HortScience 32(5):941–944. 1997.

Three Pickling Cucumber Populations: NCWBP, NCMBP, and NCEP1

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Additional index words. Cucumis sativus, quantitative genetics, germplasm, synthetic population, processing cucumber, vegetable breeding

Three American pickle-type populations were developed at North Carolina State Univ. over the last 20 years for use as a starting point to produce inbreds and hybrids. The populations had either a wide, medium, or elite germplasm base. Selection methods were developed that optimized gain for yield and other traits (Wehner, 1989). Selection in the three populations was for fruit shape, and total, marketable, and early yield in the spring season, and for 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.

There was also unintentional selection of the three populations 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. Those traits can be easily overlooked, but I have observed many cultivars in performance trials over the years that have reminded me of their importance.

Modified half-sib recurrent selection was effective in improving the NCMBP and NCEP1 populations for important horticultural traits, as shown by continuous improvement over cycles 0 through 9 in multiple environments (Wehner and Cramer, 1996). There is 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 wide-base pickle (NCWBP) population was developed by randomly intercrossing for 6 years (1981 to 1986) in isolation all available cultivars, breeding lines, and plant introduction accessions (collectively referred to as cultigens hereafter), totaling 1165. Cultigens included were American pickling, American slicing, European pickling, European greenhouse, Oriental trellis, German schalgurken, round (hermaphroditic) garden novelty, and small-fruited wild cucumbers. Thus, the population comprised all the major types of cucumber (Wehner and Horton, 1986). After the first year of intercrossing, half-sib families were harvested from the isolation block and separated into short (pickling) and long (slicing) groups. The long-fruited families were used to develop a slicing population, and the short fruits were used to develop the NCWBP population. The only selection practiced during the 6 years of intercrossing was for American pickle-type fruits. Cycle 0 was tested in 1987, and the best families selected and intercrossed to form cycle 1.

The North Carolina medium-base pickle (NCMBP) population consisted of 69 cultivars, breeding lines, and PI accessions (Fig. 1). The work began by intercrossing four groups of cultigens separately: diverse PI accessions, elite monoecious pickling inbreds, elite gynoecious pickling inbreds crossed with a selection having the compact (*cp*) mutant, and large-fruited (German schalgurken and Dutch greenhouse) cultivars with LJ 90430 (a multibranched, multifruiting accession of *Cucumis sativus* var. *hardwickii* (R.) Alef. That was followed by intercrossing the groups from 1976 to 1982. During intercrossing, the only selection practiced was for pickling-type fruits for each half-sib family.

The North Carolina elite pickle 1 (NCEP1) population was developed by crossing eight elite inbreds in a half diallel in 1981, and intercrossing their F_2 in 1982. The inbreds (including two proprietary inbreds that were used to produce the Harris 4J73 F_1 hybrid) were chosen for having the best combining ability for yield, earliness, fruit quality, and/or disease resistance in the previous 2 years of performance trials. The eight inbreds used were Gy 2, Gy 4, Clinton, M 21, MSU 598G, WI 2757, and the two inbreds in 4J73.

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 (7 for NCWBP). Once-over harvest was simulated by spraying the foliage with paraquat (1,1′-dimethyl-4,4′-bipyridinium ion) at 0.6 kg·ha^{-1} when the controls had ≈10% oversized fruits (>51 mm in diameter) by number (Wehner et al., 1984). Half-sib families were evaluated for 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 (Wehner, 1982). The simple weighted index was calculated as: SWI = 0.2 (total yield)/2 + 0.3 (early yield) + 0.2 (percent marketable yield)/10 + 0.3 (fruit shape). Total yield was divided by 2 and percentage of marketable yield was divided by 10 to give them the same range (1 to 9) as 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, since shape rating (30%) is related to fruit appearance, and marketable yield (20%) accounts for crooked and nubbin fruits.

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). Recommended cultural practices (summarized by Schultheis, 1990) were used throughout the experiments. 'Sumter' 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·ha^{-1} before planting, with an additional 34N kg·ha^{-1} applied 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 Agriculture and Life Sciences, North Carolina State Univ., 1990).

Trials were run in the spring and summer production seasons using 'Calypso' and 'Sumter' as controls, and a randomized complete-block design. The two cultivars were used for comparison because 'Calypso' is one of the best gynoecious hybrids and 'Sumter' is one of the best monoecious inbreds, 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 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 yield is the weight of North Carolina grades no. 1, no. 2, no. 3, oversized, and cull fruits summed over six harvests. Early yield is the total weight for the first two harvests. Marketable yield is total yield minus culls. The three major fruit quality traits presented are shape, color, and seedcell size. Fruit shape was rated 1 to 9 (1–3 = pointed, crooked, constricted; 4–6 = tapered, curved, necked; 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–

Received for publication 26 Sept. 1996. Accepted for publication 8 Jan. 1997. The use of trade names in this publication does not imply endorsement by the NCARS of the products named, nor criticism of similar ones not mentioned. Thanks to 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.

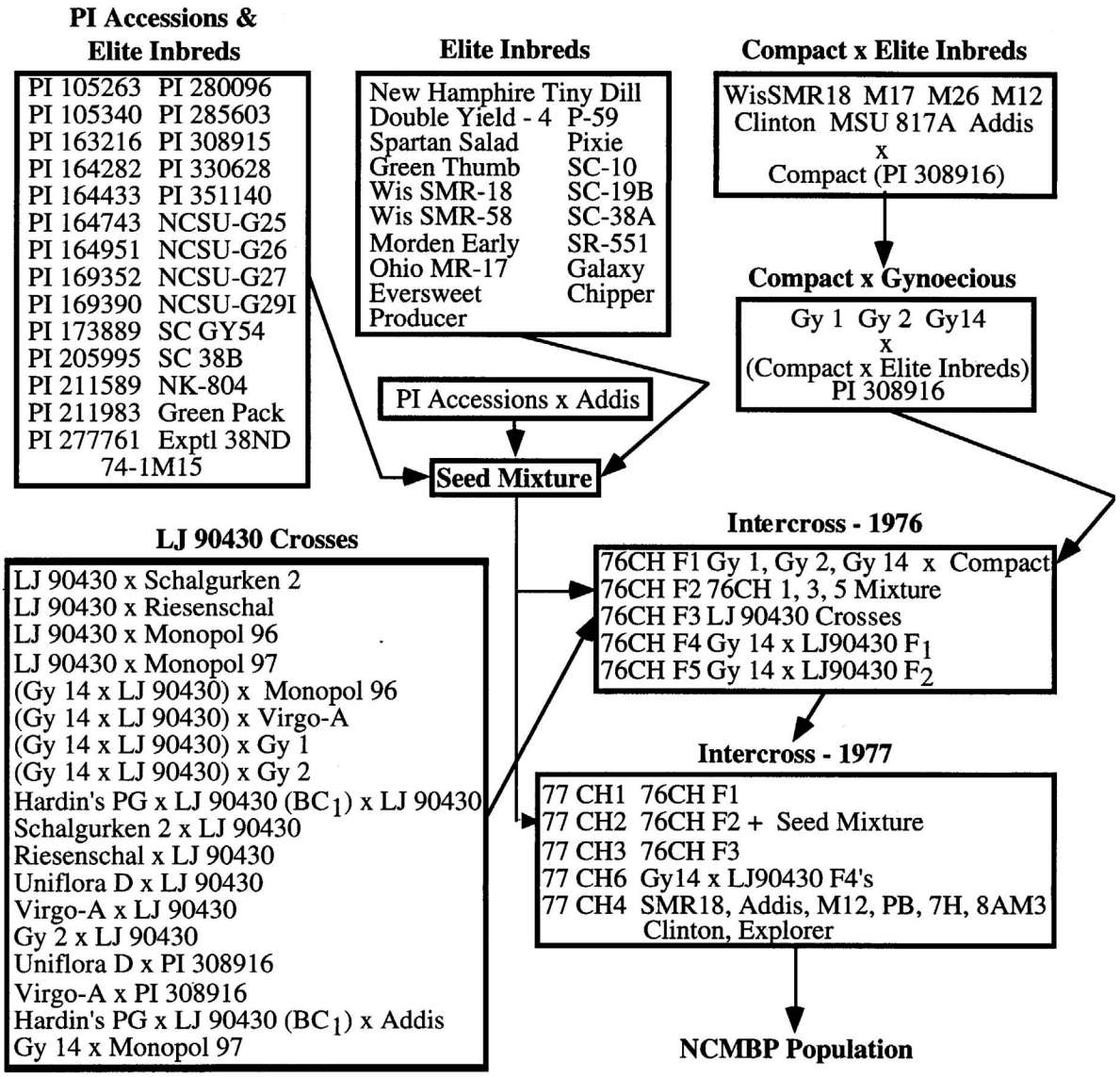

Fig. 1. Pedigree for the development of the NCMBP pickling cucumber population.

Table 1. Horticultural performance (yield, earliness, quality, and disease resistance) of three pickling cucumber populations in spring and summer production seasons compared with two standard cultivars, 'Calypso' hybrid and 'Sumter' inbred. Data are 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.

Population	Total yield[z] ($Mg \cdot ha^{-1}$)	Early yield[y] (%)	Cull yield (%)	Quality ratings: Fruit shape[x]	Fruit color[w]	Seedcell size[v]	Firmness (N)	Anthracnose[u] damage (0–9)
			Spring trials					
Calypso	28.8	32	10	7	6	6	80.1	---
NCEP1	26.1	31	11	6	6	5	79.6	---
NCMBP	27.1	22	9	6	5	5	75.2	---
NCWBP	23.7	27	13	6	4	5	81.0	---
Sumter	19.7	16	9	7	5	7	84.1	---
LSD (5%)	5.4	7	3	1	1	2	11.0	---
			Summer trials					
Calypso	19.9	51	15	6	5	6	72.5	6
NCEP1	14.2	41	16	6	6	6	68.9	5
NCMBP	16.1	33	15	6	6	5	72.1	6
NCWBP	14.3	37	14	6	5	5	65.8	7
Sumter	10.5	23	14	6	5	7	77.8	6
LSD (5%)	5.1	9	6	1	1	2	5.2	1

[z]Weight of grade 1, 2, and 3 fruits minus oversized and cull fruits.
[y]Percentage of the six-harvest yield that occurred in the first two harvests.
[x]Fruit shape was rated 1 to 9 (1–3 = pointed, crooked, constricted; 4–6 = tapered, curved, necked; 7–9 = blocky, straight, cylindrical).
[w]Fruit color rated 1 to 9 (1–3 = light-green, 4–6 = medium-green, 7–9 = dark-green).
[v]Seedcell size rated 1 to 9 (1–3 = large, 4–6 = medium, 7–9 = small).
[u]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).

6 = medium, 7–9 = small). Firmness was the amount of force (N) required to penetrate the fruit exocarp (skin) and mesocarp (flesh) with an 8-mm-diameter tester (McCormick Fruit Tech, Yakima, Wash.). Anthracnose damage to the foliage (measured in summer only) was rated 1 week after the sixth harvest (0 = none, 1–2 = trace, 3–4 = slight, 5–6 = moderate, 7–8 = severe, 9 = dead).

Description

The three populations are similar in horticultural characteristics, but with increasing mean and decreasing genetic variance for yield, earliness, fruit quality, and disease resistance from NCWBP to NCMBP to NCEP1.

The three pickle 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 are vigorous, with rapid growth, and flowers and fruits develop early in the vegetative growth stage. Sex expression ranges from monoecious to gynoecious, with numerous staminate and pistillate flowers produced. The average family in the three populations is more gynoecious than 'Sumter' (first five nodes 64% staminate), but less gynoecious than 'Calypso' (first five nodes 15% staminate), with 52%, 48%, and 51% staminate nodes in the first five nodes of the plant for NCEP1, NCMBP, and NCWBP, respectively.

Fruits are medium to long pickle-type, with differences among families that would permit selection of any commercially useful length : diameter ratio (L/D). The L/D of the populations averages 3.2 for the grade 2B fruits measured in the spring season compared with 3.1 for 'Calypso', and 3.2 for 'Sumter'. Fruits have a shorter L/D in the summer season, averaging 3.0 for the three populations and the control cultivars. Fruit color is mottled, and medium- to dark-green, with lighter color at the blossom end. Fruits have few, large tubercles (warts), and are mostly white-spined (some black spine still segregating). Fruit seedcell size is medium (subjective rating of 5 or 6 vs. 6 or 7 for 'Calypso' and 'Sumter', where 1 is large and 9 is small). The range for fruit shape and color is very good (Fig. 2), while still permitting much choice in selecting desired types for inbreeding.

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, it should be possible to select plants resistant to the major disease problems in the southeastern United States, ranked in importance by St. Amand and Wehner (1991).

Averaged over spring and summer seasons, differences among the three populations were small and often nonsignificant (Table 1),

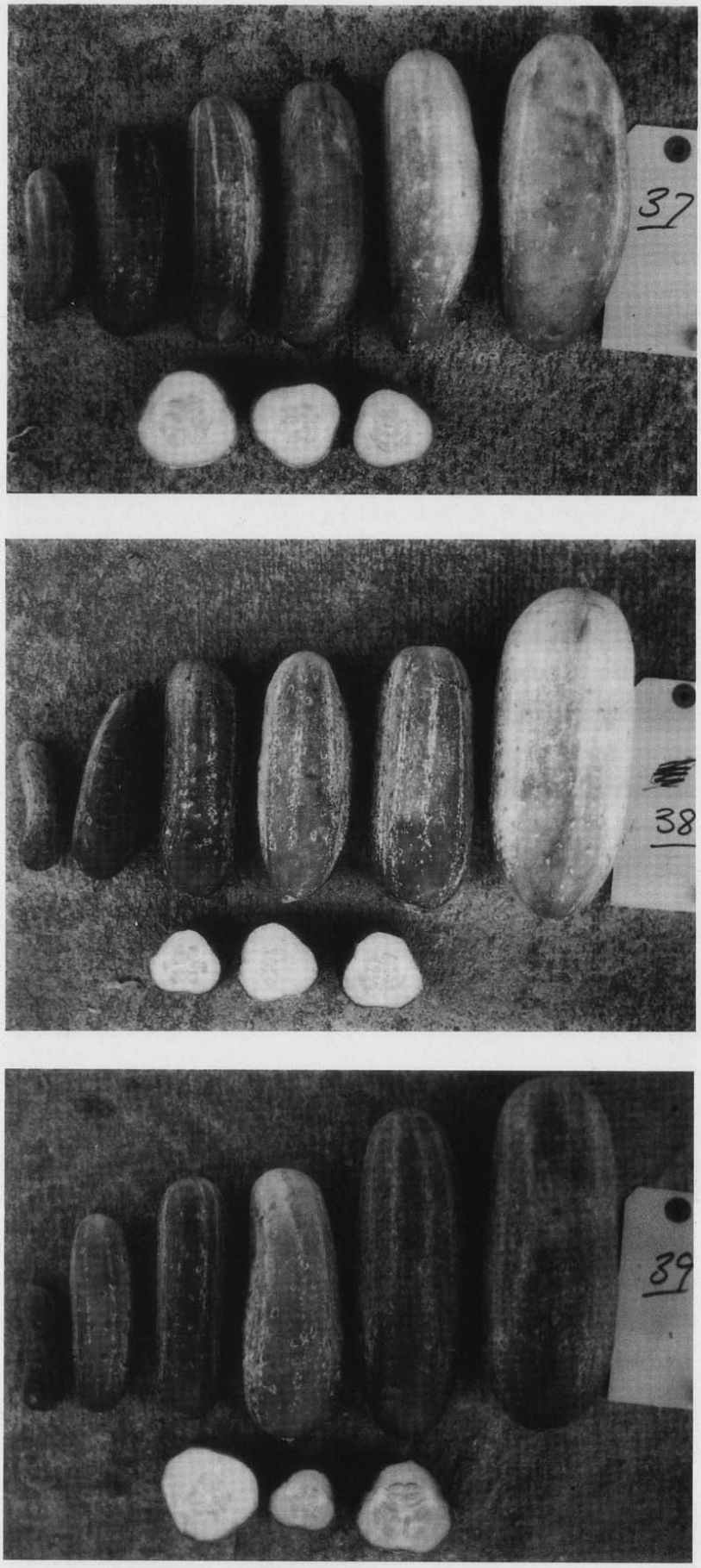

Fig. 2. Typical fruits from the latest cycles of three pickling cucumber populations: NCWBP (**top**), NCMBP (**center**), and NCEP1 (**bottom**).

with NCEP1 the best for most traits, and NCWBP the worst. NCWBP was slightly worse than the other two populations, as expected, since it has a wider germplasm base and fewer cycles of selection. The three populations performed almost as well as 'Calypso' gynoecious hybrid, and better than 'Sumter' monoecious inbred for many traits.

The three populations were generally worse than the gynoecious hybrid control 'Calypso' for yield, and about the same for fruit quality and disease resistance (Table 1). Those comparisons were for random bulks taken from each population for the latest cycle. The population mean was similar to the gynoecious hybrid 'Calypso' 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' has been an excellent cultivar for North Carolina, performing among the best for its L/D class in current trials for important traits (yield, earliness, quality, and resistance).

Availability

Seeds of the NCWBP, NCMBP, and NCEP1 cycle 10 (cycle 7 for NCWBP) populations each are stored as 300 half-sib families. The populations are distributed as one 300-seed packet each, with one seed from each half-sib family. Breeders 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 the traits of interest, selected, and pollinated to produce populations or lines for use in the development of elite cultivars.

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