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Evaluation of Oriental Trellis Cucumbers for Production in North Carolina

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Abstract. **Eighteen cucumber *(Cucumis sativus L.)* cultivars (15 oriental trellis and three standard American slicers) were grown on trellis and flat-bed production systems during the spring and summer seasons of 1995. Vine, flower, fruit quality, keeping ability, and yield traits were measured. Vine length, incidence of powdery mildew, fruit shape, fruit quality, fruit firmness, yield of Fancy plus No. 1 grade slicer fruits, marketable yield, and percentage of culled fruits were all higher when cultivars were grown on trellis support. Anthracnose damage, fruit length, fruit diameter, average fruit mass, fruit color, overall impression, fruit shriveling, seedcell size, branch number, percentage of staminate nodes, and total yield were not significantly affected by production system. The best cultivars for marketable yield (mass of Fancy, No. 1 and 2 grade slicers) were 'Summer Top', 'Tasty Bright', and 'Sprint 440' on trellis support and 'Sprint 440' and 'Poinsett 76' on flat bed. The cultivars with the best fruit quality were 'Tasty Bright', 'Summer Top', and 'Sprint 440' on trellis and 'Poinsett 76', 'Sprint 440', and 'Tasty Bright' on flat bed. The best cultivars overall on the trellis production system were 'Sprint 440', 'Summer Top', 'Tasty Bright', and '89-211', and the worst were 'Sky Horse', 'Hongzhou Green 55', and 'Fengyan'. The best cultivars overall on the flat bed were 'Poinsett 76', 'Sprint 440', and '89-211', while the worst cultivars were 'Sky Horse' and 'Hongzhou Green 55'.**

The major types of cucumbers grown for fresh-market consumption worldwide are American slicers, Dutch greenhouse slicers, middle-eastern slicers ('Beit Alpha' type), and oriental trellis slicers. American pickling cucumbers also are increasingly being used for fresh consumption in the United States because their fruits are smaller and thinner skinned than American slicer fruits. The primary differences among the four major types of cucumbers for fruit characteristics are fruit length, skin color, and fruit surface. Middle-eastern cucumber is generally lightest in color, while American slicing cucumber is darkest. Oriental trellis cucumbers may have large ridges on the fruit surface, American pickling and slicing cucumbers have prominent warts, and middle-eastern cucumbers have a smooth or dimpled surface. Oriental trellis slicers also have the greatest length : diameter (LD) ratio, while American pickling type has the smallest LD ratio (Wehner and Horton, 1986). All cucumber types have thin-skinned fruits except for the American slicer, which was bred for a thick skin for good keeping ability and protection during shipping.

Cucumbers in the United States are usually grown flat on the ground (American pickle and slicer types), trained on trellises (American slicer type) in the field, or with trellis support in greenhouses (Dutch greenhouse type). In this study, flat-bed system will refer to cucumber production on the ground as opposed to trellis. Cucumbers grown in the southern United States are usually grown on raised, shaped beds with centers 0.9 to 1.2 m apart. In the mountains of western North Carolina, American slicers are often grown using a field trellis system. Dutch cucumbers offer high fruit quality because of their thin skin and seedlessness (parthenocarpic fruit development). However, the additional costs associated with the production of Dutch greenhouse cucumbers (greenhouse heating and cooling, trellis construction, and special postharvest handling) make them more expensive to produce than the American slicer.

Although oriental trellis cucumbers are grown in greenhouses in some parts of Asia, they can also be produced outdoors on field trellises as a cheaper alternative to Dutch greenhouse cucumbers. However, oriental trellis cucumbers have not been grown commercially in the United States, and production methods have not been developed.

Some of the potential advantages of growing oriental trellis cucumbers for fresh-market sales in the United States include improved fruit quality and yield, lower cost of fruit production compared to the Dutch greenhouse cucumber, and expanded marketing opportunities in the oriental market in the United States.

Some of the advantages reported for growing cucumbers on a trellis compared to a flat bed are higher yields, improved fruit quality, better control of diseases and pests, less damage to vines during harvest, and easier harvesting of the fruits (Sanders and Davis, 1990). Konsler and Strider (1973) reported that trellising of field-grown, fresh market cucumbers increased fruit yield and quality, and provided better control of foliar and fruit diseases. Hanna et al. (1987) reported that trellising of cucumbers increased yield, pistillate flower number, leaf size, fruit fresh mass, and net photosynthesis, while reducing the incidence of belly rot (*Rhizoctonia solani* Kuhn). Hanna (1993) reported that cucumbers could be double-cropped after staked tomatoes (*Lycopersicon esculentum* Mill.) to provide an easy and inexpensive method for supporting the cucumbers on the tomato vines and trellises. In that system, yield of premium grade cucumbers was not reduced relative to a single-cropped system, although total yield was reduced. Hanna et al. (1989) also reported that double cropping tomato and cucumber permitted the grower to distribute the cost of trellising over crops and seasons.

The objective of this experiment was to evaluate 15 cultivars of oriental trellis cucumber, along with three cultivars of American slicing cucumber for comparison, for their performance on trellis vs. flat-bed production systems for plant development, fruit quality, and yield. We were specifically interested in whether trellis cucumber production could be successful in areas outside of the Appalachian mountains of North Carolina. In addition, we wanted to determine which oriental cultivars were best, and whether there were any obvious weaknesses that might be improved by breeding.

Materials and Methods

The experiment was conducted during the spring and summer seasons of 1995 at the Horticultural Crops Research Station near Clinton, N.C.

Cultivars evaluated. Eighteen cultivars were evaluated, 15 oriental trellis cucumbers and three American slicers. The American slicers were 'Sprint 440', 'Poinsett 76', and 'Marketmore 76'. The oriental trellis cucumbers were 'Jin Chun #4', 'Jin Za #2', 'Jin Yan #4' (Tianjin Academy of Agricultural Sciences, Tianjin, 300192, P.R. China); 'XZ #17' (Academy of Agricultural Sciences, Shanghai, 201106, P.R. China); 'BAU #14' (Beijing Agricultural Univ., Beijing, 100094, P.R. China); 'Tasty Bright', 'Tasty Green' (Sakata Seed America, Morgan Hill, Calif. 95037); 'Summer Top' (American Takii, Salinas, Calif.); 'Sky Horse', 'I-109', '89-211' (Japan); 'Fengyan' (Taiwan), 'Yangzhou String', 'Yangzhou Green Skin' (Yangzhou, PRC); and 'Hongzhou Green 55' (Hongzhou, PRC).

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We used three replications per entry in each season. Each cultivar was planted in single-row plots, each 6.1 m long. Each plot was planted with 50 seeds, which were thinned over a 4-week period to 40 plants per plot. The experiment was planted in the two seasons on 1 May 1995 and 13 July 1995. In previous cucumber performance trials in North Carolina, the greatest information (1/variance) was provided by using years or seasons, rather than locations or blocks, for the replication effect (Swallow and Wehner, 1989).

Cultural practices. The experiment was conducted using recommended cultural practices (Schultheis, 1990). Fertilizer was incorporated before planting at a rate of 90N–39P–74K kg·ha^{-1}; additional N (34 kg·ha^{-1}) was applied as a side-dressing at the vine tip-over stage (four to six true leaves). Seeds of all cultivars were planted on raised, shaped beds with centers 1.5 m apart. The soil was an Onslow loamy fine sand (fine-loamy, siliceous, thermic; Spodic Paleudults) with a pH of 6.4. Irrigation was applied using a drip system (lowflow 'T-Tape'; T System International, San Diego, Calif.) to maintain soil moisture above –20 cb throughout the growing season, for the cucumbers on trellis support. Overhead irrigation was applied when needed for a total of 25 to 40 mm per week (including rainfall) for cucumbers growing on the flat-bed system. Cucumbers grown on both trellis and flat-bed systems received adequate moisture to prevent stress, and to provide conditions typical of the two systems. A tank mix of 2.2 kg·ha^{-1} of naptalam {2-[(1-naphthalenylamino) carbonyl] benzoic acid} and 4.4 kg·ha^{-1} of bensulide (O,O-bis(1-methylethyl) S-{2-[(phenylsulfonyl) amino] ethyl} phosphorodithioate) was applied preplant for weed control.

Wooden posts 0.15 × 0.15 × 2.1 m (4" × 4" × 8') long, erected in holes 0.6 m deep, were used as supports for the trellis system. Spacing between posts was 3.0 m. The total length of each row on trellis was 60 m, with a total of 6 rows. Two steel wires of 2 mm diameter (9 gauge) were run across the posts on each row 0.1 m and 1.5 m above the ground, and the wires were attached to steel anchors at the ends of each row. Plants were then trained onto cotton twine attached to the top and bottom wires, with a spacing of ≈0.08 m between adjacent twines.

Traits measured. Percentage of staminate nodes, vine size, and vine length were recorded 7 weeks after planting (27 June and 24 Aug. 1995); branch number and disease ratings were recorded at the full flowering stage about 10 weeks after planting (18 July and 14 Sept.).

Vine length was measured on three plants per plot by taking the length of the vine from soil to growing point of the main stem. Branch number was the total number of branches per plant. Percentage of staminate nodes were measured on the first five nodes of five plants per plot 7 weeks after planting (26 June and 31 Aug. 1995). Predominantly gynoecious plants had few or no staminate nodes.

The plants in each plot were rated for disease (anthracnose and powdery mildew) 10 weeks after planting. Disease ratings were rated visually on a 0 to 9 scale (0 = no foliar symptoms, 1 to 2 = trace, 3 to 4 = slight, 5 to 6 = moderate, 7 to 8 = advanced, 9 = plant dead). The rating system was adapted from the categories described by Thompson and Jenkins (1985).

First harvest occurred about 8 weeks after planting, and plants were harvested twice weekly (Monday and Thursday) for a total of seven harvests (26 June to 16 July and 31 Aug. to 21 Sept. 1995). Fruits were graded according to U.S. Dept. of Agriculture standards for Fancy, No. 1, No. 2, and cull before weighing. Fancy plus No. 1 fruits were straight, with no curve, constriction, or taper; No. 2 fruits had a slight curve, constriction, or neck; and cull fruits were crooked or nubbined.

Fruits were rated for quality in harvests two, four, and six of a total of seven harvests per season. Fruit quality traits included length, diameter, fruit shape, seedcell size, fruit color, overall impression, and comments on defects observed using three or more typical fruits per cultivar. Fruit color was rated on a scale of 1 to 9 with 1–3 = light green, 4–6 = medium green, and 7–9 = dark green. Fruit shape, seedcell size, and overall impression were rated on a scale of 1 to 9, with 1–3 = poor, 4–6 = intermediate, and 7–9 = excellent. Early yield was measured as the mass of Fancy plus No. 1 grade fruits in the first two harvests (8 weeks after planting).

Three fruits per cultivar from harvests three, four, and five were evaluated for keeping ability following storage in Kraft paper bags at room temperature (23 ± 2 °C). Fruit mass was measured before storage and after 2 weeks when the fruits were rated for shriveling, disease, and firmness. Shriveling and disease were measured on a 0 to 9 scale, with 0 = none, 1–3 = slight, 4–6 = moderate, and 7–9 = advanced. Firmness was the amount of force (N) required to penetrate the exocarp (skin) and mesocarp (flesh) with an 8-mm-diameter tester (McCormick Fruit Tech, Yakima, Wash.).

A simple weighted index (SWI) was calculated for each cultivar using the formula SWI = 0.10 × (marketable yield/3.3) + 0.20 × (Fancy and No. grade 1 yield/1.5) + 0.20 × (early yield) + 0.14 × fruit shape + 0.06 × fruit color + 0.10 × seedcell + 0.05 × overall impression of fruit + 0.14 × disease resistance + 0.01 × anthracnose resistance.

Data analysis. The treatments were arranged as a split-plot in a randomized complete-block design with three replications. Season X support were main plots, and the 18 cultivars were subplots. There were 40 plants per plot, and a total of 54 field plots per season. Thus, each season had two systems with three replications of 18 cultivars each. Data were analyzed using the GLM and CORR procedures of SAS (SAS Institute, Cary, N.C.).

Results

Vine and flowering traits. Vine length gives an indication of how well the cultivars made use of the trellis support by growing vertically. Significant differences were observed between both production systems (longer vines on the trellis), and seasons (longer vines in the spring) (Table 1), and among cultivars for vine length (Table 3). Most oriental trellis cultivars had longer vines than the American slicers. Season and cultivar had significant effects on branch number per plant (Tables 1 and 3).

The percentage of staminate nodes in the plant was affected greatly by season, staminate nodes being higher in the summer (Table 1). The percentage of staminate nodes was not affected by support system (Table 1). Cultivars ranged from 8% to 81% staminate nodes (Table 3).

Disease resistance. No differences were observed between the two types of support systems and the two seasons for incidence of anthracnose (Table 1). Most oriental trellis cultivars were susceptible to anthracnose, with the exception of 'Hongzhou Green 55' and 'Jin Yan #4', when grown on trellis support (Table 3). The ratings for powdery mildew were made only in the summer growing season, since there was no powdery mildew incidence in the spring. Powdery mildew incidence was high on cultivars grown on trellis support (Table 1). Most of the oriental trellis cultivars were more susceptible to anthracnose and powdery mildew than were the standard American cultivars (Table 3).

Fruit traits. Fruit length was not affected by season or production systems (Table 1). Oriental trellis cultivars produced the longest fruits in both seasons and production systems (Table 2). 'Sky Horse' was the only oriental trellis cultivar that resembled the American type in fruit length (Table 2). The cultivars with the longest fruits over both seasons were 'BAU #14' and 'Jin Chun #4'. Fruit diameter was similar in both production systems (Table 1), but was greater during the spring season for all cultivars (Tables 1 and 2). Fruit diameter in American cultivars was greater than in oriental cultivars in both seasons and production systems. The cultivars with the largest fruit diameter were 'Sprint 440', 'Poinsett 76', and 'XZ #17' (Table 2).

No significant difference in fruit mass was observed between production systems or seasons (Table 1). Fruit mass was highly dependent on cultivar, the cultivars with the highest mass being 'BAU #14', 'Jin Chun #4', and 'Summer Top' (Table 2). Fruit color was darker green in summer than in spring, but was not affected by support (Table 1). Most of the American cultivars tested had dark green fruit color (Table 2). Differences were evident among cultivars for fruit defects: some of these defects, such as ridges, necks, and yellow-green color on fruits, would be acceptable in Asia (Table 2).

Seedcell size was not affected by support, but was smaller in summer than in spring in all cultivars (Table 2). The cultivars with the smallest seedcells were 'Sprint 440', '89-211', and 'Tasty Bright'; 'Sky Horse' had the largest seedcells (Table 2).

There were differences between the production systems for quality and fruit shape. Fruit quality for all cultivars was higher on

trellis support (Table 1). The cultivars with the best fruit quality on trellis support (averaged over both seasons) were 'Sprint 440', 'Tasty Bright', 'Summer Top', and 'Poinsett 76' (Table 2). The American cultivars had the highest fruit quality regardless of production system or season grown (Table 2). Fruit shape was better in summer than in spring, and better on trellis than on flat bed (Table 1). Of the oriental cultivars tested, 'Tasty Bright' and 'Summer Top' ranked high for fruit shape over both seasons and production systems (Table 2).

Overall impression was not significantly affected by season or support (Table 1). On trellis support, the cultivars with lowest overall impression were 'Sky Horse' and 'Yangzhou String' (Table 2).

Keeping ability trait. Fruit firmness was greater in the spring season, and on trellis support (Table 1). The American cultivars had better fruit firmness than many of the oriental trellis cultivars, especially in the spring season (Table 2). Season had a large effect on fruit shriveling in the keeping ability test, where shriveling was greater in fruits grown in spring than in those grown in summer (Table 1). Support had no effect on fruit shriveling (Table 1). Most of the American cultivars tested exhibited little shriveling during storage. The cultivars with the least amount of shriveling over both seasons were 'Sprint 440', 'Poinsett 76', 'Tasty Bright', and 'Marketmore 76' (Table 2).

Yield traits. Highly significant differences were observed between the two production systems for yield of Fancy plus No. 1 grade fruits, marketable yield, and percentage of culls (Table 1). Cultivars grown on trellis support during spring performed best for all seasons and support systems. Marketable yield varied between the two growing seasons. Highly significant differences were observed for the interaction of season and support for the yield of Fancy plus No. 1 grade, marketable and total yield.

Total yield over both seasons was 21% higher on trellis support. Total yield on trellis was 96% higher during the spring season than during the summer season. However, yield on flat beds was 42% less during the spring season than during the summer season. The cultivars with the highest yields on trellis support were 'Summer Top', 'Tasty Bright', and '89-211' (Table 3).

The yield of Fancy plus No. 1 grade cucumber fruits was 58% higher on trellis than on flat bed, and 23% higher in spring than in summer. The yield of Fancy plus No. 1 grade fruits was 164% higher on trellis support during spring, but 7% lower during summer, compared with the flat-bed production system. The yield of Fancy plus No. 1 grade fruits was lower in the spring than in summer when cultivars were grown on the flat-bed support system (Table 3).

Most of the oriental trellis cultivars were lower yielding when grown on a flat-bed system. This was probably due to the lack of trellis support, but could also be due to differences in irrigation system, or some other effect. However, we were interested in evaluating cultivar performance under the two standard production systems, and were not attempting to compare irrigation or other treatments. The American cultivars yielded more Fancy plus No. 1 grade fruits on flat bed during summer (Table 3). The cultivars that yielded best on trellis support were 'Summer Top', 'Tasty Bright', and 'Sprint 440' (Table 3). The best cultivars over both production systems for yield of Fancy plus No. 1 grade cucumbers were 'Poinsett 76', 'Sprint 440', 'Summer Top', 'Tasty Bright', and 'Jin Za #2'.

Marketable yield (mass of Fancy, No. 1, and No. 2 grades) for all cultivars was 43% higher on trellis than on the flat-bed system (Table 1). Marketable yield was 125% higher on trellis during spring, and 22% higher on flat-bed system during summer. Oriental trellis cultivars had low marketable yield when grown on flat bed. The American cultivars produced more marketable yield on flat bed during summer (Table 3). The best cultivars overall for marketable yield were 'Sprint 440', '89-211', 'Summer Top', 'Poinsett 76', 'Tasty Bright', and 'Jin Za #2' (Table 3).

Percentage of culls was 14% higher for cultivars grown on flat bed than for those grown on trellis (Table 1). The cultivars with the lowest percentage of culls were 'Poinsett 76', 'Sprint 440', 'Marketmore 76', 'Tasty Bright', and '89-211' (Table 3).

Trait indexes. A high simple weighted index (SWI) for a cultivar indicates good performance for the major traits (yield of Fancy plus No. 1 grade fruits, marketable yield, fruit shape, fruit skin color, seedcell size, overall impression, and disease resistance). Interaction between season and support system influenced SWI (Table 1). The cultivars with the highest SWI over seasons and support systems were 'Poinsett 76', 'Sprint 440', 'Tasty Bright', and 'Summer Top'; those

Table 1. Effects of season and support system on cucumber vine, fruit, yield and keeping ability traits in Clinton, N.C., in 1995.[z]

	Season				Means for:				F ratio		
	Spring		Summer		Support		Season				
Trait	Trellis	Flat	Trellis	Flat	Trellis	Flat	Spr.	Sum.	Support	Season	Ssn × Spt
Vine											
Length	32.0	26.6	20.3	21.4	26.1	24.0	29.3	21.0	6.7*	108.1**	15.9**
Branch number	11.0	10.0	7.0	11.0	9.0	10.0	10.5	9.0	5.7	2439.4**	1.3
% stam. nodes	58.6	53.8	60.5	69.8	59.6	61.8	56.2	65.2	0.6^{NS}	12.3**	7.5*
Disease ratings											
Anthracnose	6.7	7.1	5.6	5.7	6.1	6.4	6.9	5.7	5.7^{NS}	0.2^{NS}	0.1^{NS}
Powdery mildew	---	---	5.2	2.1	5.2	2.1	---	3.7	---	98.6**	---
Fruit quality											
Length (mm)	297	279	279	290	288	284	288	285	0.9^{NS}	0.5^{NS}	13.6**
Diameter (mm)	47	48	45	46	46	47	48	46	1.9^{NS}	6.2*	0.1^{NS}
Fresh mass (g)	400	372	345	377	372	374	386	361	0.05^{NS}	0.8^{NS}	2.0^{NS}
Color	6.4	6.2	7.1	6.8	6.8	6.5	6.3	7.0	4.3^{NS}	22.8**	0.2^{NS}
Seedcell	5.2	5.4	6.2	5.7	5.7	5.6	5.3	6.0	0.9 ^{NS}	6.5*	3.1^{NS}
Average quality	5.5	5.4	6.3	5.6	5.9	5.6	5.5	6.0	4.3*	5.7^{NS}	3.1^{NS}
Shape	5.4	5.2	6.3	5.7	5.8	5.4	5.3	6.0	3.5*	9.3*	0.5^{NS}
Overall impression	5.9	5.8	6.3	5.5	6.1	5.5	5.9	5.9	3.4^{NS}	0.03^{NS}	2.9^{NS}
Keeping ability											
Firmness	58.9	51.6	53.1	47.4	56	49.5	55.3	50.3	6.8*	10.9^{NS}	0.2^{NS}
Shriveling	5.8	6.3	3.3	4.9	4.6	5.6	6.0	4.1	14.3**	4.0^{NS}	1.0^{NS}
Fruit yield (Mg·ha^{-1})											
Fancy + No. 1	7.4	2.8	4.0	4.3	5.7	3.6	5.1	4.2	21.0**	4.5^{NS}	26.8**
Marketable	17.8	7.9	8.7	10.6	13.3	9.3	7.9	9.7	11.1*	6.9*	24.2**
Total	24.3	12.4	12.6	17.9	18.4	15.2	8.4	15.3	3.0^{NS}	3.6^{NS}	22.3**
% cull	31.8	29.7	42.5	35.4	37.2	32.5	15.8	39.0	14.6**	2.0^{NS}	0.1^{NS}
SWI[y]	3.8	3.0	3.8	4.1	3.8	3.6	3.4	4.0	1.8^{NS}	5.6^{NS}	9.1*

[z]The experiment had two seasons (spring vs. summer), two supports (trellis vs. flat), and three replications. Shape, color, seedcell size, and overall impression were rated 1–9 (1 = poor shape, light color, large seedcell, or poor impression, 9 = excellent shape, dark color, small seedcell, or excellent impression).

[y]SWI = Simple weighted index for yield and fruit quality.

^{NS,*,**}Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

with the lowest SWI were 'Sky Horse', 'Yangzhou String', 'Fengyan', and 'Hongzhou Green 55' (Table 3).

Discussion

Highly significant differences were observed for the following traits between summer and spring seasons: vine length, branch number, percentage of staminate nodes, fruit shape, fruit color, seedcell size, fruit diameter, fruit shriveling, fruit firmness, and marketable yield. Traits that were greater for cultivars grown on trellis were vine length, fruit shape, fruit firmness, fruit quality, powdery mildew susceptibility, yield of Fancy plus No. 1 grade fruits, marketable yield, and percentage marketable fruits.

Konsler and Strider (1973) reported that use of trellises for American slicing cucumber cultivars increased total yield by 100%, decreased the percentage of culls by 50%, gave good control of foliar and fruit diseases, and increased fruit quality. Our results indicated that, while trellising increased the yield of cultivars, it did not reduce the incidence of foliar diseases or the percentage of culls. Season played an important role in disease incidence; anthracnose was most prevalent in the spring season, and powdery mildew in the summer.

Hanna and Adams (1987) reported that trellises significantly increased marketable yield, total yield, fruit quality and fruit set, and reduced the incidence of belly rot (*Rhizoctonia solani* Kuhn), but did not affect yield of Fancy plus No. 1 grade fruits or number of pistillate flowers in comparison with a flat-bed system. Our results agree with theirs in that marketable yield and fruit quality were greater on trellis support. Our results also indicated that the percentage of staminate nodes was similar regardless of the support system. However, our results differed from theirs in that the yield of Fancy plus No. 1 grade fruits increases when cultivars were grown on trellis support.

Sanders and Davis (1990) reported that trellising of cucumbers improved the percentage of marketable fruits, fruit quality, fruit color, and fruit shape. Those results were similar to ours for most traits. A notable exception was disease incidence: we found differences only in the incidence of powdery mildew between the different support systems.

The increase in the marketable yield of cultivars on the trellis system may be due to an increase in the photosynthetic activity of the plants, because of larger leaf size on the trellis support system. Hanna and Adams (1987) reported an increase in the photosynthetic rate in cultivars that were vertically trained. The increase in the yield of Fancy plus No. 1 grade fruits may have been due to easier harvesting of fruits at the proper stage from trellises, resulting in fewer cull and oversized fruits. Improved fruit quality on trellis may have been associated with reduced contact with the soil, or to reduced shading from the vines.

Table 2. Fruit quality, keeping ability, fruit characteristics and comments data for cucumber cultivars on trellis (ranked by average quality) in Clinton, N.C., in 1995.

No.	Cultivar	Avg quality	Seedcell	Shape	Overall Impression	Firmness (N)	Shriveling	Length (mm)	Diam (mm)	Avg mass (g)	Fruit color	Defect[z] 1°	Defect[z] 2°
						Spring							
1	Sprint 440[y]	7.2	7	7	8	68	3	207	52	345	8	T	X
2	89-211	6.8	8	6	7	68	6	329	43	400	7	X	D
3	Tasty Bright	6.7	6	6	8	71	2	319	45	459	8	M	O
4	Poinsett 76[y]	6.4	6	7	7	64	4	185	48	254	7	X	A
5	Summer Top	6.4	5	7	7	73	6	333	50	558	7	X	T
6	Yangzhou Grn. Skin	6.3	6	6	7	53	8	284	50	368	8	K	T
7	BAU #14	6.0	7	5	6	71	6	370	47	527	7	X	J
8	Marketmore 76[y]	6.0	6	6	6	62	4	202	50	345	7	M	T
9	Jin Chun #4	5.4	5	5	6	59	6	367	47	440	8	K	K
10	Jin Yan #4	5.2	4	5	6	56	6	361	45	409	7	K	T
11	XZ #17	5.2	5	5	5	65	6	303	53	427	5	K	K
12	Tasty Green	5.0	5	5	5	47	7	318	45	363	5	D	X
13	I-109	4.8	4	5	5	59	6	301	48	413	7	S	A
14	Fengyan	4.7	3	5	5	46	8	283	45	336	6	J	X
15	Yangzhou String	4.7	6	4	4	42	8	338	43	400	3	T	K
16	Hongzhou Green 55	4.6	4	5	5	64	6	289	47	400	6	Y	M
17	Jin Za #2	4.4	4	5	5	59	5	337	45	404	5	X	K
18	Sky Horse	3.8	3	4	4	34	8	220	49	322	5	A	T
Seasonal mean		*5.5*	*5.2*	*5.4*	*5.9*	*58.9*	*5.8*	*297*	*47*	*400*	*6.4*	---	---
						Summer							
1	Tasty Bright	7.8	8	8	7	62	2	287	44	395	8	M	X
2	Sprint 440[y]	7.4	7	7	8	58	2	196	50	313	8	X	C
3	Poinsett 76[y]	7.1	6	7	8	61	2	181	50	277	7	K	X
4	Marketmore 76[y]	6.9	7	6	8	70	2	187	46	268	8	K	T
5	Summer Top	6.9	7	7	6	64	3	293	45	381	8	X	T
6	Jin Chun #4	6.6	7	6	6	55	2	356	46	427	8	X	D
7	XZ #17	6.6	6	7	7	52	4	296	48	341	7	P	D
8	Jin Yan #4	6.4	6	6	8	59	3	315	46	422	7	M	Y
9	Yangzhou Grn. Skin	6.3	7	7	5	47	5	262	42	295	8	K	T
10	Jin Za #2	6.2	6	6	7	49	3	340	43	395	6	A	X
11	Tasty Green	6.2	6	6	6	43	4	314	42	372	7	D	X
12	BAU #14	6.1	6	5	7	56	3	358	45	454	7	A	X
13	I-109	6.1	6	6	6	56	4	263	45	331	7	M	D
14	89-211	6.0	6	7	6	61	2	306	42	354	7	A	X
15	Fengyan	5.7	6	7	4	39	4	258	44	300	7	A	X
16	Hongzhou Green 55	5.3	5	6	5	34	6	278	46	336	8	X	C
17	Yangzhou String	4.9	5	5	5	40	4	300	35	277	4	P	K
18	Sky Horse	4.2	4	4	4	49	4	241	45	286	7	X	I
Seasonal mean		*6.3*	*6.2*	*6.3*	*6.3*	*53.1*	*3.3*	*279*	*45*	*345*	*7.1*	---	---
LSD (5%)		0.7	1.2	0.8	1.2	9.8	1.6	24.8	3.5	91	0.7	---	---
Overall mean		5.9	5.7	5.8	6.1	56	4.6	288	46	372	6.8	---	---
CV (%)		11	18	12	17	15	31	8	7	17	9	---	---

[z]Primary and secondary defects were rated in harvests 2, 4, and 6 as follows: A = warty fruit, C = crooks excessive, D = dogbone shape, I = striped, J = ridged, K = keep (excellent), M = mottled fruit, O = off type fruit, P = placental hollows, S = separated carpels, T = tapered ends, X = necks on fruit, Y = yellow fruit.
[y]American slicers (all others are oriental trellis cucumbers).

Some of the disadvantages of trellis production for cucumbers are the high cost of erecting trellises, the labor required for training and pruning, and the extra work of field cleanup at the end of the season (Sanders and Davis, 1990). Cost can be reduced by double cropping cucumber with tomato or other high value crops that would benefit from the use of trellis support. Hanna et al. (1989) reported that double cropping tomatoes and cucumbers minimized the cost of trellising cucumbers. In a later study (Hanna, 1993), the practice did not affect premium yield in the presence of the tomato skeleton on the trellis support, although total yield was reduced. He used a 0.3-m spacing between plants in the presence of the tomato skeleton, and recommended the planting of two rows of cucumber per tomato row for increased yield. Russo et al. (1991) reported that the total material costs of the trellis, excluding the cost of labor required for erecting and dismantling the trellises, could be recovered in 2 years. Profits could be further enhanced by growing more than one crop on the trellis. They also reported that trellising using steel T-posts or concrete reinforcing bars increased marketable yields over ground culture, and produced a profit considering the cost of materials used.

In our study, the best cultivars (considering all the traits evaluated) were 'Sprint 440', 'Summer Top', and 'Tasty Bright'. However, those cultivars would not be suitable for the oriental market in fruit type, since the fruits are too short. Generally, the oriental trellis cultivars had fruits with thin skin, low firmness, and significant curving. The exceptions were 'Tasty Bright' and 'Summer Top', which were similar to American slicers, but with longer fruits.

Breeding work is needed to improve disease resistance of oriental cultivars for production in eastern North Carolina. The most important resistances would be anthracnose, downy mildew, and powdery mildew, all of which could be obtained by crossing with 'Poinsett 76'.

Oriental trellis cultivars will not substitute directly for greenhouse cucumbers because the fruits are slightly shorter and are not bitterfree or seedless. However, oriental trellis cultivars are similar to Dutch greenhouse cucumbers in most other traits, both having thinner skin and fewer seeds than American slicers. Growers interested in producing for the oriental market in the United States should use trellises rather than flat bed, and should grow cultivars such as 'Jin Chun #4', which had the highest yield of the Chinese-type (long, ridged fruits) cultivars.

Literature Cited

Hanna, H.Y. 1993. Producing trellised cucumbers double-cropped with tomatoes. HortScience 28:96–98.

Table 3. Fruit yield, vine data and sex expression of cucumber cultivars on trellis (ranked by total yield) in Clinton, N.C. in 1995.

No.	Cultivar	Yield (Mg·ha^{-1}) Total	Fancy+ No. 1	Marketable	% culls	SWI[z]	Vine length (m)	No. branches[y]	% staminate nodes[x]	Disease incidence Anthracnose	Powdery mildew
						Spring					
1	Marketmore 76[w]	57	1.6	3.9	16	3.5	34.0	11	53	7	---
2	Summer Top	42	15.2	33.5	27	3.3	32.5	10	57	6	---
3	Tasty Bright	35	13.6	25.4	32	3.1	38.6	14	28	8	---
4	89-211	34	10.6	27.2	14	6.1	32.0	10	67	4	---
5	Sprint 440[w]	33	13.4	25.4	25	3.4	39.1	10	12	6	---
6	I-109	29	9.5	22.1	20	4.8	29.8	10	71	6	---
7	Jin Chun #4	26	4.1	13.1	16	4.1	32.3	8	65	8	---
8	Jin Yan #4	26	6.5	16.9	30	3.6	28.8	11	73	6	---
9	Fengyan	25	5.0	20.1	52	4.8	36.5	10	45	6	---
10	BAU #14	24	4.5	14.1	48	5.2	33.2	12	55	6	---
11	Yangzhou Grn. Skin	23	7.9	17.3	41	2.6	27.4	11	75	8	---
12	Poinsett 76[w]	21	13.6	18.1	47	3.5	34.2	10	53	7	---
13	XZ #27	21	5.1	16.3	14	2.7	28.4	10	75	5	---
14	Jin Za #2	20	9.4	20.3	56	3.9	21.5	8	77	7	---
15	Sky Horse	20	2.1	10.5	33	3.4	37.8	11	37	8	---
16	Tasty Green	19	3.9	12.9	34	2.9	30.3	11	71	7	---
17	Yangzhou String	18	4.9	12.6	34	2.3	28.6	11	73	8	---
18	Hongzhou Green 55	16	1.6	10.2	34	4.8	30.8	12	68	7	---
Seasonal mean		*24.3*	*7.4*	*17.8*	*31.8*	*3.8*	*32.0*	*11*	*58.6*	*6.7*	---
						Summer					
1	Jin Chun #4	21	4.7	8.7	36	4.2	21.6	9	64	7	3
2	Jin Yan #4	19	5.5	12.1	41	4.2	21.9	6	57	5	5
3	Summer Top	17	6.5	12.0	55	3.4	20.9	5	67	7	7
4	Sprint 440[w]	16	7.0	13.1	50	3.7	24.4	10	8	5	7
5	Tasty Bright	16	5.9	12.5	41	3.4	9.6	4	81	6	7
6	Tasty Green	15	4.8	11.5	52	3.3	19.8	6	71	5	8
7	89-211	14	3.8	9.9	33	4.6	20.6	5	69	6	5
8	Jin Za #2	13	5.3	12.8	65	4.1	19.2	4	72	5	4
9	XZ #17	13	4.5	9.3	42	3.1	14.7	8	80	7	7
10	Yangzhou Grn. Skin	13	4.2	8.9	58	2.7	22.6	7	56	6	7
11	BAU #14	12	2.6	7.0	33	4.5	21.3	10	67	5	2
12	Fengyan	12	4.9	8.9	40	4.4	23.2	12	45	6	7
13	I-109	12	2.0	7.1	51	4.3	22.9	10	47	6	5
14	Poinsett 76[w]	10	5.3	8.9	64	4.0	20.7	4	68	5	4
15	Sky Horse	10	2.0	5.3	31	3.8	21.8	6	59	4	3
16	Hongzhou Green 55	7	1.3	4.5	30	4.3	15.2	3	73	4	2
17	Yangzhou String	5	0.6	3.2	21	2.7	22.3	9	57	5	5
18	Marketmore 76[w]	2	1.0	1.7	22	4.0	22.7	10	49	6	6
Seasonal mean		*12.6*	*4.0*	*8.7*	*42.5*	*3.8*	*20.3*	*7*	*60.5*	*5.6*	*5.2*
LSD (5%)		6.8	3.6	5.7	10.6	0.4	3.6	1.7	24.0	1.2	1.2
Overall mean		18.4	5.7	13.3	37.2	3.8	26.1	9	59.6	6.1	5.2
CV (%)		31	55	37	31	15	12	26	35	17	14

[z]SWI = Simple weighted index for yield and fruit quality.
[y]Mean for three plants per plot.
[x]Measured for first five nodes for five plants per plot.
[w]American slicers (all others are oriental trellis cucumbers).

Hanna, H.Y., A.J. Adams, and R.J. Edling. 1989. Double-cropping cucumber and tomatoes to minimize the cost of staking cucumber. Proc. Fla. State Hort. Soc. 102:326–328.

Hanna, H.Y., A.J. Adams, and R.N. Story. 1987. Increased yield in slicing cucumbers with vertical training of plants and reduced plant spacing. HortScience 22:32–34.

Konsler, T.R. and D.L. Strider. 1973. The response of cucumber to trellis vs. ground culture. HortScience 8:220–221.

Russo, V.M., B.W. Roberts, and R.J. Shatzer. 1991. Feasibility of trellised cucumber production. HortScience 26:1156–1158.

SAS Institute. 1988. SAS/STAT user's guide, release 6.03. SAS Inst., Cary, N.C.

Sanders, D.C. and J.M. Davis. 1990. Trellised cucumbers. North Carolina State Agr. Ext. Hort. Info. Lflt. No. 14–B.

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

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.

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 levels. Plant Dis. 69:833–836.

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