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Cucumber Cultivars for Container Gardening and the Value of Field Trials for Predicting Cucumber Performance in Containers

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***Abstract*. Cucumber (*Cucumis sativus* L.) is one of the most popular vegetable crops grown in U.S. home and urban gardens. The objectives of this study were to identify cultivars and planting densities for high yield of container-grown cucumbers. Additional objectives were to determine the value of field trials for predicting cucumber performance in containers and to evaluate different plant types (dwarf-determinate vs. tall-indeterminate, gynoecious vs. monoecious, pickling vs. slicing) for container use and disease severity across cultivars. Fourteen cultivars and breeding lines were tested at three planting densities in two seasons for yield, quality, and disease resistance in field and patio trials. Significant differences were detected for seasons, cultivars, and densities. Yields were highest in the spring season compared with the summer season, and the best performance was obtained using three plants per 12 L container. There was a high correlation between patio and field trials, allowing extension specialists to recommend cucumber cultivars with high yield, high quality, and disease resistance based on field trial data. Home gardeners who want space-saving, high-yielding cucumbers with tender skin should consider a dwarf-determinate, pickling type that is monoecious. With monoecious type, no pollenizer is needed, and the harvest will be spread over more weeks than would be for gynoecious types.**

Cucumber (*C. sativus* L.) is a popular vegetable originating in India (Harlan, 1975), but grown throughout the world for centuries. The main types of cucumbers grown are American pickling, American slicing, Middle Eastern (Beit Alpha), European greenhouse (parthenocarpic), Asian slicer, and Oriental trellis. Cucumber types differ in fruit length, diameter, skin color, color uniformity, skin thickness, and skin surface texture based on their primary use (Wehner, 1989). Most cucumber cultivars have long vines and are grown flat on the ground or on trellis supports (oriental and greenhouse types). Pickling and slicing cucumbers are the two main types grown for commercial markets and home gardens in the United States; annual per capita consumption of fresh and processed cucumber was 2.9 and 2.2 kg, respectively in 2005 (USDA, 2005). In 2014, per capita consumption of fresh cucumbers was 3.1 kg (Statista GmbH, 2017).

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Although cucumbers require a large growing area, vines can be trained vertically on a trellis to minimize space. Alternatively, gardeners may choose to grow dwarf, determinate, or compact cucumber cultivars that have shorter vines for patio containers or small garden spaces. These cultivars are sometimes categorized as compact or bush types based on their short internodes. Plant breeders make use of the determinate (*de*) gene for the dwarf habit because the bush (*bu*) and compact (*cp*) genes are associated with poor growth or abnormal seeds. Cucumber cultivars with dwarf growth habit include ‘Bush Whopper II’, ‘Picklebush’, and ‘Bush Champion’.

Cucumber plants can produce a combination of three types of flowers: staminate (male), pistillate (female), and perfect (male and female). Based on the type of flowers present, cucumbers are monoecious (staminate and pistillate flowers), androecious (staminate flowers only), gynoecious (pistillate flowers only), hermaphroditic (perfect flowers only), or andromonoecious (staminate and perfect flowers). Cucumber plants are normally monoecious, but most current commercial cultivars are gynoecious hybrid blends (88% gynoecious plus 12% monoecious pollenizer) or parthenocarpic (pistillate flowers only, and fruit set without pollination). Gynoecious and parthenocarpic cultivars usually have earlier and more concentrated yield, whereas monoecious cultivars will produce fruit over a longer period of time. An earlier and concentrated production period is preferred by commercial growers and processors, but may not be ideal for home gardeners. In a study conducted by Wehner and Miller (1985), three versions of the hybrid ‘Meridian 76’ (gynoecious × gynoecious, gynoecious × monoecious, and monoecious × monoecious) were similar in overall yield among the hybrids. The gynoecious hybrids provided an advantage in early yield (higher yield at first harvest), but had more grade No. 2 and cull fruit than the monoecious hybrid, possibly because of the high number of pistillate flowers pollinated and grown in a tight sequence.

Urban and container gardening are two of the fastest growing gardening trends in the United States (Crandall and Crandall, 1996; Mason et al., 2008). Urban gardening can occur at the individual or community level, stimulating economic development, creating green space, and providing a source of fresh vegetables, fruits, and flowers for local communities. Urban gardens have a beneficial effect on communities, and cities are starting to include these spaces in city planning (Colasanti et al., 2012; Freeman et al., 2012; Hunter and Brown, 2012). In addition to community gardens, container gardens provide a convenient alternative for the home-production of vegetables, fruits, and flowers. As the number of people living in apartments, condominiums, and townhouses increases, so does the number of potential container gardeners.

Despite the popularity of container gardening, information is limited on cultivars and optimal production methods for container-grown vegetable production. Internet resources are plentiful, but might not be based on scientific research. Universities continuously update their extension bulletins and services, but without home gardening studies they have been unable to make research-based recommendations. One such bulletin recommended the use of cultivar H-19 littleleaf, a tall, multibranched inbred with late maturity (Hopkins et al., 2008). This pure-line cultivar does have multiple branching and high yield, but its concentrated set makes it less appealing for many home gardeners. ‘Bush Champion’ is another popular cultivar recommended by extension specialists. In older (pre 2005) resources, many of the recommended cultivars have growth habits unsuited to container production or are no longer available. Also, the cultural practices in the literature are often vague and recommend various cultivars, container sizes, media types, fertilizer, and water regimes. One would hope that they were based on local production requirements.

In addition to limited information on production practices, plant diseases can be a hindrance for urban gardeners. Because of space constraints, home gardeners often use higher plant densities than university or commercial recommendations. Increased plant densities promote disease development. With the available chemical control options, there is a need for high yielding, dwarf, and resistant cultivars for urban gardens. Heirloom cultivars often lack disease resistance, and commercial cultivars with resistance may be unavailable. Two common diseases of cucumber are powdery mildew (PM) and downy mildew (DM) (Adams and Quesada-Ocampo, 2015; Ojiambo et al., 2015). These diseases often appear in mid- to late summer and affect the leaves of the plant. Powdery mildew, caused by *Podosphaera xanthii*, produces chlorotic spots on the upper leaf surface with an eventual white ''powdery'' appearance as the disease progresses. Downy mildew, caused by *Pseudoperonospora cubensis*, causes angular chlorotic lesions on the upper leaf surface (Ojiambo et al., 2015). Both pathogens can significantly reduce yield and fruit quality in field- or container-grown plants.

In urban gardening, container size is also an important factor. Cucumber roots grow 30–60 cm deep in field soil (Sanders, 1997). Inadequately sized containers result in small plants and may reduce fruit quality and yield. In addition, small containers can dry out rapidly, resulting in poor nutrient uptake, stressed plants, and reduced yield. Large containers are often preferred, but can be difficult to move and require a large amount of potting media. Various container sizes are recommended in extension publications from U.S. universities, including a 20–40 L container with one to two plants each (Crandall and Crandall, 1996), an 8–20 L container or hanging basket (Harrison, 1996), a container with one plant per 4 L of soil volume (Bass, 1999), a larger container for vining crops (including tall-indeterminate cucumber) than crops with bush habit with 16–20 L of potting medium per plant (Demboski et al., 2001) and 12–20 L per plant (Hopkins et al., 2008; Whiting et al., 2014).

The objectives of this study were to 1) determine the optimal cucumber cultivars of several types (dwarf vs. tall, gynoecious vs. monoecious, pickling vs. slicing) and planting density for use in containers and 2) evaluate field trials as a predictor of cultivar performance in containers.

Materials and Methods

Experiments were conducted at the Horticultural Crops Research Station in Clinton, NC, during the spring (May–July) and summer (August–September) seasons in a single year. Twelve commercial cultivars were evaluated based on NC extension recommendations for field and for container production representing different plant types (monoecious, gynoecious, tall, dwarf, pickling, and slicing) (Table 1). One container garden cultivar, M 27 × NC-25, which had not been released at the time of planting, was also included. Greenhouse and trellis cucumbers were excluded from this trial. Greenhouse cucumbers should be grown in structures that exclude insects as they have bitterfree foliage and parthenocarpic fruit, and both types must be supported to prevent a large proportion of their fruit from curving (common with fruit longer than 300 mm).

For container evaluations, 12 L pots were filled with a soilless medium (Metro Mix 360). Cucumbers were direct seeded into containers and thinned to desired density. Three planting densities (12 L of soil/plant, 6 L of soil/plant, and 4 L of soil/plant) were evaluated. Plots consisted of a single container of one, two, or three plants each, set on raised, shaped beds in the field (Fig. 1.). Beds were covered with black plastic to simulate containers on a paved surface. Containers were spaced 1.5 m apart in the row, with rows 45 m long. Row centers were 1.5 m apart, with a total of nine rows. Irrigation was set up to water for 1 $h \cdot d^{-1}$ in the morning in addition to rain events. Spray emitters were used with a flow rate of 12 $L \cdot h^{-1}$. A liquid fertilizer (Peters 20–20–20) was added through the drip line daily. Plants were not treated with fungicide or insecticides and were exposed to natural levels of PM and DM inoculum.

The spring patio trial was planted on 9 May and thinned on 19 May to one, two, or three plants to provide the desired planting density. Cucumber plants were evaluated for flower type on 23 June. Gynoecious ratings were based on a visual 1 to 9 scale (1 = androecious, 2 to 3 = andromonoecious, 4 to 6 = monoecious, 7 to 8 = predominately gynoecious, 9 = gynoecious). Vine length (VL), as the maximum length of the main vine, was measured at harvest 1 on 23 June and at harvest 8 on 18 July. A disease rating for PM was recorded on 14 July. Disease ratings were based on a 0 to 9 scale where 0 = no disease, 1 to 2 = trace, 3 to 4 = slight, 5 to 6 = moderate, 7 to 8 = severe, and 9 = plant dead. The trial was harvested twice a week for a total of eight harvests. All fruit larger than 25-mm diameter were harvested and weight of marketable and cull fruit of each plot were recorded.

For the summer trial, seeds were planted in the greenhouse at the Horticulture Field Laboratory in Raleigh, NC, in 72 cell trays (Hummert Intl., St. Joseph, MO). One week after planting, seedlings were placed into a coldframe at the Clinton Research Station to harden off. The patio containers were transplanted on 11 Aug. Sex expression was rated on 24 Aug. Vine length was measured at harvest 1 on 18 Aug. and at harvest 8 on 15 Sept. A disease rating for DM was recorded on 15 Sept.

The experiment was a randomized complete block with 2 seasons (spring and summer), 14 cultigens (breeding lines and cultivars), 3 plant densities (one, two, or three plants per container), and 6 replications. For both the spring and summer container trials, corresponding field trials were run for comparison.

Field trials were direct seeded into raised beds covered with black polyethylene mulch and grown according to the North Carolina Extension Service and Southeastern US 2009 Vegetable Crops handbook recommendations (Holmes and Kemble, 2009; Sanders, 2004). The experiment was a randomized complete block design with 2 seasons, 14 cultigens, 3 replications, and 6 harvests (eight for the pickling cucumbers). The soil was an Orangeburg loamy sand (Fine-loamy, kaolinitic, thermic Typic Kandiudults). Plants were established by direct seeding into raised beds. Plots were single 6.1 m rows with 1.5 m alleys at each end. Beds were 1.5 m apart (center to center). Fertilizer consisted of 90–39–74 $kg \cdot ha^{-1}$ (N–P–K) broadcast preplant and 34–0–0 $kg \cdot ha^{-1}$ (N–P–K) side dressed at the two to four leaf stage. Curbit (active ingredient Ethalfluralin) (Loveland Products, Inc., Loveland, CO) was applied preemergence at the rate of 0.4 kg a.i./A. The plots were irrigated as needed for a total of 25–40 $mm \cdot week^{-1}$. Downy mildew was controlled by Previcur Flex (active ingredient Propamocarb hydrochloride) alternated with Tanos (active ingredient Famoxadone and Cymoxanil) beginning at the two true leaf stage.

Field plots were direct-seeded and thinned to 60 plants per plot. Dates for planting, thinning, and data collection in the field plots were the same as for the patio trials. Pickling cucumber trials were harvested eight times, twice per week. Fruit were weighed after sorting by diameter into No. 1 (0–26 mm), No. 2 (27–38 mm), No. 3 (39–51 mm), oversize, and cull (nubbins and crookeds) grades according to the recommendation of the North Carolina Pickle Producers Association (industry standard). Slicing cucumber trials were harvested six times, twice per week. Fruit were weighed after sorting by quality into Fancy, No. 1, No. 2, and cull grades according to U.S. Department of Agriculture (USDA) standards (USDA, 2016).

Fruit from patio and field trials were evaluated for shape rating, color rating, seedcell size rating, overall quality rating, length, length/diameter ratio (LD ratio), and firmness (pickling types only). Ratings for shape, color, seedcell, and overall quality were based on a 1 to 9 scale (1 to 3 = poor, 4 to 6 = intermediate, 7 to 9 = excellent). Firmness was measured on three No. 3 grade fruit using a Magness-Taylor tester with an 8 mm tip. LD ratio was calculated by measuring five No. 2 grade fruit. Slicer fruit length, diameter, and weight were recorded for three Fancy grade fruit per plot. Overall, quality was judged on all quality traits including shape, color, and seedcell.

Average monthly temperature and rainfall data were collected from the NC Climate Retrieval and Observations Network of the Southeast database (CRONOS) system (climate.ncsu.edu/cronos). Daily weather data were recorded at the Horticultural Crops Research Station using an ECONET tower maintained by the State Climate Office of North Carolina. Monthly temperature and rainfall averages were calculated directly through CRONOS.

Statistical analyses were conducted using the PROC MEANS, CORR, and GLM procedures of SAS statistical software package (SAS Institute, 2005). Traits evaluated included total yield (sum of harvests 1–8), early yield (sum of harvests 1–3), percentage marketable fruit, VL (harvests 1 and 8), gynoecious rating, PM rating (spring), and DM rating (summer).

Results

Significant differences were detected in the patio trial in plant characteristics, yield, and disease ratings among cultivars, planting densities, seasons, and replicates. Season had a significant effect for total (P = 0.0001), marketable (P = 0.044), and cull (P = 0.0001) yield across all eight harvests; total (P = 0.0001), marketable (P = 0.0001), and cull (P = 0.0103) for early yield (harvests 1–3); percentage marketable fruit (P = 0.001); and VL at harvest 1 (P = 0.0001) and 8 (P = 0.0026). Spring and summer seasons were analyzed separately for remaining analyses. When analyzed by season, cultivar was significant for every trait: total yield, early yield, percentage marketable fruit, VL at harvest 1, VL at harvest 8, gynoecious rating, PM rating, and DM rating. Planting density had a significant effect on total, marketable, and cull yield across all seven harvests, percentage marketable fruit, total and marketable early yield, and VL at harvests 1 and 8 in the spring season (Table 2). Planting density and its interaction with cultivar was not significant. During the summer season, planting density did not significantly affect VL (harvests 1 or 8), total early harvest, total and early marketable yield, total cull yield, gynoecious rating, or the percentage marketable fruit. Planting density did not significantly affect disease ratings for DM (summer season) or PM (spring season). During the summer season, there were not significant cultivar by planting density interactions for

Table 1. General characteristics of the 14 cucumber cultigens evaluated for growth in containers in two locations in North Carolina.

Cultigen	Vine type	Type	Sex expression
Slicing types			
Dasher II	Tall	Hybrid	Gynoecious
Marketmore 76	Tall	Inbred	Monoecious
Spacemaster	Dwarf	Inbred	Gynoecious
Bush Champion	Dwarf	Inbred	Monoecious
Bush Whopper II	Dwarf	Hybrid	Monoecious
Cherokee	Tall	Hybrid	Gynoecious
Pickling types			
Vlaspik	Tall	Hybrid	Gynoecious
NC-Danbury	Tall	Hybrid	Monoecious
NC-25	Dwarf	Inbred	Monoecious
M 27	Dwarf	Inbred	Monoecious
NC-74	Tall	Inbred	Monoecious
M 27 × NC-25	Dwarf	Hybrid	Monoecious
Picklebush	Dwarf	Inbred	Monoecious
Sumter	Tall	Inbred	Monoecious

Gynoecious has only pistillate flowers on the plant; monoecious has staminate followed by pistillate flowers.

Fig. 1. Patio cucumber trial using containers on a plastic mulch and drip irrigation at Horticultural Crops Research Station, Clinton, paired with field trial in the same location (not shown).

Table 2. Fruit yield and vine data for 14 cultivars, 3 densities, and 2 seasons tested in patio containers in North Carolina.

		Yield						Vine length H1 (mm)[z]		Vine length H8 (mm)[y]		Gynoecious rating (1 to 9)[x]	
	Density	Total (g/pot)		Early (g/pot)		Marketable (%)							
Cultigen	(plants/pot)	Sp[w]	Sm[v]	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm
Bu Ch[u]	1	1,572	136	386	34	80	8	515	331	948	646	3.5	4.3
	2	3,001	181	446	45	79	0	523	313	823	606	4.3	3.5
	3	2,253	91	401	—	80	0	442	280	782	613	3.5	3.5
Bu Wh II[t]	1	1,769	726	257	218	85	73	513	454	974	1,016	3.7	4.6
	2	1,837	711	189	189	84	58	492	402	1,006	1,014	4.0	4.5
	3	1,996	688	378	189	93	73	450	479	917	903	4.3	5.0
Cherokee7	1	1,981	835	696	318	73	38	832	541	1,134	904	7.0	7.2
	2	2,752	1,089	794	372	72	56	810	569	1,244	1,304	5.5	6.3
	3	2,661	896	771	408	78	68	697	548	1,052	1,085	5.8	5.8
Dasher II	1	2,253	703	816	159	79	78	868	598	1,065	1,380	8.0	6.7
	2	2,419	826	847	91	76	71	865	511	1,307	1,252	9.0	5.4
	3	2,555	998	794	287	80	72	713	572	1,048	972	7.0	7.3
NC-25	1	1,754	839	499	408	93	51	512	288	701	413	3.7	5.8
	2	1,557	1,134	454	476	93	76	465	275	652	475	4.8	4.0
	3	1,671	896	552	374	85	64	395	323	566	463	3.8	5.3
M 27	1	1,497	544	242	272	85	75	418	505	603	1,105	3.7	5.3
	2	1,633	560	423	243	80	58	397	445	623	903	3.8	5.2
	3	1,792	688	348	265	82	60	335	487	598	970	4.3	4.0
MM76[s]	1	2,132	696	333	136	95	84	735	523	1,221	1,072	4.2	4.7
	2	2,011	—	438	—	89	—	638	—	1,123	—	4.3	—
	3	2,344	786	401	83	90	88	555	438	1,046	1,137	5.2	4.0
NC-74	1	1,678	692	499	261	94	73	842	471	1,243	831	3.8	4.8
	2	1,671	567	499	249	95	81	787	526	998	978	3.7	4.8
	3	2,397	517	650	145	93	90	733	415	1,087	968	3.8	4.4
NC-Danbury	1	1,814	862	272	345	87	57	555	441	1,103	808	3.7	6.4
	2	1,996	1,168	461	386	96	83	545	481	999	989	4.0	6
	3	2,321	1,278	461	408	91	81	545	467	993	954	3.7	5.7
M 27 × NC-25	1	1,497	653	575	318	92	55	735	546	1,036	898	3.2	6.4
	2	1,973	567	635	219	91	57	732	443	932	687	3.7	4.3
	3	2,404	816	507	370	91	59	670	528	895	940	3.7	5.5
Picklebush	1	1,482	408	582	191	87	60	382	257	538	368	3.7	4
	2	2,003	544	620	257	90	36	377	290	529	367	3.7	3.7
	3	2,593	575	764	249	88	37	392	261	539	372	3.8	4.2
Spacem[r]	1	2,208	381	612	109	71	43	622	385	965	774	7.7	4.8
	2	2,510	257	711	53	73	6	567	373	870	828	7.5	5.5
	3	3,047	181	756	45	83	6	520	305	993	794	7.5	5
Sumter	1	1,399	559	537	257	92	61	905	587	1,259	1,156	4.0	5.2
	2	1,822	572	582	191	90	40	875	558	1,025	948	4.0	4.8
	3	2,011	801	688	325	86	58	773	549	1,055	1,070	3.5	4.3
Vlaspik	1	2,071	964	786	442	87	74	612	500	897	936	9.0	6.5
	2	1,996	771	862	325	91	79	483	427	652	762	9.0	6.2
	3	2,820	1,198	885	535	95	70	480	468	775	762	8.2	7.8
LSD (5%)	—	586	253	199	153	9	20	100	112	156	174	1.4	1.3

LSD = least significant difference.
[z]Vine length in mm at harvest 1.
[y]Vine length in mm at harvest 8.
[x]Gynoecious rating (1 to 9, 1 = androecious, 5 = monoecious, 9 = gynoecious).
[w]Spring season.
[v]Summer season.
[u]Cultivar Bush champion.
[t]Cultivar Bush Whopper.
[s]Cultivar Marketmore 76.
[r]Cultivar Spacemaster.

any of the traits evaluated with the exception of VL at harvest 8.

In this study, large differences were observed in cultivar performance between spring and fall seasons. Cultivars performed best in the spring season with an average yield 300% higher than the summer season (Table 2). Temperature during the spring season ranged from 24.2 to 30.4 °C for the maximum daily temperature and 9.4 to 23.2 °C for the minimum daily temperature compared with 26.6 to 29.8 °C and 19.8 to 22.7 °C for the maximum and minimum temperatures, respectively, in the summer season (Table 3). Planting density had a significant effect on yield, with the highest yield at three plants/container for only some of the cultivars evaluated (Table 2). Vine length was significantly shorter at the highest planting density. Of the cultivars tested, highest yielders were Cherokee, Dasher II, Marketmore 76, NC-Danbury, Spacemaster, and Vlaspik. The cultivars with the earliest yield were Cherokee, Dasher II, and Vlaspik. Those with the highest percentage of marketable fruit were ‘NC-Danbury’, ‘NC-25’, ‘Marketmore 76’, ‘NC-74’, and ‘Vlaspik’. The most gynoecious were ‘Dasher II’ and ‘Vlaspik’. Cultivars with longest vine at harvest 8 were Cherokee, Dasher II, Marketmore 76, and Sumter, and with the shortest vine was Picklebush.

Table 3. Monthly temperature (°C) and precipitation (cm) means, Clinton, NC.

Month	Maximum temp	Minimum temp	Avg temp	Total precipitation
May	24.2	9.4	18.5	8.94
June	28.3	17.8	23.9	12.6
July	30.4	23.3	26.6	14.15
August	29.8	22.7	26.0	9.83
September	26.6	19.8	23.9	6.17

Four of the top six yielding cucumbers (‘Cherokee’, ‘Dasher II’, ‘Marketmore 76’, and ‘Spacemaster’) and two of the top three early yielding cultivars were slicing types (Cherokee and Dasher II). Those cucumbers with the highest percentage marketable fruit were ‘Marketmore 76’ (slicing type), and ‘NC-Danbury’, ‘NC-25’, ‘NC-74’, and ‘Vlaspik’ (pickling type). Cultivars with the highest gynoecious rating were Dasher II slicer and Vlaspik pickler. ‘Bush Champion’ and ‘Spacemaster’ (slicing type) and ‘Picklebush’ (pickling type) were the most susceptible to PM. All pickling cucumbers evaluated in this study were resistant to DM except ‘M 27’ and ‘Picklebush’, and all slicing cucumbers were resistant except ‘Spacemaster’ and ‘Bush Champion’. The three gynoecious cucumbers ‘Vlaspik’, ‘Dasher II’, and ‘Cherokee’ (Table 2) were also the three highest early yielders (Table 5). The cultivars most susceptible to PM (spring season only) were Bush Champion, Picklebush, and Spacemaster. The cultivars most susceptible to DM (summer season only) were Bush Champion, M 27, Picklebush, and Spacemaster (Table 5).

Means of fruit quality traits in field trials [shape, color, seedcell size, overall quality, length, LD ratio, and firmness (pickling types only)] across both seasons were used to determine the cultivars with the best overall quality (Table 4). The highest quality pickling types were ‘NC-Danbury’, NC-74, ‘Sumter’, M 27 × NC-25 (not a cultivar), ‘Vlaspik’, and NC-25. The highest quality slicing types were ‘Marketmore 76’, ‘Bush Champion’ and ‘Dasher II’. The largest LD ratio pickling types were ‘Vlaspik’ and ‘NC-25’, ‘Sumter’, and ‘NC-Danbury’. The smallest LD ratio pickling types were ‘Picklebush’, M 27 × NC-25, M 27, and NC-74. The largest LD ratio slicing types were ‘Bush Whopper II’, ‘Cherokee’, and ‘Spacemaster’. The smallest LD ratio slicing types were ‘Bush Champion’ and ‘Dasher II’. The firmest cultivars were Sumter, NC-Danbury, NC-74, M 27 × NC-25, and Vlaspik.

Correlations between patio and field trials for sex expression and fruit yield (Table 5), and for vine and disease traits (Table 6) were

Table 4. Mean fruit quality for 14 cultivars and two seasons tested in field plots in Clinton, NC.

		Mean		Fruit shape		Fruit color		Seedcell		Overall quality		Fruit length		Fruit L/D		Fruit firmness	
Line	Overall mean	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm
Pickling type																	
NC-Danbury[z]	7.4	7.0	7.8	7.3	8.3	7.3	8.0	6.3	7.0	7.3	8.0	6.5	6.8	3.3	3.4	67	71
NC-74	7.3	7.4	7.2	7.7	8.0	7.7	7.0	7.3	7.3	7.3	6.3	6.0	5.5	3.0	2.7	71	76
M 27 × NC-25	7.1	7.1	7.1	7.3	7.3	7.3	7.0	6.7	7.0	7.3	7.0	6.4	5.7	3.2	2.8	67	67
Vlaspik	6.9	6.8	7.0	7.3	7.0	8.0	7.3	5.7	6.7	7.3	7.3	7.0	6.5	3.5	3.3	76	71
NC-25	6.8	7.1	6.4	7.3	6.7	7.3	7.3	6.7	5.7	7.3	7.0	7.6	6.6	3.8	3.3	62	58
Sumter	6.5	7.2	5.7	7.3	5.7	5.3	5.0	7.3	6.3	7.0	5.0	6.3	6.2	3.1	3.1	85	71
M 27	5.7	6.3	5.1	7.0	5.3	5.3	5.0	5.7	5.3	6.3	4.7	6.4	5.4	3.2	2.7	67	58
Picklebush	5.2	5.7	4.6	6.3	4.7	4.0	4.0	5.3	5.0	5.3	4.0	5.8	5.8	2.9	2.9	67	62
LSD (5%)	1.1	1.2	1.0	1.3	1.3	0.9	1.1	1.8	1.4	1.2	1.3	0.7	0.6	0.3	0.3	12	10
Slicing type																	
Marketmore 76	6.6	6.9	6.3	7.3	5.0	8.0	6	6.7	8.0	6.7	6.0	6.9	7.5	3.7	3.9	—	—
Bush Champion	6.6	6.1	7.0	6.0	6.7	6.0	6.7	6.3	7.3	6.0	7.0	9.1	8.2	3.5	3.8	—	—
Dasher II	6.3	6.7	5.9	7.0	5.3	8.0	6.7	5.7	6.3	7.3	6.0	8.1	7.3	3.6	3.3	—	—
Spacemaster	5.4	5.6	5.1	5.3	4.3	8.0	6.7	6.0	6.3	5.3	4.7	7.7	6.7	3.9	4.8	—	—
Cherokee	5.1	5.7	4.4	6.3	4.3	6.0	5.3	4.7	5.0	6.0	4.0	7.6	6.9	4.4	3.5	—	—
Bush Whopper II	3.7	7.3	—	7.0	—	9.0	—	8.0	—	7.0	—	9.1	—	4.5	—	—	—
LSD (5%)	1.1	1.1	1	1.4	1.4	1.1	1.4	1.5	1.3	1.4	1.2	0.9	0.7	0.4	0.3	—	—

LSD = least significant difference.
[z]Data are means of three replications summed over six harvests (eight harvests for the pickle trials). Mean quality is the average of shape, color, seedcell, and overall quality.

Table 5. Vine lengths and disease resistance for spring and summer patio and field trials for 14 cucumber cultivars.

	Vine length (mm) H1[z]				Vine length (mm) H8[y]				Powdery mildew				Downy mildew			
	Spring		Summer		Spring		Summer		Spring		Summer		Spring		Summer	
	P[x]	F[w]	P	F	P	F	P	F	P	F	P	F	P	F	P	F
Pickling type																
Sumter	773	1,055	549	1,070	750	975	885	1,028	1.0	2.0	—	—	—	—	3.8	6.0
NC-74	733	1,087	415	968	633	1,003	753	1,131	1.0	2.0	—	—	—	—	4.8	5.0
NC-Danbury	545	993	467	954	623	970	800	1,030	1.3	1.0	—	—	—	—	3.5	4.0
Vlaspik	480	775	468	762	577	915	753	980	1.0	1.0	—	—	—	—	3.8	5.0
M 27 × NC-25	670	895	528	940	527	883	843	1,007	1.0	2.0	—	—	—	—	4.2	5.0
NC-25	395	566	323	463	413	690	723	737	1.0	1.0	—	—	—	—	2.8	4.0
Picklebush	392	539	261	372	370	670	430	453	6.2	5.0	—	—	—	—	6.3	7.0
M 27	335	598	487	970	283	580	310	423	1.0	1.0	—	—	—	—	5.7	5.0
LSD (5%)	100	—	112	—	156	—	174	—	0.9	1.4	—	—	—	—	0.8	1.8
Slicing type																
Dasher II	713	1,048	572	972	780	1,097	1,197	1,567	1.0	2.0	—	—	—	—	3.0	4.0
Cherokee	697	1,052	548	1,085	770	1,437	1,217	1,513	1.0	2.0	—	—	—	—	3.0	6.0
Marketmore 76	555	1,046	438	1,137	623	1,302	1,110	1,457	1.0	4.0	—	—	—	—	3.5	4.0
Spacemaster	520	993	305	794	663	1,098	1,077	1,467	4.3	4.0	—	—	—	—	5.5	7.0
Bush Champion	442	782	280	613	430	775	623	850	5.5	3.0	—	—	—	—	5.0	7.0
Bush Whopper II	450	917	479	903	343	1,037	—	—	1.0	1.0	—	—	—	—	3.8	—
LSD (5%)	100	—	112	—	156	—	174	—	0.9	1.7	—	—	—	—	0.8	1.5
Correlation[v]	0.22 NS				0.66*				0.74**				0.66*			

LSD = least significant difference.
[z]Vine length in mm at harvest 1.
[y]Vine length in mm at harvest 8.
[x]Values for patio trial.
[w]Values for field trial.
[v]Correlation between patio and field data for spring and summer trials. Significance is indicated by *(P = 0.05), **(P = 0.01), or NS (nonsignificant).

evaluated. There were significant correlations between patio and field for total yield (r = 0.93), early yield (r = 0.73), and PM rating (r = 0.74). There were no significant strong ($r \geq 0.60$) correlations among traits in the patio trial (Table 7).

Discussion

Urban gardening has increased in popularity since the early 2000s as communities have embraced the local food movement. Gardeners are interested in cultivars that maximize yield and quality, while minimizing requirement for space. For cucumbers, most cultivars have a vining growth habit or concentrated harvest, characteristics undesirable to home gardeners. In this study, two dwarf-determinate cultivars 'NC-Danbury' and 'Spacemaster' were among the top six yielders. Neither was among the earliest to harvest because of their monoecious flowering habit. However, if the three gynoecious cultivars were excluded, four of the remaining early cultigens were dwarf-determinate type (M 27 × NC-25, NC-25, Picklebush, and Spacemaster). The dwarf-determinate cultigen NC-26 was among the top cultigens with the highest percentage of marketable fruit. The dwarf-determinate cultivars Picklebush, Bush Champion, and Spacemaster were highly susceptible to PM in the spring season. Those same cultivars plus M 27 were also susceptible to DM in the summer season. In this study, dwarf cucumber types performed as well as tall-indeterminate (vining) type.

Besides yield, fruit quality is important to consider. For home gardeners, LD ratio is less important than for commercial growers, but it may be used to compare fruit size among cultivars. Generally, pickling type cucumbers have a smaller LD ratio than slicing types. In this study, the smallest slicing type was longer than the longest pickling type. Firmness is an important trait

Table 6. Yield, marketable fruit, and gynoecious rating for spring and summer patio (three plants/pot planting density) and field trials for 14 cucumber cultivars.

	Total yield[z] (g/pot or Mg·ha^{-1})				Early yield[y] (g or Mg)				Marketable fruit				Gynoecious rating index[x]			
	Spring		Summer		Spring		Summer		Spring		Summer		Spring		Summer	
	P[w]	F[v]	P	F	P	F	P	F	P	F	P	F	P	F	P	F
Pickling type																
NC-Danbury	2,321	39.5	1,278	13.7	461	4.4	408	6.7	91	89	81	60	3.7	5	6	4
M 27 × NC-25	2,404	55.9	816	13.0	507	10.6	370	6.8	91	91	59	62	3.7	6	6	4
NC-25	1,671	42.3	896	11.9	552	8.9	374	6.4	85	79	64	48	3.8	7	5	4
M 27	1,792	26.4	688	1.4	348	1.1	265	0.7	82	87	60	20	4.3	4	4	2
NC-74	2,397	33.1	517	11.9	650	5.1	145	5.4	93	94	90	63	3.8	4	4	4
Picklebush	2,593	53.7	575	4.8	764	8.0	249	2.1	88	90	37	35	3.8	4	4	3
Sumter	2,011	49.1	801	8.2	688	7.9	325	2.9	86	85	58	37	3.5	5	4	3
Vlaspik	2,820	64.3	1,198	15.9	885	15.6	535	9.5	95	81	70	54	8.2	9	8	5
LSD (5%)	586	14.6	253	7.8	199	?	153	?	9	?	20	?	1.4	2	1	2
Slicing type																
Bush Champion	2,253	50.3	91	2.4	401	6.6	0	0.5	80	82	0	363	3.5	5	1	4
Bush Whopper II	1,996	25.2	688	—	378	0	189	—	93	82	73	—	4.3	3	5	—
Cherokee	2,661	65.5	896	15	771	24.9	408	9.9	78	84	68	42	5.8	4	6	5
Dasher II	2,555	63.6	998	17.2	794	19.4	287	12.3	80	92	72	71	7.0	7.0	7	6
Marketmore 76	2,344	33.2	786	4.5	401	2.2	83	0.5	90	96	88	73	5.2	3.0	4	4
Spacemaster	3,047	61.4	181	7.5	756	22.1	45	2.7	83	76	6	59	7.5	6.0	5	4
LSD (5%)	586	—	253	—	199	—	153	—	9	—	20	—	1.4	2.1	1	2
Correlation[u]	0.93**				0.73**				0.68*				0.51*			

LSD = least significant difference.
[z]Total yield measured as g/pot for patio trial using a 12 L container with three plants and Mg·ha^{-1} for field trial.
[y]Combined yield for the first three harvests measured as g/pot for patio trial using a 12 L container and Mg·ha^{-1} for field trial.
[x]Gynoecious rating based on a 1 to 9 scale (1 = androecious, 2 to 3 = andromonoecious, 4 to 6 = monoecious, 7 to 8 = predominately gynoecious, 9 = gynoecious).
[w]Values for patio trial.
[v]Values for field trial.
[u]Correlation between patio and field data for spring and summer trials. Significance is indicated by a *(P = 0.05), **(P = 0.01), or NS (nonsignificant).

Table 7. Pearson's correlation coefficient of plant traits evaluated for 14 cucumber cultivars in two seasons in patio trials.

	Density[z]	VL (H1)[y]	VL (H8)[x]	Gyn.R.[w]	PM[v]	DM[u]	Total yield	Early yield[t]	Marketable[s]	Cull[r]	E.Mark.[q]
VL (H1)	0.0114										
VL (H8)	–0.0715	0.5981***									
Gyn.R.	0.0152	0.1702***	0.1328***								
PM	0.1066	–0.2822***	–0.2719***	–0.0287							
DM	0.0586	–0.2926***	–0.4185***	–0.3009***	—						
Total yield	0.3234***	0.4615***	0.2257***	0.1328***	0.2481***	–0.4638***					
Early yield	0.2566***	0.5165***	0.0852	0.3199***	0.09493	–0.2066***	0.6736***				
Market.	0.2948***	0.4430***	0.2280***	0.0738	0.1703***	–0.4875***	0.9683***	0.6552***			
Cull	0.1874***	0.1846***	0.04798	0.2535***	0.26801***	–0.04495	0.36874***	0.23757***	0.12487***		
E.Mark.	0.2382***	0.4778***	0.06837	0.2296***	0.0827	–0.2414***	0.6714***	0.9477***	0.7009***	0.0587	
%Mark.[p]	0.04801	0.2991***	0.22973***	–0.0357	–0.1678***	–0.4158***	0.4954***	0.3840***	0.6310***	–0.3830***	0.5070***

LSD = least significant difference.
[z]Planting density.
[y]Vine length (mm) at Harvest 1.
[x]Vine length (mm) at Harvest 8.
[w]Gynoecious rating (1 to 9, 1 = androecious, 5 = monoecious, 9 = gynoecious).
[v]Powdery mildew rating (0 to 9, 0 = none, 9 = plant killed).
[u]Downy mildew rating (0 to 9, 0 = none, 9 = plant killed).
[t]Combined marketable yield for the first three harvests.
[s]Marketable yield.
[r]Yield of cull (crooked and nubbin) fruit.
[q]Marketable yield from the first three harvests.
[p]Percentage marketable yield.
Significant values are indicated as *(P = 0.05), **(P = 0.01), or ***($P \leq 0.001$).

for pickling types as firm fruit make better pickles. Firmness was measured only on pickling cucumbers in this study.

In terms of early yield 'Vlaspik' and 'Dasher II' were the best performing cultivars in this study. Both had high total yield, high early yield, and a high percentage of marketable fruit. Both 'Vlaspik' and 'Dasher II' are gynoecious cucumber types. If early yield is needed and a gynoecious type is being grown, then a monoecious type must be planted nearby to ensure fruit set. This is a downside to gynoecious cultivars because many gardeners may not want to deal with pollination issues. A solution for home gardeners is to choose a monoecious type, focusing on cultivars having high yield and early maturity.

For container gardeners not concerned with early yield and more interested in a continuous harvest, the best cultivars in our study were Marketmore 76 (tall, monoecious, slicing type) and NC-Danbury (tall-indeterminate, monoecious, pickling type). Both were among the top producers, had a high percentage of marketable fruit, and were moderately resistant to PM and DM.

Many container gardeners prefer to grow dwarf-determinate cultivars because they are easier to fit in a limited space. If a gardener wanted to grow a dwarf cucumber, the best performing cultivars in this study were NC-25 and Spacemaster (monoecious, slicing type). 'NC-25' had high total yield and percent marketable fruit. 'Spacemaster' had high total yield but was susceptible to PM and DM. If a gardener would rather choose a tall type, the best performing tall pickling type in this study was 'Vlaspik'. The best tall slicing types were 'Dasher II' and 'Marketmore 76'. All the cultivars suggested earlier had high quality ratings. The pickling types suggested had acceptable firmness measurements.

Based on the results of this study, the best time to plant container cucumbers is in the spring. The highest marketable yield of the spring and summer trials differed significantly. Some of this was due to the high incidence of DM and to the higher temperatures during the summer. Generally spring is a better time to plant cucumbers as disease and temperature stress is reduced during this time.

Highest marketable yield was obtained using three plants per 12 L container rather than one or two for some of the cultivars. Although cucumbers appear to grow well with 4 L of soil volume per plant, optimal production will vary by cultivar. Because we only tested three densities, it cannot be concluded that three plants per 12 L container is the best density to grow cucumbers as we did not test higher densities such as four or five plants per 12 L pot or larger pots, which could have possibly resulted in a better yield.

The correlations between patio and field trials for total yield, early yield, and PM suggest that cucumber performance in the containers could be predicted using data from field trials. This allows home gardeners to use trial results from extension leaflets and trial summaries intended for commercial producers in their area to choose cultivars for use in their container garden. There were no strong correlations among traits in the patio trial. Thus, it may not be possible to measure fewer traits as each trial appears to measure a separate aspect of cultivar performance.

Because this study did not include all possible cultivars, specific cultivar recommendations cannot be made. Instead, based on our findings in this study, we recommend that cucumber cultivars with specific qualities be used in containers to obtain the best performance. Whether grown in soil beds or containers, cucumber cultivars should have the following traits: high yield, early maturity, high fruit quality (high percentage of marketable fruit), and disease resistance. In addition, when grown in a container, the cultivar should also have the following traits: dwarf growth habit, pickling type (no need for peeling), and monoecious type (no pollinizer required). The cultivars in this study that had those specific traits were NC-74, NC-25, M 27 × NC-25, and Bush Whopper II.

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