Hybrid', which is not now at the NSSL but is of historical interest since it was the first F_1 hybrid of *C. pepo* and it has been used in interspecific crosses that are more difficult to obtain when some other *C. pepo* cultivars are used as parents. The NSSL should not accept seed of new hybrid cultivars without special merit, or additional accessions of OP cultivars already in their inventory. When stocks in the NSSL need renewal, the CCGC can advise which cultivars can be obtained from seed companies at little or no cost.

Information on the number of collections and where they are stored has already been presented. A serious omission is for genetic stocks, including mutants, multigene stocks, aneuploids, and polyploids. It would probably not be appropriate for USDA Plant Introductions to assume this responsibility, because there are special requirements for maintaining these stocks and they cannot be increased in the same, routine procedure used for plant introductions of the same species. Some are lethal or sterile as homozygotes and need to be propagated through the heterozygote. Others are very weak and need special growing conditions. Still others, such as trisomics, do not breed true but segregate. Consideration should be given to funding a Cucurbit Genetics Stock Center at a university, patterned after the very successful Tomato Genetics Stock Center that is directed by C.M. Rick at the University of California at Davis, to maintain and distribute seed of genetic and cytogenetic stocks of cucurbits.

Curators have been assigned by the Cucurbit Genetics Cooperative for maintaining stocks of cucurbit genes. Seed is not available, however, for all known mutants of the Cucurbitaceae, and increased efforts should be made to obtain and increase seed of mutants not now being maintained. The present situation for *Cucurbita* is not as serious as for some other genera of the Cucurbitaceae, since many of the known genes for *Cucurbita* are derived from commercially available cultivars. Nevertheless, there have been increasing numbers of induced or spontaneous mutants of *Cucurbita* reported recently, and it is expected that this trend will continue. As the number of known genes increases in the future, many of them not available from cultivars, there will be increased need for a Cucurbit Genetics Stock Center to maintain and distribute seed for these genes. Genetic stocks are very vulnerable with the present system of relying on only a single volunteer to preserve genes for an entire genus.

A Stock Center is needed not only for maintaining seed of mutants, but also for multigene stocks (useful for 1inkage testing and other purposes) and cytogenetic stocks, including haploids, polyploids, and aneuploids. An example of the type of cytogenetic resources of *Cucurbita* that needs to be properly maintained is the trisomic stocks developed by W. P. Bemis that contain 40 chromosomes of *C. moschata* and one chromosome of *C.* palmata; these stocks are invaluable for assigning genes to individual chromosomes.

The National Seed Storage Laboratory in the past has maintained genetic and cytogenetic stocks of barley, and perhaps could do the same for cucurbits. If the NSSL or another federal agency cannot take on this responsibility, however, serious consideration should be given to establishing with USDA funding a Cucurbit Genetics Stock Center at a university.

V Recommendations (in order of Priority)

A. It is intolerable that *Cucurbita* plant introductions are being increased by open pollination. One of the most urgent needs is for controlled pollination of all *Cucurbita* PI. Any introduction increased by open pollination in the past should be properly increased now from the original seedlot, if viable seed still exists. This should be given priority over increasing new introductions, due to the age of the original seedlot of older introductions. Improvements should be made in pollination procedures to improve fruit set when *Cucurbita* plant introductions are increased.

B. The Whitaker collection and other private collections of valuable *Cucurbita* stocks should be incorporated into the PI system and the seed increased.

C. Fund a Cucurbit Genetics Stock Center to maintain and distribute genetic and cytogenetic stocks and species of cucurbits not available from Plant Introductions.

D. An exchange of cucurbit germplasm should be made between USDA Plant Introductions and the Vavilov Institute of Plant Industry in the USSR and Latin American seed banks.

E. Exploration trips for new introductions should be made to Mexico and Latin American countries for *C. pepo, C. moschata*, and wild species of Cucurbita; to South America for *C.* maxima and *C. andreana*; and to Florida for *C. okeechobeensis*.

F. The National Seed Storage Laboratory needs to acquire stocks for the many *Cucurbita* cultivars not in their collection now. Seed of most of the squash and pumpkin cultivars of the past 25 years are not in the NSSL inventory, and they lack seed of a number of heirloom cultivars of squash and pumpkin. Seed of each *Cucurbita* PI should be kept at the NSSL as well as a PI station to guard against accidental loss. The problem of renewing NSSL stocks that are not P needs to be addressed. It is recognized that the budget for the NSSL has not kept pace with these needs, but eliminating F1 hybrids and duplicates of OP cultivars at the NSSL will engender more efficient use of their resources.

G. Personnel at Plant Introduction stations increasing seed of *Cucurbita* PI should become familiar with the taxonomy of *Cucurbita* species, or seek help from knowledgeable researchers, in order to correct the binomial of misclassified plant introductions. The USDA Systematic Botany Lab should assist in the correct species identification of cucurbit introductions. Seed of *Cucurbita* introductions should be examined at Beltsville for species identity before being sent to Plant Introduction stations.

H. The CCGC should periodically advise the USDA about additional accessions that Plant Introductions and the NSSL should acquire. In the past, not all members of this CAC have been able to attend meetings, due to lack of travel funds. Unlike other CAC's that involve only one crop, the CCGC includes several crops, and a committee member may not be able to justify travel with state funds to attend the CAC unless it is in conjunction with a meeting for the particular cucurbit crop he works with. It is difficult, for example, for a squash breeder to justify travel funds when the CAC meets with the National Muskmelon Research Group. It would be helpful if this group, the Pickling Cucumber Improvement Committee, the Squash Breeders Meeting, and the watermelon researchers would meet together with the CCGC. USDA has funded travel by state researchers to attend annual meetings of Regional PI stations, and should consider funding travel to the annual meeting for members of the CCGC.

VI Reflections

There have been improvements by Plant Introductions in recent years. They have acquired many *Cucurbita* introductions from the center of origin for the genus. Mislabeled introductions have been correctly classified as to species. Improvements have been made in pollination procedures.

But further improvements are needed in each of these areas and others. More primitive accessions are needed from the Western Hemisphere, more PI need to be corrected for taxonomy, and **all** PI stations need to use controlled, not open pollination, for seed increases. There is no need for all the cultivars in NSSL stocks to become PI, since many can be replaced at little or no cost by seed companies when they need to be renewed. Only heritage cultivars, no longer available commercially, need to be increased by the USDA.

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Table 1. Numbers of accessions of Cucurbit Stocks at the National Seed Storage Lab, 1987; by species, cultivar.

Cucurbita maxima

Atlantic Giant	1	Hubbard, Blue	4
Autumn Pride	1	Hubbard, Blue New England	1
Baby Blue	1	Hubbard, Chicago Warted	2
Banana	1	Hubbard, Golden	2
Banana, Jumbo Pink	1	Hubbard, Green	1
Banana, Orange	1	Hubbard, Improved Green	2
Banana, Pink	2	Hubbard, Truegreen Improved	1
Banana, Pink G	1	Hubbard, Warted	1
Banana, Red Gold	1	King of Mammoth (Mammoth Chili)	3
Banquet	2	Male Sterile6	8
Big Mex	1	Mammoth King (Mammoth Poitron)	1
Big Moon	2	Mammoth Poitron (Mammoth King)	1
Buttercup	1	Marblehead	1
Buttercup, Blue	1	Marblehead, Umatilla	1
Buttercup, Burgess Strain	1	Marblehead, Yakima	1
Buttercup, Bush	1	Minnesota Breed Lines	13
Buttercup, Seneca Blue	1	Mooregold	1
Deliciou6	1	Quality	2
Genuine Mammoth	7	Rainbow	1
G-170	2	Redskin	1
Giant	1	Red Warren Turban	2
Gold Nugget	2	Silver Bell	1
Goldpack	1	Sweet Meat	1
Golden Delicious	2	Turks Turban	1
Golden Turban	1	Queensland Blue	4
Green Delicious	1	Warren Turban	
Greengold	1		

Cucurbita mixta

Cushaw, Green Stripe	3
Japanese Pie	1

Cucurbits moschata

Alagold	1	Butternut, Rhode Island	1
Bumitkin	1	Butternut, Waltham	1
Butternut	4		
Butternut 23	1		
Butternut, 77	1		
Butternut, Baby	2		
Butternut, Dwarf	3		
Butternut, Eastern	1		

Cheese, Large	2	Fortune	1
Cushaw, Golden	2	Longfellow	1
Improved	1	Tennessee Sweet Potato	1
White Crookneck	1	Virginia Mammoth	1
Dickinson	1		

(Continued)

Table 1. (Continued)

Cucurbita pepo

Acorn, Royal	1	Scallop, White	2
Acorn, Large	1	Scallop, Benning	3
Ambassador	1	Scallop, Early Golden	1
Black Beauty	1	Southern Field	1
Black Knight	1	Straightneck, Early Prolific	4
Black Magic	1	Straightneck, Giant	1
Bushkin	1	Sugar, Early	1
Cheyenne Bush	1	Sugar, Small	2
Coccozelle	4	Sugar, Pie	1
Confederate Gold	1	Sweet Nut	1
Connecticut Field	1	Table King	1
Cornfield	1	Table Queen	1
Cozzini	3	Table Queen, Bush	1
Crookneck, Yellow	8	Table Queen, Mammoth	1
Eastern 717	1	Table Queen, Swan White	1
Eat All	1	Tatume	1
Ebony	2	Thomas Halloween	1
Fordhook Vine	1	Tricky Jack	1
Genovese	1	Triple Treat	1
Golden Acorn	1	Tuckernuck	1
Golden Pippin	1	Uconn	1
Golden Zucchini	1	Vegetable Marrow, Green	1
Howden	1	Vegetable Marrow, White	1
Little Boo	1	Wood's Earliest Prolific	1
Mammoth Field	1	Winter Luxury	1
Mammoth White Bush	1	Young’s Beauty	1
Patty Pan	1	Zucchini	2
Ranger	2	Zucchini, Black	3
Royal Knight	1	Zucchini, Grey	3
SC 2	1	Zucchini, Dark Green	1
		Zucchini, Fordhook	1

Table 2. Cultlvars in ASHS Vegetable Variety List but not included in NSSL stocks, by species

Cucurbita maxima

Boston Marrow Special
Giant Marblehead
Golden Crown
New Hampshire Bush Buttercrop

Cucurbita moschata

Early Butternut
Peraoro

Cucurbita pepo

Apollo
Black Eagle
Blackini
Burpee's Bush Table Queen
Burpee's Crystal Ball
Burpee Hybrid Zucchini
Butterball
Chefini
Cozella
Cracker
Daytona
Diplomat
Dixie
Eldorado
Fordhook Zucchini
Forzini Hybrid
Genie
Gold Rush
Gold Slice
Goldhorn
Goldzini
Golden Eagle
Golden Girl
Greenzini
Harris Improved Cocozelle
Ingot
Lemondrop
Lemondrop L
Moneymaker
Napolini
Patty Green Tint
President
Prima Qualita
Right Royal
Scallopini
Seneca Baby Crookneck
Seneca Gourmet
Seneca Prolific
Seneca Zucchini
Senator
Slenderella
Slendergold
Storrs Green Hybrid
Summer Crookneck 15
Summer Sun
Sundance
Table Ace
Yankee Hybrid
Yellow Acorn
Zish
Zucchini Elite

Tab1e 3. *Cucurbita* cultivars listed in “The Garden Seed Inventory,” C. K. Whealy, ed.) and not included in NSSL stocks; by Species & Cultivar

Cucurbita maxima

Banana, Blue
Banana, Guatemalen Blue
Boston Marrow, Necky
Burgess Giant Pumpkin
Buttercup, Kindred
Buttercup, Perfection
Emerald
Hokkaido, Green
Hokkaido, Orange
Hubbard, Baby
Hubbard, Little Gem
Hubbard, Sugar
Hundredweight
Hungarian Mammoth
King of Giants
Kuri, Blue
Kuri, Red
Mammoth Gold
Manitoba Miracle
Mayo White Giant
Mountaineer
Oregold
Red Chestnut
Red Cold
Show King
Sweet Keeper
Turban, Golden
Virginia Mammoth

Cucurbita mixta

Cushaw, Douglas Striped
Cushaw, Gold Striped
Hopi
Magdalena Striped
Papago

Cucurbita moschata

Badger's Heirloom Pumpkin
Big Cheese
Butterbush
Chirimin
Kentucky Field
Neck Pumpkin
Ponca
Puritan
Tahitian

Cucurbita pepo

Acorn, Des Moines
Acorn, Jersey Golden
Acorn, Table Gold
Acorn, Table King
Acorn, Table Queen
Baby Pam
Cinderalla
Crookneck, Confederate gold
Crookneck, Early Yellow Summer
Cupid
Delicata
Gourmet Globe
Half Moon
Huicha
Jack O'Lantern

Lady Godiva
Little Gem
Luxury Pie
Mini Jack
Pankow's Fleld
Storr's Green
Streaker
Sundance
Sweet Dumpling
Sweet Potato
Tatume
Vegetable Spaghetti
Winter Queen
Zucchini, Burpee’s Golden