Plant Breeding 112, 234—238 (1994)

ISSN 0179-9541

Evaluation of the U.S. Cucumber Germplasm Collection for Early Flowering

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With 1 figure and 1 table

Received April 24, 1993 / Accepted September 2, 1993
Communicated by W. E. Weber

Abstract

A greenhouse study was conducted to evaluate 866 cultigens (718 accessions, 38 breeding lines, and 110 new and obsolete cultivars) of cucumber (*Cucumis sativus* L.) for early staminate flower production. Complete data were obtained for 866 cultigens. The study was conducted on plants that were part of a root-knot nematode experiment. Plants were grown from seeds in greenhouses in each of 3 seasons with 2 replications per season. There were significant differences for mean time of flowering over all cultigens among the 3 seasons. Days from planting to first staminate flower ranged from 26 to 45, with a mean of 35 for all cultigens. Root-knot nematode infestation may be related to flowering, since early-flowering cultigens had more root galling. The earliest flowering cultigen was PI 249561 (26 days to flowering); the latest was PI 470254 (45 days to flowering).

Key words: *Cucumis sativus* — vegetable breeding — flowering — early pollenizer — root-knot nematode infestation.

The majority of cucumber (*Cucumis sativus* L.) cultivars grown before 1980 were monoecious. In monoecious cultivars, the staminate flowers are produced first (nodes 1 to 9), followed by an alternating staminate-pistillate stage, and finally, a continuous pistillate stage (SHIFRISS 1961, TASDIGHI et al. 1981). Yield is dependent on pollination since fruits develop after bees pollinate the pistillate flowers. Fruits can develop without pollination if the plant is parthenocarpic (WHITAKER 1962).

In the last decade, most cultivars of pickling and slicing cucumber used in the U.S. were gynoecious or predominantly gynoecious hybrids. Gynoecious plants usually have a ratio of pistillate to staminate flowers of 9 : 1 (MCMURRAY and MILLER 1969). Gynoecious cultivars intended for field production are blended with a monoecious hybrid or inbred to provide the pollen necessary for fruit set, with 10 to 15 % monoecious plants being optimum (MILLER 1976). 'Sumter' or 'Wisconsin SMR 18' pickle, and 'Poinsett 76' or 'Marketmore 76' slicer are often used as the pollenizer for gynoecious cultivars, although proprietary monoecious hybrids are becoming more common.

As harvest labor became more difficult and expensive for growers to use, plant breeders developed hybrids that had a concentrated set of fruits. Concentrated fruit-set provided high yields in few harvests, and provided a way to use once-over harvest machines. In order to maximize yield for once-over harvest systems, gynoecious hybrids must have pollen available for fruit set when the first pistillate flowers develop. This requires a pollenizer several days earlier than 'Sumter'. One current favorite is 'Armstrong Early Cluster', which has unacceptable fruit type for use in pickling, but usually has not set fruits when the gynoecious hybrid is harvested once-over. It would be valuable if adapted monoecious cultivars could be developed for use as early pollenizers in once-over harvest systems.

The objective of this study was to screen the cucumber germplasm collection of 866 cultigens (718 accessions, 38 breeding lines, and 110 new and obsolete cultivars) for early flowering. We defined early flowering as the number of days from planting to opening of the first staminate flower. In addition, we identified early-flowering cultigens which had acceptable fruit type for use in blends with pickling or slicing types.

Materials and Methods

Materials: A greenhouse experiment was conducted to evaluate 900 cultigens obtained from many sources for early staminate flowering (Table 1). 718 U.S.D.A. accessions were obtained from the Regional Plant Introduction Station, Ames, IA (RPIS). New cultivars were obtained from seed companies, and discontinued cultivars from the National Seed Storage Laboratory, Fort Collins, CO (NSSL), altogether 148 accessions. Additional seed sources were obtained from Turkey (167), P.R. China (101), Yugoslavia (62), Iran (58), India (45); including one accession of *Cucumis sativus* var. *hardwickii* (R.) Alef., Japan (43), former USSR (40), and others (202).

The test was conducted on plants that were part of a root-knot nematode study (WALTERS 1991) involving 3 root-knot nematode species (*Meloidogyne incognita* race 3, *M. hapla*, and *M. arenaria* race 2). Of the 900 cultigens tested, 25 did not germinate well, 6 were not vigorous enough to rate, and 3 did not flower before the experiment was terminated 47 days

Table 1. Days to flower and fruit type for the cucumber germplasm collection of the earliest flowering 26 and the latest flowering 14 cultigens compared with standard cultivars (from the evaluation of 866 total). Data are means of 3 greenhouse seasons with 2 replications of 1 plant each, counting number of days from planting to first staminate flower

Rank	Cultigen	Seed source	Days to flower	Fruit type[1] Fruit	Skin	Spine
Early						
1	PI 249561	Thailand	26	W	W	B
2	PI 343451	USSR	28	P	W	W
3	PI 466921	USSR	28	P	W	B
4	Early Cluster	NSSL	29	P	W	B
5	PI 164819	India	29	P	N	B
6	PI 263047	USSR	29	P	W	W
7	PI 263080	USSR	29	P	N	B
8	PI 267087	USSR	29	P	W	B
9	PI 306179	Poland	29	P	N	B
10	PI 342950	Denmark	29	P	W	B
11	PI 357863	Yugoslavia	29	S	N	B
12	PI 418989	P.R. China	29	S	W	B
13	Armstrong Early Cluster	SunSeeds	30	W	W	B
14	PI 105340	P.R. China	30	G	R	R
15	PI 137844	Iran	30	P	W	B
16	PI 164816	India	30	P	W	B
17	PI 169397	Turkey	30	W	W	B
18	PI 257486	P.R. China	30	S	N	B
19	PI 356809	USSR	30	W	S	B
20	PI 370019	India	30	P	N	B
21	PI 390253	Japan	30	P	N	B
22	PI 390954	USSR	30	P	W	B
23	PI 432893	P.R. China	30	G	R	R
24	PI 435947	USSR	30	P	W	W
25	PI 436608	P.R. China	30	G	R	W
26	PI 466922	USSR	30	P	N	B

after planting (PI 135122, PI 183127 and PI 188807), providing data on 866.

Cultural practices: All cucumber plants were grown from seed in 150-mm diameter (17,000 mm^3 volume) clay pots on benches in the greenhouse. Small squares of wire mesh (76 × 76 mm) were placed in the bottom of each pot to prevent soil from washing out. A 1 : 1 mix (v:v) of soil : sand was used for potting medium. Five seeds were sown in each pot. Plants were thinned to two per pot at the 2-leaf stage, and to one plant at the 3-leaf stage. Planting dates were 24 May, 16 August and 20 November 1989 for the summer, fall and winter seasons, respectively.

Plants were trained up a trellis 1.8 m high, and were not pruned. Irrigation with fertilizer (200 ppm N) was supplied twice daily using drip tubes. Plants were allowed to grow 11 weeks before being evaluated for resistance to root-knot nematodes. Greenhouse temperatures were 32 ± 8 °C in the summer, 27 ± 6 °C in the fall, and 23 ± 4 °C in the winter.

Experimental design: The experiment was a split-plot treatment arrangement in a randomized complete block design with 2 replications. Whole plots

Table 1 (*continued*)

Rank	Cultigen	Seed source	Days to flower	Fruit type[1] Fruit	Skin	Spine
Checks						
188	Addis	NC State Univ.	34	P	W	W
189	Arkansas H-19	Univ. Arkansas	34	P	W	W
190	Calypso	NC State Univ.	34	P	W	W
446	Sumter	Clemson Univ.	35	P	W	W
459	Gy 14A	NC State Univ.	36	P	W	W
561	Wisconsin SMR 18	Wisconsin AES	36	P	W	B
567	Clinton	NC State Univ.	37	P	W	W
568	Dasher II	Peto Seed	37	S	W	W
575	LJ 90430	USDA, La Jolla	37	W	W	B
712	Marketmore 76	Cornell Univ.	39	S	W	W
804	Poinsett 76	Cornell Univ.	40	S	W	W
834	WI 2757	USDA-Wis	41	B	W	W
851	Tablegreen 72	Cornell Univ.	42	S	W	W
Late						
852	A & C	Niagara	43	S	W	W
853	PI 163222	India	43	W	W	B
854	PI 164465	India	43	—	—	—
855	PI 164679	India	43	W	W	B
856	PI 261608	Spain	43	—	—	—
857	PI 267942	Japan	43	S	N	B
858	PI 356832	Netherlands	43	G	R	W
859	PI 422184	Czechoslovakia	43	G	R	W
860	PI 500365	Zambia	43	—	—	—
861	Nepal Local 7	Nepal	44	—	—	—
862	PI 167223	Turkey	44	W	W	W
863	PI 175120	India	44	W	W	B
864	PI 279466	Japan	44	S	W	B
865	PI 285608	Poland	44	G	R	W
866	PI 470254	Indonesia	45	S	W	W
LSD (5 %)			3			
Mean (all cultigens)			35			
CV (%)			7			

[1] Fruit type: B = Beit Alpha, G = Greenhouse, P = Pickle, S = Slicer, W = Wild type (small, round). Skin type: N = Netted, R = Ridged, S = Smooth, W = Warty. Spine type: B = Black, R = Brown, W = White.

were the 3 seasons and subplots were the 900 cultigens. Plots were greenhouse pots thinned to 1 plant each.

Traits measured: Flowering data were taken for 21 days after the appearance of the first staminate flower on the earliest plant in each of the 3 seasons. Number of days from planting to first staminate (or pistillate in the case of gynoecious cultigens) flower was recorded for each plant. Pollinations were made on the earliest and latest cultigens to observe fruit, skin and spine type.

Data analysis: Data were analyzed using the GLM and CORR procedures of SAS (SAS Institute, Cary, NC). Pearson product-moment correlations were used to evaluate the effect of root-knot nematode on flowering date. Cultigen means were compared using Fisher's LSD, which was used if the F ratio was significant at the 5 % level.

Results and Discussion

Significant differences existed among the 3 seasons for mean days to flower over all cultigens. The greenhouse temperature dropped gradually from summer to winter (32 to 23 °C), reducing the number of heat units per day. Mean days to first staminate flower was 35 over 3 seasons and 866 cultigens, and was 34, 35 and 38 days for summer, fall and winter seasons, respectively. Earliness of flowering was distributed normally for the 866 cultigens evaluated (Fig. 1). Most cultigens (544, or 62 %) produced their first staminate flower 33 to 37 days after planting.

Root-knot nemadodes (used as part of another study) may have had a small effect on flowering, with early-flowering cultigens having more root galling. The correlation was small and not significant between earliness of flowering and gall damage by *Meloidogyne hapla* or *M. arenaria*, but was significant (−0.08**) for *M. incognita*. Thus, there was a slight tendency for the more susceptible cultigens to flower earlier when attacked by the latter species.

Two checks, 'Sumter' and 'Wisconsin SMR 18', were included in this study, since they are used frequently as pollenizers for gynoecious pickling cucumber hybrids. The two did not differ significantly from each other for earliness of flowering (35 and 36 days, respectively) and were close to the mean of all cultigens evaluated.

The days to the first flower for all cultigens in the germplasm collection are shown in Fig. 1. PI 249561 was the earliest flowering cultigen (26 days from planting to first staminate flower). It was not significantly different from the earliest 11 cultigens, however. The latest flowering cultigen was PI 470254 (45 days). Three cultigens (PI135122, PI 183127 and PI 188807) did not flower before the experiment was terminated.

Fruit, skin and spine type for the earliest and latest flowering cultigens, along with several check cultigens are also listed in Table 1. Knowledge of the fruit, skin and spine types will permit cucumber breeders to match early

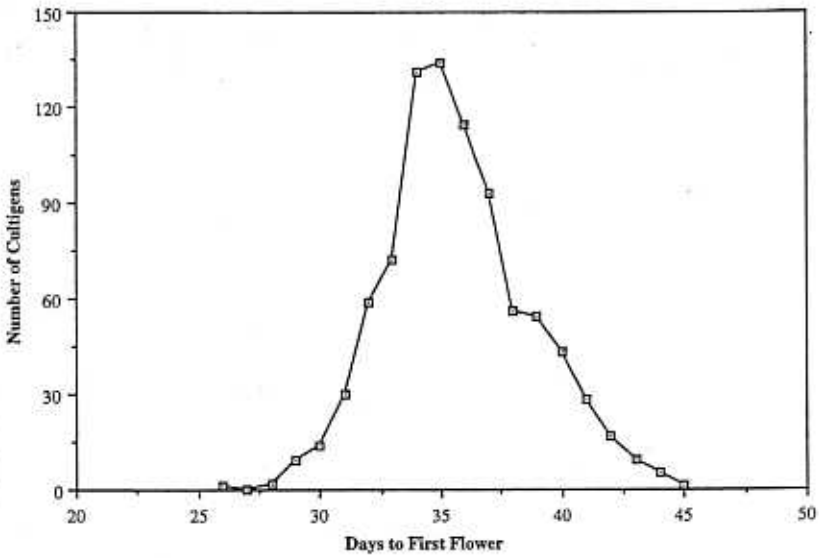

Fig. 1. Distribution of 866 cucumber cultigens for days to first staminate flower. Data are means of 3 greenhouse seasons and 2 replications of 1 plant per treatment unit

flowering cultigens to the fruit type of gynoecious cultivars being grown for pickling or slicing. If a cultigen were needed as a pollenizer for blending with a gynoecious pickling cultivar, then PI 343451 would be a good choice, since it has a pickle type fruit with warty skin and white spines (Table 1). Also, it was not significantly later (28 days) than the earliest flowering cultigen.

The ultimate goal for cucumber breeders is to develop a pollenizer that flowers earlier than those currently in use. 'Sumter' is commonly used as a pollenizer for gynoecious pickling cultivars, and could be improved by crossing with PI 249561 (the earliest flowering cultigen) for progeny selection. A breeding program has been initiated to make early flowering versions of 'Sumter' and 'Poinsett'.

The complete data set for the 866 cultigens evaluated for early flowering (either pistillate or staminate) will be entered into the Germplasm Resources Information Network (U.S.-D.A., Wash. D.C.).

Zusammenfassung

Untersuchung der Frühblütigkeit an einer U.S.-Sammlung von Gurkengenotypen

An 866 Genotypen von Gurken (*Cucumis sativus* L.) (718 Herkünfte, 38 Zuchtstämme und 110 neue und alte Sorten) wurde im Gewächshaus der Zeitpunkt der Ausbildung männlicher Blüten ermittelt. Untersucht wurden Pflanzen aus einem Versuch mit Wurzelgallennematoden. Die Pflanzen wurden während dreier Vegetationsperioden in je zwei Wiederholungen aus Samen angezogen. Bei Zusammenfassung aller Genotypen für die mittlere Blütezeit gab es zwischen den drei Anbauperioden signifikante Unterschiede. Die Zeit von der Aussaat bis zur Ausbildung der ersten männlichen Blüte schwankte für alle Genotypen zwischen 26 und 45 Tagen bei einem Mittelwert von 35 Tagen. Möglicherweise hängt der Befall mit Wurzelgallennematoden mit der Blütezeit zusammen, da frühblühende Formen mehr Gallen ausbildeten. Der am frühesten blühende Genotyp war PI 149561 (26 Tage bis zur Blüte); die am spätesten blühende Form war PI 470254 (45 Tage bis zur Blüte).

References

McMURRAY, A. L., and C. H. MILLER, 1969: The effect of 2-Chloroethanephosphonic Acid (Ethrel) on the sex expression and yields of *Cucumis sativus*. J. Amer. Soc. Hort. Sci. **94**, 400—402.

MILLER, C. H., 1976: Effects of blending gynoecious and monoecious cucumber seeds on yield patterns. HortScience **11**, 428—430.

SHIFRISS, OVED, 1961: Sex control in cucumbers. J. Hered. **52**, 5—12.

TASDIGHI, M., and L. R. BAKER, 1981: Comparison of single and three-way crosses of pickling cucumber hybrids for femaleness and yield by once-over harvest. J. Amer. Soc. Hort. Sci. **106**, 370—373.

WALTERS, S. A., 1991: Root-knot nematode resistance in *Cucumis sativus* and *Cucumis metuliferus*. M.S. Thesis, North Carolina State Univ., Raleigh, NC.

WHITAKER, T. W., 1962: Cucurbits — Botany, Cultivation and Utilization. Interscience Publishing, Inc., New York.