HortScience 35(6):1141–1150. 2000.

Screening the Cucumber Germplasm Collection for Combining Ability for Yield

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Additional index words. Cucumis sativus, fruiting, germplasm evaluation, vegetable breeding, fruit number

Abstract. **Cucumber (*Cucumis sativus* L.) plant introduction (PI) accessions from the regional PI station at Ames, Iowa were evaluated in open-field production for single-harvest yield at Clinton, N.C. and Ames, Iowa. Check cultivars and experimental inbreds were also tested for comparison with the PI accessions (the three groups hereafter collectively referred to as cultigens). In order to make the evaluation more uniform for all cultigens regardless of sex expression and fruit size, all were crossed with Gy 14, a gynoecious pickling cucumber inbred used commonly in the production of commercial hybrids. The resulting 761 gynoecious hybrids were tested for early, total, and marketable yield using recommended cultural practices. Results were obtained for 725 cultigens at both locations. Significant differences were observed among cultigens for all traits evaluated. Differences between the two locations were also significant for total yield, corrected total yield, and percentage of early fruit. The interaction of cultigen and location was significant for standardized total yield and standardized corrected total yield. The highest yielding hybrids at both locations were produced using the following cultigens as male (paternal) parents: PI 422185, PI 390253, PI 175120, PI 173889, PI 267087, PI 175686, PI 178888, PI 385967, PI 458851, and PI 171601. The highest and lowest yielding paternal parents from the germplasm screening study were retested, along with check cultigens in a multiple-harvest trial at Clinton, N.C. Cultigens were evaluated directly, rather than as hybrids with Gy 14, and fruit number, fruit weight, and sex expression were recorded. Most cultigens performed as expected for the yield traits in the retest study. The exceptions were 'Wautoma' and PI 339250, which were among the low and high yielders in the first test, but were ranked as medium and low, respectively, in the retest study.**

Cucumber is thought to have originated in India (Harlan, 1975), with domestication occurring later throughout Europe. Breeding for yield has been one of the important objectives of many cucumber breeding programs since the 1900s (Wehner, 1989). Yield of pickling cucumber has been improved by incorporating disease resistance into cultivars (Peterson, 1975) and using improved cultural practices (Cargill et al., 1975). Increased yield has also resulted from improvement of qualitative traits such as gynoecious sex expression and uniform green fruit color (improved percentage of marketable fruit) (Wehner, 1989).

However, improvement in yield in recent years has been limited. Additional yield improvement might be achieved by identifying new sources of germplasm for high yield. The cucumber germplasm collection is a good place to find new sources of high yielding cultigens because no previous work has been done on screening the collection for yield. However, measurement of yield in a diverse array of cucumber cultigens can be difficult. Yield is usually measured as fruit number, weight, or value per unit area or per plant. Fruit number was more stable than fruit weight or fruit value for yield measurement in a once-over harvest trial of cucumber (Ells and McSay, 1981) and had a higher heritability (0.17) than fruit weight (0.02) (Smith and Lower, 1978).

Large-plot, multiple-harvest trials in multiple years, locations, seasons, and replications would be ideal for yield measurement. However, it would be nearly impossible to include >700 cultigens in such trials. Single harvest trials are efficient for yield measurement, but introduce the problem of the optimum time to harvest each plot for maximum yield. Miller and Hughes (1969) reported that harvesting when 14% to 31% of the fruits in a plot were oversized (>51 mm diameter for pickling cucumber and >60 mm diameter for fresh market cucumber) was optimum for maximum value in once-over harvest for 'Piccadilly' and 'Southern Cross' gynoecious hybrids in North Carolina. Chen et al. (1975), using a computer simulation, reported that plots harvested at 10% oversized fruit stage gave an optimum yield for 'Piccadilly' hybrid under North Carolina conditions. Colwell and O'Sullivan (1981) reported that the optimum harvest stage to maximize yield for 'Femcap' and 'Greenstar' gynoecious hybrids occurred when 5% to 15% of the fruit in a plot were oversized.

Small-plot trials are efficient, but plots should not be too small. Yield of cultivars in single-plant hills was poorly correlated with large, replicated plots harvested several times (Wehner, 1986; Wehner and Miller, 1984). In addition, greenhouse evaluation of yield, based on fruit number of single plants, was not correlated (r = 0.09–0.15) with yield in field trials (Nerson et al., 1987). Once-over harvest trials with three replications are optimum for determining which cucumber cultigens should be tested further in multiple-harvest trials (Wehner, 1986; Wehner and Miller, 1984). A plot size of 1.2 m × 1.5 m was found to be optimum for yield evaluation of pickling cucumber when paraquat (1,1´-dimethyl-4,4´-bipyridinium ion) was used to simulate once-over harvest (Swallow and Wehner, 1986). In cucumber, small-plot, single-harvest trials were more efficient than large-plot, multiple-harvest trials (Wehner, 1986, 1989; Wehner and Miller, 1987).

Swallow and Wehner (1989) suggested that maximum information (1/variance) was obtained by allocating test plots of cucumber cultigens over different seasons and years rather than different locations and replications. However, use of locations and replications was less expensive than use of seasons and years. Field evaluation at the Clinton location was more efficient than at three other locations tested in North Carolina (Wehner, 1987a).

The >700 cultigens in the U.S. Dept. of Agriculture (USDA) cucumber germplasm collection range from androecious to monoecious to gynoecious. Thus, measuring yield of a diverse set of cultigens in a single-harvest trial is difficult, even though that method is the most efficient. Some of the cultigens are highly staminate in flowering habit, so will not produce much fruit. Even so, androecious cultigens might have useful genes for yield. For that reason, we crossed each cultigen with Gy 14 to make gynoecious hybrids. In that way, yield of all cultigens from the germplasm collection could be expressed in a gynoecious background with the potential to set fruit at many nodes. By measuring the combining

Received for publication 7 Sept. 1999. Accepted for publication 14 Feb. 2000. The use of trade names in this publication does not imply endorsement by the North Carolina Agricultural Research Service (NCARS) of the products named, nor criticism of similar ones not mentioned. Research funded in part by a grant from the North Carolina Pickle Producers Association. We gratefully acknowledge the technical assistance of R.R. Horton, Jr. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.
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Table 1. Fruit yield traits (yield in 1000 fruit/ha)[z] for the cucumber germplasm collection tested at two locations for combining ability with Gy 14 (cultigens ranked by standardized corrected total fruit number over both locations).

	Both locations					Iowa					North Carolina					
Cultigen	Total	Std. total	Corr. Total	Std. corr. total	Early (%)	Total	Std. total	Corr. Total	Std. corr. total	Early (%)	Total	Std. total	Corr. Total	Std. corr. total	Early (%)	Marketable (%)
High yielding male parents																
PI 422185	91	97	171	167	0	---	---	---	---	---	91	97	171	167	0	98
PI 390253	104	119	147	166	39	22	79	39	139	100	131	132	183	175	19	91
PI 175120	87	145	114	160	55	36	151	36	138	100	138	139	192	182	11	93
PI 173889	88	153	104	157	65	41	171	41	156	100	135	136	168	159	30	95
PI 267087	81	151	86	157	75	44	183	54	202	100	118	119	118	112	50	99
PI 175686	86	149	104	156	68	38	165	38	149	100	133	134	170	162	35	95
PI 178888	96	128	115	152	58	24	103	34	137	100	143	145	169	162	29	99
PI 385967	27	111	38	150	100	27	111	38	150	100	---	---	---	---	---	---
PI 458851	55	117	92	150	52	37	155	43	159	100	73	78	141	141	4	100
PI 171601	110	123	130	149	44	19	69	39	137	100	140	141	160	153	26	96
Polaris	51	107	63	149	67	25	98	44	162	100	102	125	102	121	0	89
PI 427090	109	110	153	147	7	---	---	---	---	---	109	110	153	147	7	77
PI 226461	82	138	101	146	58	34	143	34	132	100	131	132	169	161	16	99
PI 169397	92	148	94	145	68	35	146	38	148	100	149	150	149	143	37	96
PI 171610	74	117	83	145	59	27	114	45	175	100	120	121	120	116	19	97
PI 370019	20	82	37	145	100	20	82	37	145	100	---	---	---	---	---	---
PI 169380	88	140	91	145	68	32	134	39	152	100	143	145	143	138	36	95
PI 391568	41	113	51	144	70	32	130	47	177	100	59	81	59	78	9	91
PI 370022	37	155	37	143	100	37	155	37	143	100	---	---	---	---	---	---
PI 179678	49	120	57	141	50	43	186	59	228	100	56	55	56	54	0	100
Check/Cultivars																
Regal	78	135	78	126	55	35	148	35	135	100	122	123	122	117	10	99
Gy 4	72	101	79	122	59	24	96	42	157	100	104	104	104	99	32	97
Calypso	77	124	77	115	54	32	133	32	122	100	115	115	115	110	15	97
Dasher II	76	122	76	113	51	28	119	28	109	100	124	125	124	118	1	87
Sprint 440	76	109	76	103	41	27	109	27	102	100	105	108	105	103	5	95
M 21	71	108	71	101	46	25	102	25	94	74	117	115	117	108	17	97
Gy 5	58	91	62	100	65	20	85	28	108	100	97	97	97	92	30	96
Gy 2	62	103	62	96	62	25	107	25	98	100	99	99	99	94	24	91
SMR 58	53	89	53	84	50	23	96	23	89	100	82	82	82	80	0	96
Sumter	47	87	48	84	52	25	105	26	100	100	69	69	70	67	3	96
Addis	36	79	40	79	50	28	116	28	108	100	43	42	52	50	0	87
Wautoma	32	70	33	72	49	22	92	25	97	90	43	44	43	42	0	100
M 27	46	48	46	47	40	6	13	6	17	100	72	71	72	68	0	96
WI 2757	13	24	16	36	41	8	39	15	67	81	16	14	16	14	0	100
Marketmore	16	34	16	33	42	12	50	12	49	70	20	18	20	18	0	100
Low yielding male parents																
PI 357856	25	45	28	54	45	16	70	23	94	100	30	29	30	28	9	100
PI 183127	21	58	21	54	50	23	100	23	92	100	18	16	18	17	0	100
PI 458855	36	49	42	53	52	14	48	14	46	100	50	49	60	57	3	89
PI 370450	22	35	30	52	50	14	48	23	80	100	27	26	35	33	0	79
Magnolia	32	54	32	51	0	---	---	---	---	---	32	54	32	51	0	67
PI 379283	22	43	31	50	0	---	---	---	---	---	22	43	31	50	0	100
PI 370447	11	36	14	45	67	12	38	16	53	100	11	32	11	30	0	100
PI 183056	12	44	12	44	50	26	108	26	104	100	4	2	4	3	0	100
PI 379284	28	44	28	42	40	16	58	16	55	100	36	35	36	34	0	100
PI 379282	25	36	31	42	40	13	43	13	42	100	32	31	44	42	0	95
PI 432874	22	37	26	39	56	16	53	16	49	100	24	29	31	34	33	83
Stono	12	38	12	38	100	12	38	12	38	100	---	---	---	---	---	---
Cubit	18	28	18	28	50	15	48	15	45	100	22	9	22	11	0	100
PI 368554	14	23	15	25	35	6	30	7	36	88	20	18	20	18	0	87
PI 357853	6	14	9	25	50	8	24	15	56	100	5	9	5	9	0	100
PI 368559	12	18	13	23	40	11	38	15	57	100	13	11	13	12	10	100
Mean	61	100	65	100	58	24	100	26	100	100	100	100	105	100	15	93
LSD	21	29	24	31	5	9	27	11	26	9	41	47	46	47	20	11
CV (5%)	30	26	31	28	17	24	17	27	16	6	26	30	27	29	84	8
Range	119	141	164	144	100	38	172	52	211	30	166	170	192	183	63	80
Range/LSD	6	5	7	5	20	4	6	5	8	3	4	4	4	4	3	7
F ratios																
Cultigen	3.8^{**}	4.9^{**}	3.2^{**}	4.0^{**}	6.1^{**}	4^{**}	8^{**}	3^{**}	8^{**}	4^{**}	3^{**}	2^{**}	3^{**}	2^{**}	3^{**}	3^{**}
Location	42.0^{**}	2.0^{NS}	38.9^{**}	2.2^{NS}	210.0^{**}											
Cult. × loc.	2.6^{**}	1.8^{**}	2.3^{**}	1.8^{**}	1.7^{**}											

[z]Data are means of three replications per location.

[NS, *, **]Nonsignificant or significant at $P \leq 0.05$ or 0.01 level, respectively.

ability of yield, we would be able to identify cultigens that contributed useful, dominant genes for yield to their hybrid.

A disadvantage of measuring yield of the germplasm collection as combining ability with a gynoecious tester is that cultigens with recessive genes for yield would not perform as well. Therefore, cultigens that rank high in this evaluation of combining ability for yield would be excellent choices for use in a breeding program for yield, but cultigens that do not rank high might also be excellent choices. Therefore, low performers should be retested for yield using methods other than combining ability.

In the breeding program at North Carolina State Univ., we intend to measure yield of the cucumber germplasm collection using a three-stage process. First, testing of all available cultigens using combining ability with a gynoecious tester in small-plot, single-harvest trials. Second, testing of all available cultigens for yield *per se* in small-plot, single-harvest trials after treating the plants with ethrel (2-chloroethylphosphonic acid) to increase gynoecious sex expression. Third, evaluation of the high-yielding cultigens from the previous two stages using large-plot, multiple-harvest trials in multiple seasons and years. This study deals with the first stage of that process.

The objective of this study was to evaluate all available cucumber cultigens for combining ability for yield at two locations using a gynoecious tester. Identification of the highest yielders was followed by a retest of performance *per se* to verify performance for use in yield improvement in breeding programs for commercial cultivars.

Materials and Methods

All experiments were conducted at the Horticultural Crops Research Station, Clinton, N.C., and the Regional Plant Introduction Station, Ames, Iowa. The experiments were

Table 2. Correlations among fruit yield traits for the cucumber germplasm collection tested at two locations.

	Both locations				Iowa					North Carolina					
Cultigen	Std. total	Corr. total	Std. Corr. total	Early (%)	Total	Std. total	Corr. total	Std. Corr. total	Early (%)	Total	Std. total	Corr. total	Std. Corr. total	Early (%)	Marketable (%)
							Both locations								
Total	0.81	0.92	0.73	–0.14	0.44	0.43	0.30	0.31	0.13	0.92	0.91	0.87	0.86	0.44	0.04
Standardized total	---	0.69	0.86	0.26	0.76	0.77	0.54	0.56	0.16	0.85	0.86	0.78	0.78	0.47	0.12
Corrected total		---	0.79	–0.27	0.40	0.39	0.39	0.39	0.14	0.77	0.77	0.89	0.89	0.37	0.00
Standardized corrected total			---	0.15	0.67	0.66	0.72	0.74	0.17	0.73	0.75	0.81	0.83	0.37	0.06
Early yield (%)				---	0.17	0.19	0.05	0.08	0.10	0.26	0.26	0.16	0.15	0.63	0.15
							Iowa								
Total					---	0.99	0.76	0.76	0.17	0.33	0.33	0.32	0.32	0.25	0.14
Standardized total						---	0.73	0.75	0.16	0.34	0.34	0.32	0.32	0.26	0.15
Corrected total							---	0.99	0.16	0.18	0.19	0.21	0.22	0.14	0.08
Standardized corrected total								---	0.15	0.19	0.21	0.21	0.23	0.16	0.10
Early yield (%)									---	0.10	0.10	0.12	0.12	0.08	0.04
							North Carolina								
Total										---	0.99	0.91	0.90	0.51	0.05
Standardized total											---	0.90	0.91	0.49	0.05
Corrected total												---	0.42	0.02	0.02
Standardized corrected total													---	0.16	0.16
Early yield (%)														---	0.16

Table 3. Mean sandardized corrected yield (1000 fruit/ha) for 761 cucumber cultigens tested at two locations (cultigens ranked by average yield at both locations.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
PI 422185	Czechoslovakia	167	---
PI 390253	Japan	175	139
PI 175120	India	182	138
PI 173889	India	159	156
PI 267087	USSR	112	202
PI 175686	Turkey	162	149
PI 178888	Turkey	162	137
PI 385967	Kenya	---	150
PI 458851	USSR	141	159
PI 171601	Turkey	153	137
Polaris	NSSL	121	162
PI 427090	P.R. China	147	---
PI 226461	Iran	161	132
PI 169397	Turkey	143	148
PI 171610	Turkey	116	175
PI 370019	India	---	145
PI 169380	Turkey	138	152
PI 391568	P.R. China	78	177
PI 370022	India	---	143
PI 179678	India	54	228
PI 401732	Puerto Rico	140	140
PI 344445	Iran	139	140
PI 169391	Turkey	152	118
PI 174172	Turkey	150	128
PI 342950	Denmark	145	133
PI 280096	USSR	138	139

Table 3. Continued.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
PI 344442	Iran	173	86
PI 172846	Turkey	149	127
PI 205995	Sweden	132	146
PI 263083	P.R. China	122	151
PI 390953	USSR	88	152
Ansansky	NSSL	136	---
Producer	NSSL	144	127
PI 354952	Denmark	108	162
PI 418963	P.R. China	141	127
PI 308916	USSR	116	151
PI 288992	Hungary	130	137
PI 357855	Yugoslavia	103	163
PI 167134	Turkey	147	118
PI 175690	Turkey	125	140
PI 222244	Iran	115	149
PI 175696	Turkey	132	132
PI 113334	P.R. China	130	134
Shamrock Resistant	NSSL	173	91
PI 183231	Egypt	151	113
Pixie	NSSL	130	133
PI 263047	USSR	131	132
PI 169393	Turkey	127	136
PI 419108	P.R. China	134	128
PI 169378	Turkey	135	127
PI 285605	Poland	133	128
PI 226510	Iran	125	135
PI 436648	P.R. China	112	147
PI 279465	Japan	121	155

Table 3. Continued.

Cultigen name	Seed source[z]	Fruit yield[y] North Carolina[z]	Fruit yield[y] Iowa[z]
PI 137844	Iran	146	112
PI 105340	P.R. China	129	129
PI 432873	P.R. China	99	174
PI 478365	P.R. China	123	138
PI 175693	Turkey	127	130
PI 118279	Brazil	136	121
PI 181753	Syria	141	116
PI 222243	Iran	127	130
PI 360939	Netherlands	105	163
PI 419010	P.R. China	134	120
PI 179676	India	88	168
PI 164950	Turkey	130	125
PI 171607	Turkey	132	123
PI 466922	USSR	118	141
PI 206425	Turkey	138	117
PI 339250	Turkey	151	103
PI 169304	Turkey	159	95
Long of Keschmet	NSSL	100	136
PI 422176	Czechoslovakia	122	133
PI 288237	Egypt	125	128
PI 114339	Japan	118	134
PI 279468	Japan	96	156
PI 165499	India	117	135
PI 271328	India	118	134
PI 271326	India	104	148
Snows Pickling	NSSL	111	141
PI 164951	Turkey	123	128
PI 422191	Czechoslovakia	148	92
Regal	Check[x]	117	135
PI 211988	Iran	111	140
PI 275410	Netherlands	118	133
PI 432875	P.R. China	126	124
PI 171613	Turkey	110	140
PI 390247	Japan	125	---
PI 342951	Denmark	123	126
PI 172843	Turkey	148	101
PI 432889	P.R. China	149	87
PI 271754	Netherlands	127	121
PI 221440	Afghanistan	117	129
PI 432848	P.R. China	132	115
PI 326594	Hungary	128	119
PI 271753	Netherlands	119	128
PI 169398	Turkey	126	121
PI 177359	Turkey	122	125
PI 211982	Iran	118	127
PI 169392	Turkey	130	115
PI 175683	Turkey	141	104
PI 432850	P.R. China	123	122
Gy 4	Check[x]	99	157
PI 400270	Japan	145	87
PI 283900	Czechoslovakia	123	121
PI 204567	Turkey	122	122
PI 164819	India	123	120
PI 172841	Turkey	121	123
PI 422168	Czechoslovakia	117	128
PI 177364	Iraq	164	79
PI 302443	P.R. China	131	112
PI 204568	Turkey	119	124
PI 326597	Hungary	129	114
PI 174166	Turkey	118	124
PI 422179	Czechoslovakia	109	157
Tiny Dill	NSSL	134	107
PI 249561	Thailand	110	131
PI 220860	Korea	110	131
PI 356809	USSR	130	111
PI 458852	USSR	136	98
PI 285609	Poland	121	---
PI 137836	Iran	142	99
PI 174170	Turkey	125	115
PI 103049	P.R. China	124	117
PI 227207	Japan	115	125
PI 432894	P.R. China	129	111
PI 176951	Turkey	125	115
PI 262974	India	122	118
PI 165509	India	92	148

Table 3. Continued.

Cultigen name	Seed source[z]	Fruit yield[y] North Carolina[z]	Fruit yield[y] Iowa[z]
PI 422173	Czechoslovakia	114	129
PI 264668	Germany	114	126
PI 193496	Ethiopia	128	111
PI 339247	Turkey	139	101
PI 196289	India	109	130
PI 355052	Israel	113	126
PI 478367	P.R. China	121	117
Texas Long	NSSL	95	132
PI 267942	Japan	99	133
PI 169385	Turkey	134	105
PI 169403	Turkey	122	115
PSI	NSSL	128	106
PI 263080	USSR	117	121
PI 181910	Syria	109	128
PI 478364	P.R. China	139	89
PI 175694	Turkey	137	101
PI 284699	Sweden	116	122
PI 109484	Turkey	111	126
PI 169328	Turkey	115	123
PI 422167	Czechoslovakia	124	116
PI 264230	France	121	116
PI 234517	U.S.–S.C.	117	119
PI 422184	Czechoslovakia	95	141
PI 314426	USSR	115	121
PI 188749	Egypt	126	109
PI 227664	Iran	96	132
PI 200815	Burma	114	129
PI 179921	India	116	119
PI 344349	Turkey	124	111
PI 181756	Lebanon	127	107
PI 357862	Yugoslavia	144	77
PI 172852	Turkey	112	122
PI 193497	Ethiopia	115	119
PI 422177	Czechoslovakia	109	125
PI 432892	P.R. China	120	114
Sunny South	NSSL	131	95
PI 285607	Poland	124	109
PI 390252	Japan	105	151
PI 176517	Turkey	131	103
PI 182188	Turkey	119	115
PI 169395	Turkey	94	151
PI 351139	USSR	114	120
PI 174177	Turkey	121	112
PI 339241	Turkey	125	108
PI 181942	Syria	125	107
PI 269481	Pakistan	117	115
PI 105263	Turkey	107	125
PI 169401	Turkey	108	124
PI 357841	Yugoslavia	118	114
PI 451975	Canada	120	110
PI 137856	Iran	125	106
PI 487424	P.R. China	116	---
PI 175695	Turkey	121	109
PI 267943	Japan	117	114
PI 176521	Turkey	116	115
Calypso	Check[x]	110	122
PI 174167	Turkey	116	114
PI 181940	Syria	113	122
PI 248778	Iran	136	93
PI 285603	Poland	122	108
PI 183677	Turkey	106	124
PI 137846	Iran	119	111
PI 137857	Iran	113	116
Early Green Cluster	NSSL	114	115
PI 432865	P.R. China	130	91
PI 135345	Afghanistan	122	106
PI 264228	France	104	124
PI 422174	Czechoslovakia	77	170
PI 227209	Japan	103	131
PI 267741	Japan	108	124
PI 164816	India	108	120
PI 419079	P.R. China	110	118
PI 137848	Iran	107	121
PI 109482	Turkey	125	102
PI 092806	P.R. China	101	126

conducted using recommended horticultural practices (Hughes et al., 1983; Schultheis, 1990). Fertilizer was incorporated before planting at a rate of 90N–39P–74K kg·ha^{-1}, with an additional 34 kg·ha^{-1} N applied at the vine tip-over stage. Curbit® [(ethalfluralin *N*-ethyl-*N*-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine)] was applied for weed control. Irrigation was applied when needed for a total (irrigation plus rainfall) of 25 to 40 mm per week. 'Sumter' pollenizer was planted on the sides of the plots to provide pollen.

Plots were disease free through once-over harvest stage (26 June) when oversized fruit averaged 15% across all the plots in the field. Although the usual index for yield evaluation for testing populations in our breeding program is 10%, we used a 15% index in this study to allow late-flowering cultigens to produce fruit.

Cultural practices. In North Carolina, seeds were planted on raised, shaped beds 1.5 m apart. Plots were 1.2 m long × 1.5 m wide with 1.2-m alleys at each end. Guard rows were planted on the outside of the field, and at the end of each row. Plots were planted with 14 seeds on 12 May and thinned to a uniform stand of 10 plants per plot on 29 May.

In Iowa, seeds were planted in beds 1.5 m apart. Plots were 6.0 m long and 1.5 m wide with 1.5-m alleys at each end. Guard rows were planted on the outside of the field, and at the end of each row using 'Sumter' as a pollenizer. The plots were planted with 25 seeds on 12 May and thinned to a uniform stand of 20 plants per plot.

Cultigens evaluated. In this experiment, 761 cultigens (746 PI accessions and 15 check cultivars and breeding lines) were evaluated. Accessions designated with a PI number were obtained from the USDA germplasm collection in Ames, Iowa. Cultigens with an NSSL seed source were obtained from the National Seed Storage Laboratory in Fort Collins, Colo. The cultigens originated from 44 different countries. Countries with the most cultigens were Turkey (166), the People's Republic of China (P.R. China) (85), Iran (64), the former Yugoslavia (63), India (47), Japan (44), the former Soviet Union (USSR) (37), the former Czechoslovakia (27), The Netherlands (19), United States (16), and

Table 3. Continued.

Cultigen name	Seed source[z]	Fruit yield[y] North Carolina[z]	Fruit yield[y] Iowa[z]
PI 483344	Korea	35	192
PI 263046	USSR	105	122
Dasher II	Check[x]	118	109
PI 209064	U.S.–Ohio	104	123
PI 264667	Germany	141	85
PI 414157	U.S.–Ore.	96	125
PI 171602	Turkey	116	110
PI 288238	Egypt	114	113
PI 324239	Sweden	120	106
PI 344434	Iran	109	117
PI 458849	USSR	130	95
PI 285606	Poland	120	106
PI 169384	Turkey	113	---
PI 172845	Turkey	127	98
PI 436672	P.R. China	106	122
PI 212233	Japan	110	115
PI 181874	Syria	105	120
PI 356832	Netherlands	108	116
PI 176957	Turkey	109	115
PI 109481	Turkey	113	112
PI 172849	Turkey	108	116
PI 289698	Australia	114	111
PI 422171	Czechoslovakia	96	136
PI 169396	Turkey	100	124
PI 435946	USSR	112	113
PI 171604	Turkey	112	113
PI 167389	Turkey	110	114
PI 174174	Turkey	115	109
PI 263048	USSR	106	117
PI 255938	Netherlands	131	92
PI 209068	U.S.–Ohio	110	113
PI 379278	Yugoslavia	103	125
PI 264665	Germany	109	114
PI 267746	India	116	107
PI 172847	Turkey	117	106
Clinton	N.C. State Univ.	110	114
PI 392292	USSR	103	125
PI 176525	Turkey	137	86
PI 422172	Czechoslovakia	97	154
PI 255933	Netherlands	122	100
PI 172848	Turkey	116	105
PI 211977	Iran	110	112
PI 171612	Turkey	116	106
PI 211962	Iran	94	127
PI 344351	Turkey	106	115
Boston Pickling	NSSL	94	136
PI 419183	P.R. China	138	92
PI 263082	P.R. China	113	108
PI 390258	Japan	78	143
PI 308915	USSR	110	111
Robin	NSSL	46	142
PI 178886	Turkey	113	107

Table 3. Continued.

Cultigen name	Seed source[z]	Fruit yield[y] North Carolina[z]	Fruit yield[y] Iowa[z]
PI 279464	Japan	115	105
PI 224668	Korea	80	141
PI 432883	P.R. China	113	107
PI 172844	Turkey	108	112
PI 344353	Turkey	112	108
PI 390259	Japan	83	138
PI 343452	USSR	122	98
PI 169394	Turkey	114	106
PI 271331	India	103	116
PI 137853	Iran	120	99
PI 279463	Japan	107	113
PI 483342	Korea	105	116
PI 182190	Turkey	108	111
PI 436609	P.R. China	113	107
PI 418962	P.R. China	108	111
PI 391570	P.R. China	---	109
PI 339246	Turkey	126	92
PI 264664	Germany	95	124
PI 175689	Turkey	117	101
PI 344350	Turkey	100	118
PI 321006	Taiwan	113	104
PI 390269	Japan	97	121
PI 355053	Iran	101	117
PI 211978	Iran	132	85
Staygreen	NSSL	101	120
PI 419136	P.R. China	122	96
PI 368548	Yugoslavia	84	145
PI 419017	P.R. China	123	87
PI 182192	Turkey	110	107
PI 137835	Iran	117	100
PI 169388	Turkey	106	112
PI 369717	Poland	111	104
PI 173892	India	95	122
PI 357850	Yugoslavia	115	102
Giant White Arnstadt	NSSL	---	108
PI 106063	P.R. China	107	110
PI 390255	Japan	90	127
PI 257494	Iran	112	105
PI 283899	Czechoslovakia	104	112
PI 209065	U.S.–Ohio	107	108
PI 175680	Turkey	107	108
PI 263084	P.R. China	126	90
PR 39	NSSL	69	146
PI 257286	Spain	106	109
PI 432864	P.R. China	80	150
PI 357851	Yugoslavia	98	117
PI 211117	Israel	113	102
PI 211980	Iran	107	108
PI 209069	U.S.–Ohio	95	119
PI 357858	Yugoslavia	113	99
PI 288990	Hungary	90	124
PI 288996	Hungary	116	98

Table 3. Continued.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
PI 288995	Hungary	95	120
PI 376063	Israel	119	89
PI 171605	Turkey	77	137
PI 401734	Puerto Rico	123	91
PI 288993	Hungary	108	106
PI 172838	Turkey	122	92
PI 432853	P.R. China	108	105
PI 169319	Turkey	112	101
PI 169350	Turkey	110	103
PI 175679	Turkey	117	96
PI 172842	Turkey	105	108
PI 267747	U.S.–Okla.	118	95
PI 167197	Turkey	134	79
PI 419214	Hong Kong	121	91
PI 183224	Egypt	125	88
PI 212985	India	107	105
PI 246930	Afghanistan	110	103
PI 435947	USSR	89	132
PI 267743	P.R. China	98	115
PI 167050	Turkey	99	111
PI 164670	India	83	129
PR 27	NSSL	92	120
PI 264226	France	86	126
PI 422198	Czechoslovakia	78	134
PI 321007	Taiwan	103	109
PI 281448	Korea	99	113
PI 489754	P.R. China	124	78
PI 357842	Yugoslavia	100	111
PI 165046	Turkey	114	100
Chicago Pickling	NSSL	118	82
PI 338235	Turkey	98	113
PI 390267	Japan	114	93
Nappa 63	NSSL	92	119
PI 357852	Yugoslavia	101	110
PI 211983	Iran	101	110
PI 267745	Brazil	88	122
PI 275412	Netherlands	111	100
PI 344435	Iran	113	93
PI 368550	Yugoslavia	78	133
PI 211985	Iran	115	95
PI 169386	Turkey	110	101
PI 206043	Puerto Rico	97	113
PI 357838	Yugoslavia	73	137
PI 164952	Turkey	122	88
PI 251520	Iran	100	110
PI 292010	Israel	103	107
PI 432877	P.R. China	93	129
PI 206954	Turkey	105	---
PI 306179	Poland	98	112
Earliest of All	NSSL	93	116
PI 418964	P.R. China	108	100
PI 422170	Czechoslovakia	92	117
PI 257486	P.R. China	103	106
PI 169377	Turkey	80	129
PI 179260	Turkey	110	99
PI 262990	Netherlands	110	99
PI 372898	Netherlands	83	147
PI 267197	P.R. China	115	94
PI 432870	P.R. China	134	74
PI 344067	Turkey	126	82
PI 419009	P.R. China	104	105
PI 171609	Turkey	89	119
PI 249550	Iran	99	109
Favor II	NSSL	98	110
PI 177363	Syria	112	96
PI 226509	Iran	105	103
PI 432878	P.R. China	---	104
PI 169383	Turkey	120	87
PI 169382	Turkey	102	105
PI 169389	Turkey	112	95
PI 197086	India	99	108
PI 229309	Iran	108	99
PI 171606	Turkey	109	98
PI 176522	Turkey	100	105
PI 339245	Turkey	104	102

Table 3. Continued.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
PI 321010	Taiwan	87	119
PI 227208	Japan	104	102
PI 357839	Yugoslavia	118	88
PI 172851	Turkey	96	110
PI 269480	Pakistan	115	92
PI 343451	USSR	112	94
Arlington Wt. Spine	NSSL	117	89
PI 174164	Turkey	109	99
PI 274902	Great Britain	115	91
Sprint 440	Check[x]	103	102
PI 137847	Iran	103	102
PI 264229	France	99	106
PI 432861	P.R. China	111	97
PI 173674	Turkey	117	88
PI 217644	India	109	96
PI 293923	U.S.–S.C.	129	76
PI 164734	India	101	103
PI 169353	Turkey	110	94
PI 176519	Turkey	102	---
PI 344444	Iran	118	86
PI 176952	Turkey	118	86
PI 344439	Iran	98	107
PI 204569	Turkey	122	83
PI 176516	Turkey	111	93
PI 183445	India	90	114
PI 171600	Turkey	111	93
PI 390256	Japan	116	81
PI 167198	Turkey	107	97
PI 432866	P.R. China	103	100
PI 169315	Turkey	103	100
PI 171611	Turkey	106	98
PI 293432	Lebanon	102	---
PI 326595	Hungary	110	93
PI 285608	Poland	111	92
PI 172840	Turkey	86	117
PI 422190	Czechoslovakia	87	117
PI 228344	Iran	90	113
National Pickling	NSSL	112	87
PI 489752	P.R. China	102	101
PI 182189	Turkey	108	95
PI 432886	P.R. China	91	108
PI 458847	USSR	101	---
PI 357859	Yugoslavia	102	101
PI 220790	Afghanistan	117	85
M 21	Check[x]	108	94
PI 304803	U.S.–N.Y.	89	113
PI 419041	P.R. China	---	101
PI 192940	P.R. China	91	111
PI 211943	Iran	103	97
PI 482464	Zimbabwe	107	92
Model	NSSL	105	95
PI 422188	Czechoslovakia	97	106
PI 179263	Turkey	111	90
PI 211975	Iran	87	114
PI 233932	Canada	101	99
PI 137845	Iran	106	94
PI 169402	Turkey	112	88
PI 339244	Turkey	74	126
PI 163221	India	88	113
PI 176953	Turkey	75	125
PI 368556	Yugoslavia	92	112
PI 344348	Turkey	103	97
PI 326598	Hungary	90	109
Gy 5	Check[x]	92	108
PI 356833	Great Britain	122	78
Palmetto	NSSL	117	83
Straight 8	NSSL	89	110
PI 227210	Japan	100	---
PI 391573	P.R. China	100	99
PI 227013	Iran	86	113
PI 222782	Iran	111	87
PI 167079	Turkey	108	90
PI 261609	Spain	98	100
PI 263079	USSR	96	102
PI 267086	USSR	67	131

Afghanistan (14). The cultigens designated as checks were tested as the cultigens *per se* (not their F_1 with Gy 14).

The 761 cultigens consisted of PI accessions, obsolete cultivars, current cultivars, and experimental inbreds and hybrids. In order to produce gynoecious hybrids, the cultigens were crossed with Gy 14, a popular, publicly-released, gynoecious pickling cucumber inbred. All crosses were made by hand at the Horticultural Science greenhouses, Raleigh, during the previous year. The hybrids could then be evaluated for yield regardless of sex expression of the male parent. In order to represent each cultigen properly, each hybrid was made up from a mixture of seeds obtained by crossing several plants of each accession with Gy 14.

Traits measured. Data were collected as plot means, and consisted of number of plants per plot, and number of early, total, and cull fruit per plot in both locations. Early fruit were the number of oversized fruit at harvest (>51 mm diameter for pickles and >60 mm for slicing cucumber). The number of marketable fruit was calculated as total fruit minus culls. Cull fruits were misshapen (crooked or nubbined). Data for marketable fruits were not recorded in Iowa.

Data analysis. The experiment was a randomized complete-block design with 761 cultigens and three replications at two locations. Data were analyzed using GLM and CORR procedures of SAS (SAS Institute, Cary, N.C.). Yield traits were expressed as thousands of fruit/ha for ease of comparison of yield over locations, and with previously published studies.

The data were analyzed using actual yield and corrected yield for both locations. Plots with a stand count (plant number) of <50% of the expected 20 plants were eliminated from the statistical analysis. Plots with stand counts ranging from 50% to 75% were corrected according to Cramer and Wehner (1998), using the formula: corrected yield = (total yield/stand count) × 20. The corrected yield and total yield were then standardized to a mean of 100 and a SD of 30 (a SD of 30 would give a range of 0 to 200 if individuals were within three SD of the mean) for each location and replication using the STANDARD procedure of SAS. Standardization permitted comparison of cultigens when some plots were missing from locations or replications. The most useful traits are those where the range/LSD is large. If the range/LSD is small (<1), then the best cultigen cannot be statistically separated from the worst cultigen in the test.

Table 3. Continued.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
PI 211979	Iran	87	111
PI 163214	India	94	103
PI 169352	Turkey	95	102
PI 169400	Turkey	89	108
PI 222987	Iran	94	103
PI 357847	Yugoslavia	94	103
PI 177360	Turkey	101	96
PI 390241	Japan	76	121
PI 169351	Turkey	93	104
PI 288994	Hungary	89	107
PI 458848	USSR	82	145
PI 379285	Yugoslavia	101	93
PI 222986	Iran	96	100
PI 220791	Afghanistan	87	114
PI 401733	Puerto Rico	76	105
PI 306785	Canada	112	83
PI 436610	P.R. China	116	88
PI 292012	Israel	92	106
PI 414158	U.S.–Hawaii	100	93
PI 458846	USSR	101	91
PI 172839	Turkey	95	99
PI 355055	Iran	99	95
PI 304805	U.S.–N.Y.	66	128
PI 368558	Yugoslavia	128	66
PI 339248	Turkey	103	91
PI 275411	Netherlands	120	73
PI 255936	Netherlands	100	94
PI 251519	Iran	90	103
PI 292011	Israel	97	96
PI 220171	Afghanistan	103	87
PI 167358	Turkey	110	83
PI 357863	Yugoslavia	103	87
PI 344441	Iran	106	87
PI 174173	Turkey	109	84
PI 277741	Netherlands	108	85
Gy 2	Check[x]	94	98
PI 390952	USSR	104	88
PI 176956	Turkey	94	98
PI 432860	P.R. China	99	92
PI 422186	Czechoslovakia	105	87
PI 222783	Iran	94	98
PI 137839	Iran	85	106
PI 263081	P.R. China	94	97
PI 135123	New Zealand	85	106
PI 200818	Burma	87	105
PI 344347	Turkey	110	81
PI 176524	Turkey	89	101
PI 414159	U.S.–Hawaii	79	111
PI 178884	Turkey	114	75
PI 165506	India	80	110
PI 174160	Turkey	96	94

Table 3. Continued.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
PI 432862	P.R. China	92	99
PI 419135	P.R. China	110	72
PI 267744	P.R. China	91	98
PI 432857	P.R. China	86	103
PI 206955	Turkey	110	79
PI 296387	Iran	67	122
PI 267088	USSR	94	94
PI 223437	Afghanistan	89	99
PI 436673	P.R. China	110	79
Early Fortune	NSSL	97	91
PI 326596	Hungary	96	92
PI 357844	Yugoslavia	105	83
PI 212599	Afghanistan	107	74
PI 390248	Japan	97	87
PI 373918	England	89	100
PI 357846	Yugoslavia	---	94
PI 169387	Turkey	98	89
PI 390239	Japan	75	121
PI 167043	India	101	86
PI 432858	P.R. China	97	90
PI 264666	Germany	94	92
PI 169390	Turkey	83	103
PI 167052	Turkey	89	97
PI 264231	France	99	87
PI 164173	India	88	98
PI 344433	Iran	91	95
PI 390251	Japan	41	118
PI 357865	Yugoslavia	107	78
PI 422182	Czechoslovakia	101	84
PI 368551	Yugoslavia	96	87
PI 338234	Turkey	102	83
PI 211984	Iran	85	99
PI 344432	Iran	88	97
PI 211589	Afghanistan	104	81
PI 370448	Yugoslavia	97	84
York State Pickle	NSSL	94	86
PI 175691	Turkey	104	84
PI 390250	Japan	82	108
PI 227235	Iran	85	99
PI 217946	Pakistan	91	93
PI 255935	Netherlands	113	71
PI 344443	Iran	109	74
PI 321011	Taiwan	96	87
PI 267935	Japan	100	84
PI 319216	Un. Arab. Repub.	101	82
PI 321009	Taiwan	94	88
PI 422181	Czechoslovakia	70	123
PI 165029	Turkey	93	90
PI 164284	India	84	98
PI 135122	New Zealand	81	101
PI 283902	Czechoslovakia	101	81

Table 3. Continued.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
PI 222099	Afghanistan	94	88
PI 204692	Turkey	104	78
PI 179259	Turkey	115	67
PI 283901	Czechoslovakia	74	108
PI 279467	Japan	70	112
PI 164743	India	90	92
PI 169381	Turkey	78	104
PI 257487	P.R. China	84	100
PI 163217	India	97	84
PI 357868	Yugoslavia	78	102
PI 222985	Iran	84	94
PI 357867	Yugoslavia	82	98
PI 176954	Turkey	67	113
PI 220789	Afghanistan	97	83
PI 175681	Turkey	80	100
PI 432867	P.R. China	92	87
PI 285604	Poland	102	77
PI 390265	Japan	76	103
PI 357857	Yugoslavia	104	79
PI 458850	USSR	108	80
PI 176924	Turkey	93	86
PI 390261	Japan	45	133
PI 339243	Turkey	68	110
PI 390240	Japan	48	151
PI 204690	Turkey	101	77
PI 255937	Netherlands	75	99
PI 163213	India	89	89
PI 390262	Japan	101	70
PI 390264	Japan	65	112
PI 306180	Poland	67	110
PI 109275	Turkey	84	95
PI 368549	Yugoslavia	---	89
PI 171608	Turkey	97	80
PI 209067	U.S.–Ohio	88	---
PI 357845	Yugoslavia	91	85
PI 458856	USSR	92	83
PI 271334	India	96	76
PI 197085	India	72	104
PI 422169	Czechoslovakia	63	113
PI 357836	Yugoslavia	90	87
PI 422200	Czechoslovakia	68	101
PI 209066	U.S.–Ohio	49	125
PI 176523	Turkey	90	84
PI 288991	Hungary	85	89
PI 109483	Turkey	73	101
PI 357834	Yugoslavia	80	94
PI 288332	India	78	95
PI 432879	P.R. China	64	110
PI 177361	Turkey	112	70
PI 264227	France	94	79
PI 249562	Thailand	51	123
PI 250147	Pakistan	96	77
PI 218199	Lebanon	90	83
PI 321008	Taiwan	97	79
PI 391569	P.R. China	95	81
PI 173893	India	73	95
PI 178887	Turkey	89	82
PI 296120	Egypt	97	75
PI 357840	Yugoslavia	62	101
PI 220169	Afghanistan	80	92
PI 338236	Turkey	71	100
PI 261608	Spain	84	87
PI 197087	India	72	99
PI 218036	Iran	100	63
PI 390246	Japan	54	132
PI 181752	Syria	108	62
PI 314425	USSR	89	78
PI 211986	Iran	84	85
SMR 58	Check[x]	80	89
PI 223841	Philippines	91	77
PI 478366	P.R. China	92	72
Gy 14	Check[x]	86	81
PI 357833	Yugoslavia	62	106
Sumter	Check[x]	67	100

Table 3. Continued.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
Everbearing	NSSL	70	97
PI 357837	Yugoslavia	89	78
PI 285610	Poland	86	81
PI 368557	Yugoslavia	83	---
PI 419078	P.R. China	72	101
PI 137851	Iran	83	---
PI 357849	Yugoslavia	72	95
PI 458853	USSR	41	125
PI 432863	P.R. China	80	87
PI 211967	Iran	79	87
PI 269482	Pakistan	85	80
PI 432890	P.R. China	91	66
PI 432851	P.R. China	60	116
PI 432893	P.R. China	86	79
PI 436608	P.R. China	86	77
PI 358814	Malaysia	74	104
Muronium	NSSL	78	86
PI 368560	Yugoslavia	68	108
PI 175950	Turkey	70	93
PI 202801	Syria	81	81
PI 267742	P.R. China	70	92
PI 175692	Turkey	112	50
Delicatesse	NSSL	67	95
PI 390954	USSR	79	83
PI 207476	Afghanistan	90	70
PI 176526	Turkey	91	73
PI 357832	Yugoslavia	110	51
Davis Perfect	NSSL	---	80
PI 372587	Netherlands	88	67
PI 432888	P.R. China	54	97
PI 212059	Greece	52	107
PI 432859	P.R. China	98	53
PI 481616	Bhutan	---	79
PI 263078	USSR	58	100
Addis	Check[x]	50	108
PI 169334	Turkey	84	73
PI 206953	Turkey	88	69
PI 422196	Czechoslovakia	76	81
White Wonder	NSSL	56	100
PI 390245	Japan	47	109
PI 279466	Japan	84	72
Delcrow	NSSL	73	84
MR 200	NSSL	86	65
PI 357831	Yugoslavia	62	92
PI 344438	Iran	70	83
Shogoin	NSSL	79	72
PI 432895	P.R. China	102	59
PI 197088	India	69	83
Redlands	Australia	47	106
PI 390257	Japan	72	82
PI 390266	Japan	40	99
PI 163223	India	70	81
PI 390260	Japan	56	93
PI 344440	Iran	62	93
PI 481614	Bhutan	.	74
PI 255934	Netherlands	77	72
PI 357860	Yugoslavia	73	74
PI 344352	Turkey	66	80
PI 390244	Japan	56	98
PI 357830	Yugoslavia	49	97
PI 222720	Iran	63	81
PI 357864	Yugoslavia	3	95
Wautoma	Check[x]	42	97
PI 296121	Egypt	52	92
PI 357854	Yugoslavia	64	80
PI 263049	USSR	56	87
PI 418989	P.R. China	19	97
PI 368552	Yugoslavia	22	119
PI 368555	Yugoslavia	32	129
WS Davis Perfect	NSSL	72	65
PI 432855	P.R. China	90	49
PI 211728	Afghanistan	75	65
PI 214049	India	65	74
PI 432885	P.R. China	51	87

Retest. Eight high-yielding and four low-yielding cultigens were retested along with four checks at the Horticultural Crops Experiment Station, Clinton, in 1989. In the retest, the cultigens *per se* were tested rather than their hybrids with Gy 14. Seeds were planted on raised, shaped beds 1.5 m apart. Plots were 1.2 m long × 1.5 m wide with 1.2-m alleys at each end. The guard rows were planted on the outside of the field, and at the end of each row using 'Sumter' as a monoecious pollinizer.

The experiment was a randomized complete-block design with 16 cultigens and eight replications. Plots were harvested six times (twice each week for 3 weeks) during Spring 1989, number and weight of marketable and cull fruit were recorded. Plant stand and flower count data were taken 3 and 5 weeks after planting. Number of pistillate and staminate nodes at the first five nodes of five plants were counted on each plot. Data were analyzed using the GLM procedure of SAS.

Results and Discussion

The cultigens produced hybrids differing significantly for all the traits evaluated (Table 1). We detected significant differences between the two locations for total yield, corrected total yield, and percentage of early fruit. Cultigen × location interaction was significant ($P < 0.01$) for all the traits that were evaluated at both locations. The location effect was removed by standardizing the data to form standardized total and standardized corrected total yield.

The traits that were most reliable over both locations were total yield, corrected total yield, standardized total yield, and standardized corrected total yield. Correction for plant stand improved the data by reducing the CV relative to that for corrected total yield. Therefore, data are presented as the standardized corrected total yield for all cultigens over both locations. In the analysis of variance, mean squares for location and cultigen by location interaction were highly significant, so standardized corrected total yields for cultigens were reported for each location, rather than the mean standardized corrected total yields over both locations. This was consistent with the findings of Wehner (1987b) who reported that genotype and environment were important sources of variation for yield in once-over harvest trials.

The cultigen mean square was significant for all traits evaluated, indicating that some cultigens yielded significantly more than others. The corrected yield had a better (smaller) CV, and a better (larger) range/LSD than did total yield. Therefore, we decided to choose corrected total yield over total yield (Table 1). An additional benefit was that corrected total yield took into consideration the differences in plant stand. We decided to present yield as standardized corrected total because it had a better (lower) CV, better (lower) LSD, and a better (higher) range/LSD than did corrected total yield. The other advantage of using standardized corrected total yield was that it permitted comparison of cultigens even when some were missing from some replications.

We observed highly significant differences for location and location by cultigen interaction for percentage of early fruit (Table 1). The percentage of early fruit for Iowa had a mean of 100, a range of 30, and a range/LSD of 3. The percentage of early fruit for North Carolina had a mean of 15, a range of 63, and range/LSD of 3. Marketable yield was recorded only in North Carolina.

In general, correlations between locations for the yield traits were low (Table 2); *r* values for total yield, standardized total yield, corrected total yield, and standardized corrected total yield were 0.33, 0.34, 0.21, and 0.23, respectively. Although the correlations for standardized corrected total yield were slightly lower than those for total and standardized total yield, standardized corrected yield was more useful because it was corrected for both plant stand and location.

Standardized corrected total yield, which was the only trait reported for the 761 gynoecious hybrids, differed significantly in North Carolina and Iowa (Table 3). Several PI accessions produced high-yielding hybrids with Gy 14. There were 284 cultigens whose hybrids yielded more than the standard check 'Calypso'. Thus, yield might be improved by using the high performing cultigens identified in this study. The highest yielding hybrids at both locations were produced using the following paternal parents: PI 422185, PI 390253, PI 175120, PI 173889, PI 267087, PI 175686, PI 178888, PI 385967, PI 458851, and PI 171601. The highest yielding hybrids at North Carolina were produced using the following paternal parents: PI 175120, PI 390253, PI 344442, 'Shamrock', PI 422185, PI 177364, PI 175686, PI 178888, PI 226461, and PI 173889. The highest yielding hybrids at Iowa were produced using the following paternal parents: PI 179678, PI 267087, PI 483344, PI 391568, PI 171610, PI 432873, PI 422174, PI 179676, PI 360939, and PI 357855.

A majority of the cultigens that were classified as high or low yielders in the germ-

Table 3. Continued.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
PI 422180	Czechoslovakia	20	117
PI 206952	Turkey	103	33
Pacer	Harris-Moran	19	117
PI 372893	Netherlands	66	70
PI 379280	Yugoslavia	72	64
PI 205181	Turkey	50	84
PI 344437	Iran	86	54
PI 432896	P.R. China	58	82
PI 271327	India	40	93
PI 357843	Yugoslavia	59	72
PI 481617	Bhutan	–1	99
PI 279469	Japan	44	86
PI 212896	India	8	122
PI 422192	Czechoslovakia	64	66
PI 379287	Yugoslavia	51	78
PI 265887	Netherlands	62	67
PI 489753	P.R. China	68	59
PI 390268	Japan	55	70
PI 357869	Yugoslavia	60	65
PI 432871	P.R. China	49	88
PI 368553	Yugoslavia	34	89
PI 357848	Yugoslavia	51	72
PI 175111	India	43	83
PI 357835	Yugoslavia	51	65
PI 175688	Turkey	33	92
PI 370449	Yugoslavia	49	68
PI 379281	Yugoslavia	53	61
PI 390951	USSR	25	99
PI 357856	Yugoslavia	28	94

Table 3. Continued.

		Fruit yield[y]	
Cultigen name	Seed source[z]	North Carolina[z]	Iowa[z]
PI 183127	India	17	92
PI 458855	USSR	57	46
PI 370450	Yugoslavia	33	80
Magnolia	NSSL	51	---
PI 379283	Yugoslavia	50	---
M 27	Check[x]	68	17
PI 370447	Yugoslavia	30	53
PI 183056	India	3	104
PI 379284	Yugoslavia	34	55
PI 379282	Yugoslavia	42	42
PI 432874	P.R. China	34	49
Stono	NSSL	---	38
WI 2757	Check[x]	14	67
Marketmore 76	Check[x]	18	49
Cubit	NSSL	11	45
PI 368554	Yugoslavia	18	36
PI 357853	Yugoslavia	9	56
PI 368559	Yugoslavia	12	57
Mean		100	100
LSD (5%)		47	27
CV		29	17
Range		183	172
Range/LSD		4	6

[z]Some countries listed as the origin of some accessions (e.g., Czechoslovakia, USSR, Yugoslavia) now no longer exist as political units.
[y]Data are means of three replications.
[x]For the checks, yield was measured *per se*, rather than as combining ability with Gy 14.

Table 4. Fruit yield traits[z] for the 17 cultigens retested at Clinton, N.C. (cultigens ranked by total fruit number).

Cultigen	Seed source	Yield class	Total fruit/ha No. (1000s)	Total fruit/ha Wt (Mg)	Fruit Marketable (%)	Fruit Cull (%)	Nodes[y] Pistillate (%)	Nodes[y] Staminate (%)
PI 169397	Turkey	High	915	67	84	16	6	89
Producer	NSSL	High	662	58	91	9	29	66
Regal	Harris Moran	Check	646	74	91	9	73	21
Poinsett 76	Petoseed	Check	615	66	87	13	37	49
PI 342950	Denmark	High	600	40	90	10	9	86
PI 175696	Turkey	High	586	74	83	17	7	90
Wautoma	USDA–Wisc.	Low	512	45	95	5	1	92
PI 174172	Turkey	High	508	51	86	14	5	87
Wis. SMR 18	Northrup King	Check	484	54	87	13	8	85
PI 178888	Turkey	High	458	49	80	20	7	87
PI 206425	Turkey	High	430	33	94	6	0	90
Pacer	Harris Moran	Low	382	30	91	9	10	77
Marketmore 76	Asgrow Seed	Check	355	21	89	11	1	89
PI 339250	Turkey	High	348	60	81	19	12	84
PI 357853	Yugoslavia	Low	274	25	91	9	0	90
Mean			518	50	88	12	14	79
CV (%)			47	90	7	49	55	1
LSD (5%)			244	17	6	6	8	10
Range			641	53	15	15	73	71
Range/LSD			3	3	3	3	9	7

[z]Data are means of eight replications.
[y]Nodes not pistillate or staminate were barren.

plasm screening study ranked as predicted in the retest (Table 4), despite the fact that the retest was conducted using the cultigens *per se* and not combining ability with Gy 14. Two exceptions were 'Wautoma' and PI 339250, which were low or high yielding when crossed with Gy 14 in the germplasm screening, but were ranked at the middle and bottom in the retest study, respectively. Thus, yield of a cultigen tested as a gynoecious hybrid (in the germplasm screening), is similar to yield of the cultigen *per se* with few exceptions

Once-over harvest yield might be improved using the highest yielding cultigens crossed to inbreds such as Gy 14. The top yielding cultigens could also be intercrossed to form a population from which to develop high yielding inbreds. A useful future study would be to screen the germplasm collection using ethrel to convert all cultigens to a gynoecious form for yield testing.

Literature Cited

Cargill, B.F., D.E. Marshall, and J.H. Levin. 1975. Harvesting cucumbers mechanically. Mich. State Univ. Ext. Bul. 859.

Chen, L.H., C.H. Miller, and R.S. Sowell. 1975. Simulation models for harvesting of pickling cucumbers. J. Amer. Soc. Hort. Sci. 100:176–179.

Colwell, H.T.M. and J. O'Sullivan. 1981. Economics of harvest timing for once over harvesting of cucumbers. J. Amer. Soc. Hort. Sci. 106:163–167.

Cramer, C.S. and T.C. Wehner. 1998. Stand correction methods for cucumber fruit yield. Cucurbit Genet. Coop. Rpt. 21:18–20.

Ells, J.E. and A.E. McSay. 1981. Yield comparisons of pickling cucumber cultivar trials for once-over harvesting. HortScience 16:187–189.

Harlan, J.R. 1975. Crops and man. Amer. Soc. Agron., Madison, Wis.

Hughes, G.R., C.W. Averre, and K.A. Sorensen. 1983. Growing pickling cucumbers in North Carolina. N.C. Agr. Ext. Serv. Bul. No. AG-315.

Miller, C.H. and G.R. Hughes. 1969. Harvest indices for pickling cucumbers in once-over harvest systems. J. Amer. Soc. Hort. Sci. 94:485–487.

Nerson, H., H.S. Paris, Z. Karchi, A. Govers, M. Edelstein, and Y. Burger. 1987. Comparison of fruit-set concentration of pickling cucumbers under greenhouse and field conditions. Cucurbit Genet. Coop. Rpt. 10:2–3.

Peterson, C.E. 1975. Plant introductions in the improvement of vegetable cultivars. HortScience 10:575–579.

Schultheis, J.R. 1990. Pickling cucumbers. North Carolina State Agr. Ext. Hort. Inform. Leaflet No. 14–A.

Smith, O.S. and R.L. Lower. 1978. Field plot techniques for selecting increased once-over harvest yields in pickling cucumbers. J. Amer. Soc. Hort. Sci. 103:92–94.

Swallow, W.H. and T.C. Wehner. 1986. Optimum plot size for measurement of yield in multiple and once over harvest trials of pickling and fresh market cucumbers. Euphytica 35:493–501.

Swallow, W.H. and T.C. Wehner. 1989. Optimum allocation of plots to years, seasons, locations, and replications, and its applications to once-over harvest cucumber trials. Euphytica 43:59–68.

Wehner, T.C. 1989. Breeding for improved yield in cucumber. Plant Breed. Rev. (ed.) J. Janick. Vol. 6:323–359.

Wehner, T.C. 1987a. Value of 12 season-location combinations for cucumber yield trials in North Carolina. Cucurbit Genet. Coop. Rpt. 6:38–39.

Wehner, T.C. 1987b. Genotype–environment interaction for cucumber yield in 23 North Carolina environments. Cucurbit Genet. Coop. Rpt. 10:25–26.

Wehner, T.C. 1986. Efficiency of three single-harvest tests for evaluation of yield in pickling cucumber. Euphytica 35:493–501.

Wehner, T.C. and C.H. Miller. 1987. Optimum plant density for multiple-harvest yield of determinate cucumbers. Cucurbit Genet. Coop. Rpt. 10:29–30.

Wehner, T.C. and C.H. Miller. 1984. Efficiency of single-harvest methods for measurement of yield in fresh-market cucumbers. J. Amer. Soc. Hort. Sci. 109:659–664.

Wehner, T.C., T.J. Monaco, and A.R. Bonanno. 1984. Chemical defoliation of cucumber vines for simulation of once-over harvest in small-plot yield trials. HortScience 19:671–673.