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Two Special Cucumber Populations: NCH1 and NCBA1

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Two special cucumber populations, NCH1 and NCBA1, were developed at North Carolina State Univ. over the last 15 years for use as a starting point to develop inbreds and hybrids. NCH1 has a multi-branched pickling-type (*Cucumis sativus* var. *hardwickii* line LJ 90430) background, and NCBA1 has a middle-eastern slicer ('Beit Alpha' type) background. Selection methods were developed that optimized gain for yield and other traits (Wehner, 1989). Selection in the two populations was for total, marketable, and early yield, as well as fruit shape in the spring season, and for resistance to foliar fungal diseases in the summer season. Diseases were mainly anthracnose [*Colletotrichum orbiculare* (Berk. and Curt.) Arx] and gummy stem blight [*Didymella bryoniae* (Auersw.) Rehm].

There was also unintentional selection for general adaptation. For example, to be successful, each of the cucumber families had to produce sufficient seeds to plant the test and intercross plots, seeds had to germinate and emerge rapidly, vines had to grow rapidly, and plants had to produce fruits of the same type and at the same time as the control cultivar. Many cultivars in performance trials have performed poorly because of deficiencies in those areas.

Modified half-sib recurrent selection was effective in improving the NCH1 and NCBA1 populations for important horticultural traits, as shown by continuous improvement over cycles 0 through 9 in multiple environments (Wehner and Cramer, 1996a, 1996b). There has been much interest in using the populations in commercial breeding programs, so the most advanced cycle of each population is being released.

Origin

The North Carolina hardwickii 1 (NCH1) population was developed by crossing LJ 90430 (a *Cucumis sativus* var. *hardwickii* accession) with 12 cultigens representing elite cultivars and breeding lines of American pickling (gynoecious or monoecious, tall or compact or determinate), European greenhouse, and German schalgurken type (Fig. 1). The European greenhouse cultivars with very long fruits, and the German schalgurken, with very large-diameter fruits, were used to counter the very short, small-diameter fruits of LJ 90430. The cultigens used were intercrossed four times from 1976 to 1982 to form the cycle 0 population, which was tested and selected beginning in 1983. The cycle 0 population contained 8% Gy 14 (an elite, gynoecious pickling inbred) and 35% LJ 90430 (*C. sativus* var. *hardwickii*). Thus, the population was developed from cultigens representing the major types of cucumber (Wehner and Horton, 1986). During population improvement, selection was for the traits summarized in the simple weighted index, as well as for American pickling-type fruits. However, there was no selection for characteristics of the hardwickii plant type, such as small leaves or multiple branching.

The North Carolina Beit Alpha 1 (NCBA1) population was developed by crossing nine cultigens twice by hand in the greenhouse, and twice using bees in field isolation blocks. The cultigens were chosen for having high yield, high fruit quality, and multiple disease resistance in a short-fruited, uniform green, wartless type typical of middle-eastern cultivars such as 'Beit Alpha'. All cultigens used were from the U.S. Dept. of Agriculture program at the Univ. of Wisconsin, Madison, and had been developed by crossing pickling cucumber lines of high yield and quality with plant introduction accessions having resistance to important diseases. The exception was 'Marketmore 70' (Cornell Univ.), which was chosen for quality and disease resistance, even though it is an American slicer. The first generation of hand pollination was performed as follows: WI 2731 x WI 2372 F_5, WI 3696E x WI 1909 F_1, WI 2921 x WI 3634B F_1, (CCR9M x 1321 F_2) x 'Marketmore 70'. The second generation of hand pollinations involved all possible crosses of the progeny from those crosses. During population improvement, selection was for the traits summarized in the simple weighted index, as well as for middle-eastern type fruits.

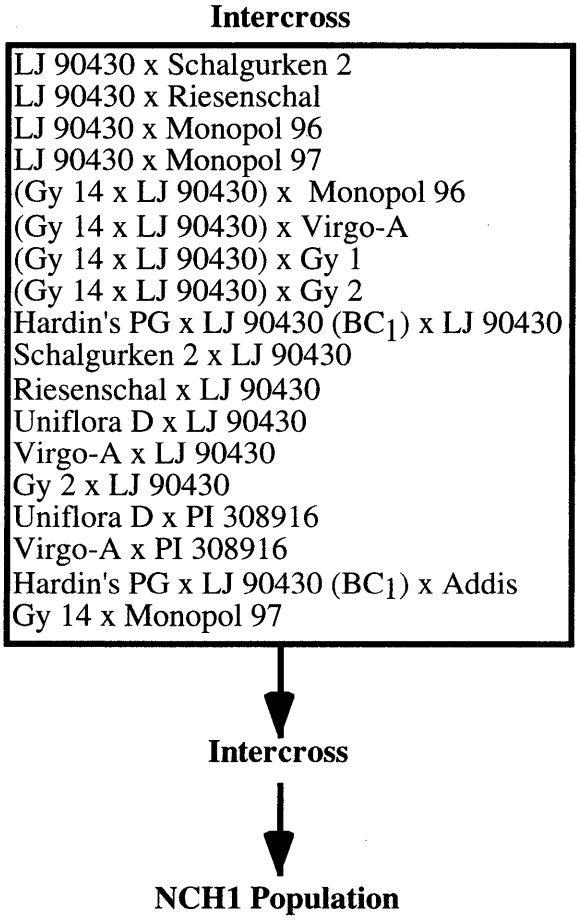

Fig. 1. Pedigree for the development of the NCH1 pickling cucumber population.

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Table 1. Yield, earliness, quality, and disease resistance of two cucumber populations in spring and summer production seasons compared with those of two standard cultivars. Data are summarized over 4 years (1992 through 1995), three replications, and six harvests for two seasons (spring, summer) at the Horticultural Crops Research Station near Clinton, N.C.

	Yield			Quality ratings				
Population	Total[z] ($Mg \cdot ha^{-1}$)	Early[y] (%)	Cull (%)	Fruit shape[x]	Fruit color[w]	Seedcell size[v]	Firmness (N)[u]	Anthracnose (0–9 rating)[t]
				Pickling cucumber				
Spring trials								
NCH1	26.2	26	12	6	6	6	76	---
Calypso	28.8	32	10	7	6	6	80	---
Sumter	19.7	16	9	7	5	7	84	---
Summer trials								
NCH1	17.7	45	14	5	7	6	73	6
Calypso	19.9	51	15	6	5	6	72	6
Sumter	10.5	23	14	6	5	7	78	6
$LSD_{0.05}$	5.1	8	4	1	1	2	8	1
				Slicing cucumber				
Spring trials								
NCBA1	31.4	20	21	6	5	5	67	---
Dasher II	31.7	19	12	7	7	6	76	---
Poinsett 76	25.0	6	9	7	7	6	62	---
Summer trials								
NCBA1	20.4	20	35	7	6	6	---	4
Dasher II	19.6	22	18	7	7	7	---	5
Poinsett 76	18.6	10	22	6	7	6	---	4
$LSD_{0.05}$	2.2	5	3	1	1	2	9	1

[z]Mass of all grades including oversized and cull fruits.
[y]Percentage of the six-harvest yield that occurred in the first two harvests.
[x]Rated 1 to 9 (1–3 = pointed, crooked, constricted; 4–6 = tapered, curved, necked; 7–9 = blocky, straight, cylindrical).
[w]Rated 1 to 9 (1–3 = light green, 4–6 = medium green, 7–9 = dark green).
[v]Rated 1 to 9 (1–3 = large, 4–6 = medium, 7–9 = small).
[u]Force (N) required to drive an 8-mm-diameter tip on a punch tester into the exocarp (skin) and mesocarp (flesh) of the fruit until failure.
[t]Measured in summer only, 1 week after the final harvest, and rated 0 to 9 (0 = none, 1–2 = trace, 3–4 = slight, 5–6 = moderate, 7–8 = severe, 9 = dead).

Populations were improved by testing in the spring season, followed by intercrossing the best families in isolation blocks in the summer season for 10 cycles. Once-over harvest was simulated by spraying the foliage with paraquat (1,1′-dimethyl-4,4′-bipyridinium ion) at 0.6 $kg \cdot ha^{-1}$ when the controls had ≈10% oversized (>51 mm diameter) fruits by number (Wehner et al., 1984). Half-sib families were evaluated for the following five traits: total yield (number of fruits per plot), early yield (number of oversized fruits per plot), marketable yield (total yield minus crooked and nubbin fruits), fruit shape rating (1 = poor to 9 = excellent), and a simple weighted index (SWI) (Wehner, 1982). The index was calculated as: SWI = 0.2(total yield)/2 + 0.3(early yield) + 0.2(% marketable yield)/10 + 0.3(fruit shape). Total yield was divided by 2 and percent marketable yield was divided by 10 to give them the same range (1 to 9) used for the other traits. Each trait was then given a weight (20% or 30%) to reflect its importance in the breeding program. SWI was weighted (70%) toward yield traits, but with significant emphasis on quality, because shape rating (30%) is based on fruit appearance, and marketable yield (20%) accounts for crooked and nubbin fruits.

Performance of random samples bulked from half-sib families of each population was evaluated in performance trials for yield, earliness, fruit quality, and disease resistance using optimized trialing methods (Wehner, 1987). Populations were represented by a bulk from the most advanced cycle available (cycles 9, 10, 10, or 11 for NCH1, and cycles 7, 8, 8, or 9 for NCBA1) for the four trial years, respectively. Recommended cultural practices (summarized by Schultheis, 1990) were used throughout the experiments. A monoecious inbred ('Sumter' for NCH1, 'Coolgreen' for NCBA1) was planted in field border rows and end tiers as a pollinizer, and to provide border competition for the trial. Irrigation was applied when needed for a total of 25 to 40 mm per week (including rainfall). Fertilizer was incorporated at a rate of 90N–39P–74K $kg \cdot ha^{-1}$ before planting, with additional N at 34 $kg \cdot ha^{-1}$ being applied at the vine-tip-over (4 to 6 true leaf) stage. Herbicide [ethalfluralin; *N*-ethyl-*N*-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine] and insecticide (carbaryl; 1-Naphthyl *N*-methylcarbamate) were applied at recommended rates (College of Agriculture and Life Sciences, 1990).

Trials were run in the spring and summer production seasons using control cultivars ('Calypso' and 'Sumter' for NCH1, 'Dasher II' and 'Poinsett 76' for NCBA1) and a randomized complete-block design. The control cultivars were chosen to represent an elite gynoecious hybrid and an elite monoecious inbred that had been used widely for many years. Plots were harvested six times (twice weekly). Data were summarized over 4 years (1992 through 1995), three replications, and six harvests for two crop production seasons (spring, summer) at the Horticultural Crops Research Station near Clinton, N.C.

Data from the performance trials are presented for eight major horticultural traits (Table 1). Total fruit yield was the fresh mass of marketable fruit grades, oversized, and cull fruits summed over six harvests; early yield was the total mass for the first two harvests. Percentage of culls was the mass of crooked and nubbin fruits relative to total fruit mass. The three major fruit quality traits presented were shape, color, and seedcell size. Fruit shape was rated 1 to 9 [1–3 = pointed, crooked, constricted; 4–6 = tapered, curved, necked (constriction of the fruit at the peduncle end); 7–9 = blocky, straight, cylindrical] and reflected how straight, uniform, and cylindrical the fruits in a plot were (Strefeler and Wehner, 1986). Fruit color was rated 1 to 9 (1–3 = light green, 4–6 = medium green, 7–9 = dark green). Seedcell size was rated 1 to 9 (1–3 = large, 4–6 = medium, 7–9 = small). Firmness was the amount of force (N) required to drive an 8-mm-diameter tip on a punch tester (McCormick Fruit Tech, Yakima, Wash.) into the exocarp (skin) and mesocarp (flesh) of the fruit. Anthracnose damage to the foliage (measured in summer only) was rated 1 week after the 6th harvest (0 = none, 1–2 = trace, 3–4 = slight, 5–6 = moderate, 7–8 = severe, 9 = dead) using the system of Thompson and Jenkins (1985).

Description

The two populations have excellent horticultural characteristics, with the NCH1 being suitable for the development of inbreds and hybrids of the pickling type, and NCBA1 suitable for the development of inbreds and hybrids of the middle-eastern type. American slicer-type cucumbers are objectionable to some because of large fruit size, large seeds, or tough skin. Currently, middle-eastern cultivars are not popular in the United States, but could become so if marketed as a smaller, thinner-skinned, version of the American slicer-type cultivars.

The two populations have medium-sized seeds, with rapid germination and emergence from either cool or warm soil. Vines have tall, indeterminate growth habit, some lateral branching, and normal-sized, medium-green leaves. Plants grow rapidly and vigorously, and flowers and fruits develop early in the vegetative growth stage. Sex expression ranges from monoecious to gynoecious, with numerous flowers produced on the plants. The average family in the two populations was more gynoecious than 'Sumter' and 'Poinsett 76', but less gynoecious than 'Calypso' and 'Dasher II'.

Fruits of NCH1 are mottled and medium- to dark-green with lighter color at the blossom end. Fruits of NCBA1 are uniform green, and light- to medium-green. Fruits of NCH1 have few, large tubercles (warts) and are mostly white spined (some black spine still segregating). Fruits of NCBA1 are smooth (wartless). Fruit seedcell size is medium (subjective rating of 5 to 7 vs. 6 or 7 for the controls, where 1 is large and 9 is small). The range for fruit shape and color is good (Fig. 2), still permitting choice in selecting desired types for inbreeding.

Fig. 2. Typical fruits from cycle 10 of NCH1 (**top**) and NCBA1 (**bottom**) cucumber populations.

Populations are segregating for resistance to anthracnose [*Colletotrichum orbiculare* (Berk. & Mont.) Arx], angular leafspot [*Pseudomonas syringae* van Hall pv. *lachrymans* (Smith & Bryan) Young et al.], downy mildew [*Pseudoperonospora cubensis* (Berk. & M.A. Curtis) Rostovzev], powdery mildew [*Erysiphe cichoracearum* DC and *Sphaerotheca fuliginea* (Schlechtend.:Fr.) Pollacci], scab (*Cladosporium cucumerinum* Ellis & Arth.), and cucumber mosaic virus. Selection of plants resistant to those major diseases (St. Amand and Wehner, 1991) should be possible.

NCH1 generally yielded less than the gynoecious hybrid control ('Calypso'), but was rated about the same for fruit quality and disease resistance (Table 1). NCBA1 matched the performance of the gynoecious hybrid control ('Dasher II') for yield, quality ratings, and disease resistance. Those comparisons were for random bulks taken from each population from the latest cycle. The population mean was similar to the gynoecious hybrid controls for the important horticultural traits. Thus, improved cultivars could be developed by selecting those families that are significantly better than the population mean while inbreeding and testing in hybrid combinations. One would expect the new cultivars to be better than the mean of the population from which they were developed, and better than current cultivars as well. 'Calypso' and 'Dasher II' have been excellent cultivars for North Carolina, performing among the best in their class in current trials for important traits (yield, earliness, quality, and resistance).

Availability

Seeds of the NCH1 and NCBA1 cycle 10 populations are available as 300 half-sib families. The populations are each distributed as one 300-seed packet, with one seed from each half-sib family. Breeders receiving seeds should recreate the population by planting the 300 seeds and self-pollinating the resulting plants to produce 300 S_1 lines. The lines can then be tested for the traits of interest, selected, and pollinated to produce populations or lines for use in the development of elite cultivars.

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