HORTSCIENCE 33(1):168–170. 1998.

Three Slicing Cucumber Populations: NCWBS, NCMBS, and NCES1

Todd C. Wehner
Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Additional index words. Cucumis sativus, germplasm, synthetic population, fresh-market cucumber, vegetable breeding

Three American slicer-type cucumber (*Cucumis sativus* L.) populations were developed at North Carolina State Univ. over the last 15 years for use in the development of inbreds and hybrids. Those populations were developed from a wide, medium, or elite germplasm base, using selection methods that optimized gain for yield and other economically important traits (Wehner, 1989). The three populations were improved using modified half-sib family recurrent selection. Traits used in selection were total, marketable, and early yield and fruit shape in the spring season, and resistance to foliar fungal diseases, mainly anthracnose [*Colletotrichum orbiculare* (Berk. and Curt.) Arx] and gummy stem blight [*Didymella bryoniae* (Auersw.) Rehm], in the summer season. In addition, there was indirect selection for general performance, including rapid emergence of seedlings, vigorous vine growth, and early production of flowers.

In a previous study, modified half-sib family recurrent selection was effective in improving the North Carolina medium-base pickle and elite slicer 1 populations for important horticultural traits, as shown by continuous improvement over Cycles 0 through 9 in multiple environments (Wehner and Cramer, 1996). There has been much interest in using these improved populations in commercial breeding programs.

Origin

The North Carolina wide-base slicer (NCWBS) population was developed by intercrossing for 6 years (1981–86) in isolation, a total of 1165 cultivars, breeding lines, and plant introduction accessions (collectively referred to as cultigens). Those cultigens included types such as American pickling, American slicing, European pickling, European greenhouse, Middle Eastern slicers, Oriental trellis, German schalgurken, round (hermaphroditic) garden novelty, and small-fruited, wild-type cucumbers from India [including accessions of *Cucumis sativus* var. *hardwickii* (R.) Alef.]. Thus, the population contained all the major types of cucumber (Wehner and Horton, 1986). After the 1st year of intercrossing, all fruits were harvested from the isolation block, and separated into short (≤180 mm length) and long (>180 mm) groups to develop the pickling and the NCWBS populations, respectively. After 6 years of intercrossing, the population was designated Cycle 0, and put into the recurrent selection program in 1987.

The North Carolina medium-base slicer (NCMBS) population was developed by intercrossing 143 elite cultivars and breeding lines that were American slicers, Middle Eastern slicers, or greenhouse slicers from public and private breeding programs in Europe, Japan, and the United States (Table 1). Those cultigens were intercrossed in 1981 and 1982 to form the Cycle 0 population.

The North Carolina elite slicer 1 (NCES1) population was developed by crossing eight cultigens and their F_1 in a half-diallel, by hand in the greenhouse, and then intercrossing their F_2 using bees in an isolation block in 1982. The cultigens were chosen because of their different genetic backgrounds and their good yields, earliness, fruit quality, or disease resistance in the previous 2 years of North Carolina trials. The eight cultigens were 'Dasher' (Petoseed), 'Poinsett 76' (Cornell Univ.), Exp. 7 (Sakata Seed), Exp. 22 (Sakata Seed), 'Sprint 440' (Asgrow Seed), 'Tablegreen 72' (Cornell Univ.), WI 1321 [U.S. Dept. of Agriculture (USDA)–Wisconsin], and WI 1394 (USDA–Wisconsin).

Populations were improved by testing in the spring season followed by intercrossing the best (≈12%) of the families in isolation blocks in the summer season for 10 cycles (seven for NCWBS), as described by Wehner and Cramer (1996). Once-over harvest was simulated by spraying the foliage with paraquat (1,1′-dimethyl-4,4′-bipyridinium ion) at 0.6 kg·ha^{-1} (Wehner et al., 1984) when the 'Dasher II' control plots had ≈10% (by number) oversized (>60 mm in diameter) fruits.

Half-sib families were evaluated at the once-over harvest stage for five traits: total

Table 1. The 143 elite cultivars and breeding lines that were intercrossed to form the North Carolina medium-base slicer (NCMBS) population.[z]

Aodai-Nazare	Farbiola	Medalist	Sakata Exp 22
Arabel	Fembaby	Minisol	Sandra
Ashley	Femgreen	Miracross	Sensation
Aurora	Femland	Mirella	Setter
Bambina	Femscore	Monique	Shamrock
Bambola	Fertila	MSU 844 G	Slice
Belair	Fidelio	NCX 5504	Slice Rite
Belcanto	Fletcher	NCX 5505	Slicemaster
Bella	Fortuna	P 51	Sluis & Groot 891
Birget	Fuga	Pacer	Southernsett
Boneva	Gemini	Palomar	Spacemaster
Brilliant	Gemini 7	Pandex	Spacemaster 80
Bugrostan	Girola	Pandorex	Sporu
Burpee Hybrid	Gourmet	Patio Pik	Sprint 440
Burpeeana Hybrid	Green Knight	Pepinex 69	Stereo
Burpless Hybrid	Gy 57u	Petita	Stokes Early
Bush Champion	Harris C4DM	PI 418962	Stono
Castle 2501	Harris G4U4	PI 418964	Straight 8
Castle 2506	Harris G8M	PI 418989	Streamliner
Challenger	Harris GRM	PI 419010	Sunnybrook
Cherokee 7	Harris GUM	PI 419214	Superator
China	Herta	PI 436609	Sweet Slice
Concorde	High Mark II	PI 436610	Tablegreen 65
Coolgreen	HySlice	Picador	Tablegreen 72F
Corona	Kamaron	Poinmarket	Tableslice
Cypress	Kora	Poinsett 76	Tirana
Daleva	Long Green Improved	Pot Luck	Toska 70
Damascus	Marion	Primio	Triumph
Dasher	Marketer	Raider	Vaughan
Debonaire	Marketer, Early	Ramona	Verana
Dual	Marketer, Long	Reform	Virgo A
Dublin	Marketmore 76	Renova	WI 1394
Dura	Marketmore 76F	Sakata Exp 1	WI 1397
Early Surecrop	Marketmore 80	Sakata Exp 7	WI 1700
Famosa	Marketsett	Sakata Exp 10	Windermoor Wonder
Farbio	Matara	Sakata Exp 12	

[z]Cultivars and breeding lines were obtained from public and private cucumber breeding programs, and represented American slicer, greenhouse slicer, and Middle Eastern slicer types.

Received for publication 24 Jan. 1997. Accepted for publication 30 June 1997. The use of trade names in this publication does not imply endorsement by the NCARS of the products named or criticism of similar ones not mentioned. I thank Rufus R. Horton, Jr., for technical assistance. 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.

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 to 9), and a simple weighted index (Wehner, 1982). Fruit-shape rating reflected how straight, uniform, and cylindrical the fruits were, with 1–3 = poor, 4–6 = intermediate, and 7–9 = excellent (Strefeler and Wehner, 1986). The simple weighted 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 adjust values to the same range (1 to 9) as the other traits evaluated. Each trait was then given a weight (20% or 30%) to reflect its importance in the North Carolina breeding program.

Description

The three populations are similar in that they have American slicer-type fruits. However, the population mean increases, and the variance for yield, earliness, and fruit quality decreases, from NCWBS to NCMBS to NCES1 (Strefeler and Wehner, 1986).

The three slicer populations have medium-sized seeds, tall vines, indeterminate growth habit, and some lateral branching. Plants are vigorous and monoecious to gynoecious, and flowers and fruits develop early. Fruits are medium to long slicer-type, with medium-green to dark-green, uniform to mottled skin color (Fig. 1). Fruits have few, large warts, and are mostly white-spined. Fruit seedcell size is small to medium.

Plants are segregating for resistance to anthracnose, 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. Thus, selecting plants that are resistant to major diseases in the southeastern United States should be possible (St. Amand and Wehner, 1991).

Performance of random samples bulked from half-sib families of each population were evaluated in performance trials for yield, earliness, fruit quality, and disease resistance using optimized trialing methods (Wehner, 1987). Trials were conducted in the spring and summer production seasons in North Carolina using 'Dasher II' and 'Poinsett 76' as controls in a randomized complete-block design. The two cultivars were used for comparison because 'Dasher II' is one of the better cultivars and 'Poinsett 76' is one of the most disease-resistant, and they have been used as controls in North Carolina performance trials for the past 15 years. Plots were harvested six times (twice weekly). Data were summarized over 4 years (1992–95), and three replications for two crop production seasons (spring, summer) at the Horticultural Crops Research Station near Clinton, N.C.

'Poinsett 76' was planted in field border

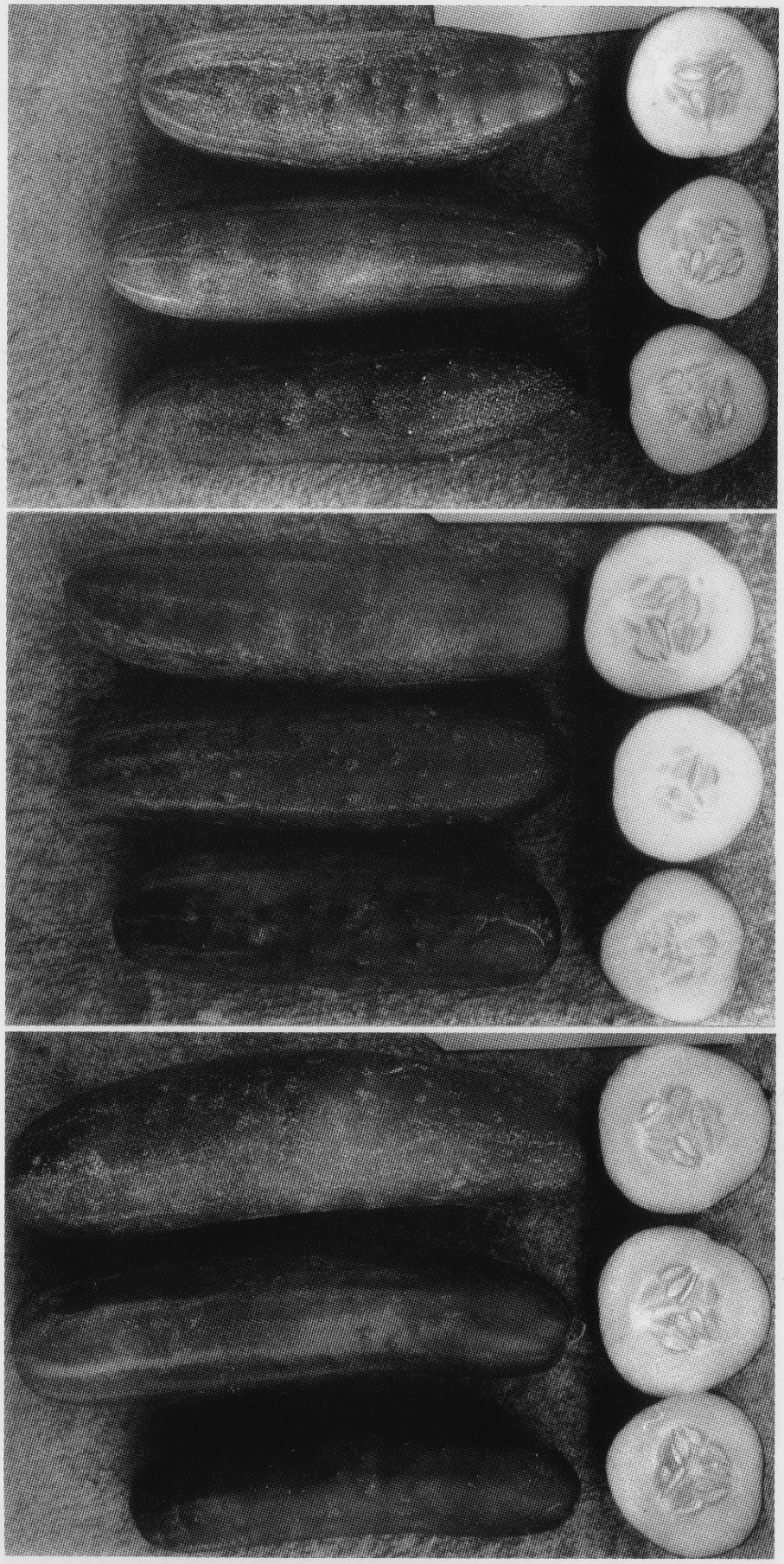

Fig. 1. Typical fruits from the latest cycles of the (**top**) North Carolina wide-base slicer (NCWBS), (**middle**) North Carolina medium-base slicer (NCMBS), and (**bottom**) North Carolina elite slicer 1 (NCES1) slicing cucumber populations.

Table 2. Horticultural performance (yield, earliness, quality, and disease resistance) of three slicing cucumber populations in spring and summer production seasons compared with two standard cultivars, 'Dasher II' hybrid and 'Poinsett 76' inbred.[z]

Population	Yield (Mg·ha^{-1})			Fruit	Fruit	Seedcell		Anthracnose
	Total[y]	Early[x]	Marketable[w]	shape[v]	color[v]	size[v]	Firmness[u]	damage[t]
				Spring season				
NCES1	33.4	6.8	29.0	6	7	6	62	---
NCMBS	36.8	7.2	30.1	6	7	6	67	---
NCWBS	35.2	6.8	27.1	5	4	5	67	---
Dasher II	31.7	6.0	27.8	7	7	6	76	---
Poinsett 76	25.0	1.6	22.6	7	7	6	62	---
LSD ($P < 0.05$)	5.8	2.7	5.0	2	1	2	9	---
				Summer season				
NCES1	25.3	7.8	19.7	6	7	6	---	5
NCMBS	24.3	5.8	17.2	6	7	6	---	5
NCWBS	19.9	5.9	14.0	5	5	5	---	5
Dasher II	19.6	4.3	16.1	7	7	7	---	5
Poinsett 76	18.6	1.9	14.6	6	7	6	---	4
LSD ($P < 0.05$)	5.2	2.7	4.0	1	1	2	---	1

[z]Data are summarized over 4 years (1992–95), three replications, and six harvests for spring and summer.
[y]Mass of USDA Fancy, No. 1, No. 2, and cull over 6 harvests.
[x]Total mass for the first two harvests.
[w]Total yield minus culls.
[v]Rated 1 to 9 (1–3 = poor shape, light-green color, large seedcell; 4–6 = moderate shape, medium-green color, medium-sized seedcell; 7–9 = excellent shape, dark-green color, small seedcell).
[u]Measured using a punch with an 8-mm-diameter tip.
[t]Foliar damage was rated 1 week after the sixth harvest (0 = none, 1–2 = trace, 3–4 = slight, 5–6 = moderate, 7–8 = severe, 9 = dead).

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 (irrigation plus rainfall). Fertilizer was incorporated at a rate of 90N–39P–74K kg·ha^{-1} before planting, with additional N applied at 34 kg·ha^{-1} at the vine-tip-over (four to six true leaf) stage. Herbicide [Curbit; ethalfluralin; *N*-ethyl-*N*-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl) benzenamine] and insecticide (Sevin; carbaryl; 1-naphthyl *N*-methylcarbamate) were applied at recommended rates (College of Agricultural and Life Sciences, 1990). Other cultural practices were as recommended (Schultheis, 1990).

Data from the performance trials included eight major horticultural traits (Table 2). Total yield is the mass of USDA grade Fancy, No. 1, No. 2, and cull fruits summed over six harvests. Early yield is the total mass for the first two harvests. Marketable yield is total yield minus culls. Fruit quality for shape, color, and seedcell size were rated 1 to 9 (1–3 = poor shape, light-green color, large seedcell; 4–6 = moderate shape, medium-green color, medium-sized seedcell; and 7–9 = excellent shape, dark-green color, small seedcell). Firmness (measured in spring only) was the amount of force (N) required to punch into the fruit exocarp (skin) and mesocarp (flesh) with a tester (McCormick tester; McCormick Fruit Tech, Yakima, Wash.) having an 8-mm-diameter tip. Anthracnose damage to the foliage (measured in summer only) was rated 1 week after the sixth harvest on a 0 to 9 scale (0 = none, 1–2 = trace, 3–4 = slight, 5–6 = moderate, 7–8 = severe, and 9 = dead), following the guidelines of Thompson and Jenkins (1985).

Averaged over spring and summer seasons, differences among the three populations were small and often nonsignificant (Table 2). NCES1 was generally the best performer of the three populations in the summer season, and NCMBS was the best in the spring season. The performance of NCWBS was slightly worse than the other two populations in the two-season trial, probably because it was not selected for as many cycles and had a much broader germplasm base.

The three populations were usually better than the monoecious inbred control 'Poinsett 76', but generally the same as the gynoecious hybrid control 'Dasher II', for total, early, and marketable yield. The populations were similar to 'Dasher II' for fruit color and anthracnose resistance, and a little worse for fruit shape and firmness (Table 2). Those comparisons were for random bulks taken from each population for the latest cycle. Therefore, inbred lines developed from each population by testing and selection during generations of self-pollination should be better.

Availability

Seeds of each population (NCWBS, NCMBS, and NCES1) Cycles 7 to 10 are sampled from 300 half-sib families, and can be obtained by writing to the author. The populations are distributed as one 300-seed packet each, with one seed from each half-sib family. Each plant breeder receiving seeds should recreate the population by growing the 300 seeds and self-pollinating the resulting plants to produce 300 S_1 lines. The lines can then be tested for traits of interest, selected, and mated to produce populations or lines for use in the development of slicer cultivars.

Literature Cited

College of Agricultural and Life Sciences. 1990. The 1990 North Carolina agricultural chemical manual. North Carolina State Univ., Raleigh.

Schultheis, J.R. 1990. Pickling cucumbers. N.C. Agr. Ext. Serv. Hort. Info. Lflt. no. 14-A.

St. Amand, P.C. and T.C. Wehner. 1991. Crop loss to 14 diseases in cucumber in North Carolina for 1983 to 1988. Cucurbit Genet. Coop. Rpt. 14:15–17.

Strefeler, M.S. and T.C. Wehner. 1986. Estimates of heritabilities and genetic variances of three yield and five quality traits in three fresh-market cucumber populations. J. Amer. Soc. Hort. Sci. 111:599–605.

Thompson, D.C. and S.F. Jenkins. 1985. Pictorial assessment key to determine fungicide concentrations that control anthracnose development on cucumber cultivars with varying resistance level. Plant Dis. 69:833–836.

Wehner, T.C. 1982. Weighted selection indices for trials and segregating populations. Cucurbit Genet. Coop. Rpt. 5:18–20.

Wehner, T.C. 1987. Efficient methods for testing vegetable cultivars. HortScience 22:1220–1223.

Wehner, T.C. 1989. Breeding for improved yield in cucumber. Plant Breeding Rev. 6:323–359.

Wehner, T.C. and C.S. Cramer. 1996. Ten cycles of recurrent selection for fruit yield, earliness, and quality in three slicing cucumber populations. J. Amer. Soc. Hort. Sci. 121:362–366.

Wehner, T.C. and R.R. Horton, Jr. 1986. Performance of cultivars of four different cucumber types for fresh-market use in North Carolina. Cucurbit Genet. Coop. Rpt. 9:53–54.

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.