Optimum planting density and harvest stage for little-leaf and normal-leaf cucumbers for once-over harvest

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Schultheis, J. R., Wehner, T. C. and Walters, S. A. 1998. **Optimum planting density and harvest stage for little-leaf and normal-leaf cucumbers for once-over harvest.** Can. J. Plant Sci. 78: 333–340. Optimum planting density and harvest stage were determined for once-over harvest of little-leaf and normal-leaf cucumbers. Three harvest stages (10, 25, and 50% oversize fruit) and four plant densities (37,000, 75,000, 150,000, and 300,000 plants/ha) were evaluated on little-leaf cucumber (H-19) and normal-leaf cucumber (Sumter and Regal). Plant density did not affect skin color, seedcell size, and seed size in the cultivars evaluated. However, lighter skin color, larger seedcell, and larger seed size were detected at the later harvest stages in H-19. Harvest stage did not influence fruit skin color in Regal and Sumter, but seedcell size and seed size increased quadratically with harvest stage. H-19 produced the highest yield (tonne/ha) and dollar value ($/ha) followed by Regal and Sumter. Considering fruit quality and dollar value, the 10% harvest stage at 330 000 plants ha^{-1} was the optimum stage and density for once-over harvest of H-19 under North Carolina growing conditions. Higher yield occurred at the later harvest stages, but poorer fruit quality (increased seed and seedcell size, and a lighter skin color) was associated with those stages. Fruit quality and dollar value of Regal was best at the 10% harvest stage at approximately 240 000 plants ha^{-1}, while 200 000 plants ha^{-1} was best for Sumter.

Key words: *Cucumis sativus*, cucumber, plant type, spacing, crop ideotype, vegetable production

Schultheis, J. R., Wehner, T. C. et Walters, S. A. 1998. **Densité de plantation et stade de maturité de récolte optimaux du concombre à petites feuilles et à feuilles normales pour la récolte unique.** Can. J. Plant Sci. 78: 333-340. Nous avons établi la densité de plantation et le stade de maturité de récolte optimaux pour la récolte en un seul passage du concombre à petites feuilles et du concombre à feuilles normales. Trois stades de récolte (10, 25 et 50 % de gros fruits) et 4 densités de peuplement (37 000, 75 000, 150 000 et 300 000 plantes par hectare) étaient comparés sur le concombre à petites feuilles H-19 et les concombres à feuilles normales Sumter et Regal. La densité de peuplement n'avait pas d'effet sur la coloration de la peau ni sur la taille du placenta et des graines des cultivars étudiés. Chez H-19, les fruits récoltés aux stades plus avancés de maturité étaient plus pâles, contenaient un placenta plus grand et des graines plus grosses. Chez Regal et Sumter, le stade de maturité à la récolte n'avait pas d'effet sur la coloration de la peau, mais la taille du placenta et celle des graines augmentaient en fonction quadratique avec chaque stade de récolte. C'est H-19 qui produisait le plus en tonnes de fruits et en dollars par hectare, suivi de Regal et de Sumter. Compte tenu de la qualité du fruit et de la valeur économique, le stade de récolte 10 % à la densité de peuplement de 330 000 plantes par hectare était l'idéal pour la récolte unique de H-19 en Caroline du Nord. La récolte aux stades de maturité plus avancée procurait des rendements plus élevés mais aux dépens de la qualité du fruit (placenta et graines plus gros) et de la couleur de la peau (plus pâle). En qualité et en rendement économique, Regal atteignait l'optimum au stade de récolte 10 % pour une densité de peuplement d'environ 240 000 plantes par hectare. La densité idéale pour Sumter était de 200 000 plantes.

Mots clés: *Cucumis sativus*, type de plante, écartement, idéotype cultural, production légumière

The little-leaf cucumber (*Cucumis sativus* L.) type was discovered in an inbred selection in Arkansas (Goode et al. 1980; Goode et al. 1989). The little-leaf type has leaves, stems, and flowers that are smaller than the normal-leaf type, as well as multi-branched vines not present in normal-leaf types. It offers several advantages over normal-leaf cucumbers, including concentrated fruit set, high fruit-to-vine ratio, parthenocarpy, ability of the fruit to withstand rough handling, and better growth under dry or windy conditions (Goode et al. 1980; Bowers et al. 1981; Wehner et al. 1987; Goode et al. 1989). However, Cook et al. (1991) reported reduced brining quality with fruit greater than 51 mm in diameter. A superior little-leaf line, H-19, was released that has high yields, few crown fruit, and multiple lateral branching habit (Plant Variety Protection Certificate 1993).

Cucumber growth and yield are directly affected by plant density. Several studies have shown the effect of cucumber plant density on yield (Morrison and Ries 1968; Chambliss and Turner 1972; Downes et al. 1972; Cantliffe and Phatak 1975; Widders and Price 1989; Van Wann 1993), but only two were concerned with the little-leaf cucumber type (Cook et al. 1991; Staub et al. 1992). The relationship between plant density and growth or yield was difficult to determine, since it is dependent upon the genotype of the plant (Nienhuis et al. 1984) as well as the environment (O'Sullivan 1980; Tan et al. 1983). Cantliffe and Phatak (1975) reported cucumber fruit development is slower at high plant populations (250 000 to 850 000 plants ha^{-1}) than at lower densities (50 000 to 200 000 plants ha^{-1}) and the number of fruits per plant decreased with increasing plant density. Also, as numbers of plants per hectare increased,

Abbreviations: L/D, length to diameter ratio gynoecious plants produced more staminate flowers than usual (Nienhuis et al. 1984). Widders and Price (1989) found that increases in plant density resulted in less biomass accumulation and reduced fruit production on a per-plant basis. The potential for using increased plant densities to increase yield depended on the reduction in fruit yield per plant relative to the increased plant number.

In once-over harvest, the maximum number of fruits must be marketable at harvest to obtain a high return on investment (Cargill et al. 1975; Motes 1977). The value of cucumbers changes as the grade size changes, so the timing of harvest is especially important in once-over harvest systems. Pickling cucumbers can have a 40% increase in weight over a 24 h period (Cargill et al. 1975). For once-over harvest systems, several reports indicate that fruits should be harvested when fruits greater than 51 mm in diameter are found in the field (Morrison and Ries 1968; Miller and Hughes 1969). Fruit characteristics such as seedcell size, seed size, skin color, and skin toughness all affect the brining quality of fruit.

Vine length is an important trait for machine harvest. Cultivars having a small vine would permit the harvester to operate more efficiently. A small vine also permits the fruits to move through the harvester more easily.

Because of its multiple branching habit and concentrated fruit set, the little-leaf cucumber type has the potential to increase yield in a once-over harvest pickling cucumber system at a high plant density. The potential increase in yield is related to its habit of multiple branching which results in a dense plant canopy (Serquen et al. 1997). Goode et al. (1980) suggested that optimum yield of the little-leaf cucumber type could be obtained if planting density were increased relative to the normal-leaf type. The objective of this study was to determine the optimum planting density and harvest stage for indeterminate, monoecious little-leaf cucumber in a once-over harvest system, and to compare that to normal-leaf cucumber. Only one detailed study has been published which compares various little-leaf planting densities; however, Staub et al. (1992) evaluated determinate, gynoecious little-leaf types.

MATERIALS AND METHODS

Research was conducted at the Horticultural Crops Research Station, Clinton, NC. The experiment was a split-plot treatment arrangement in a randomized complete block design. The main plots were the three harvest stages [10, 25, or 50% oversized fruits (>51 mm diameter)], the sub-plots were the three cultivars (Sumter [normal-leaf, monoecious inbred], Regal [normal-leaf, predominantly gynoecious hybrid], and H-19 [little-leaf, monoecious inbred]), and the sub-sub-plots were the four densities (37 000, 75 000, 150 000, and 300 000 plants ha^{-1}). The experiment was conducted for 2 yr (1990 and 1991), with two seasons per year (spring and summer), and five replications for each field planting. Plots were 3 m long and four rows wide (3 m), with two rows planted on each bed. Fruit from plants in the middle two rows were harvested from each plot, leaving the outside rows as border rows. Planting beds were formed on 1.5 m centers. Sowing was by hand in preformed furrows 25 mm deep.

Table 1. Vine and fruit characteristics of cucumbers harvested at three stages[z]

Cultivar	Harvest	Vine length (cm)	Fruit characteristics: L/D ratio	Skin color	Skin toughness
H-19	10%	86.3	3.1	6.8	81.8
	25%	95.8	3.0	5.5	83.2
	50%	103.5	2.9	5.6	85.0
	Mean	95.2	3.0	6.0	83.3
Regal	10%	104.7	3.3	6.8	77.0
	25%	109.5	3.2	6.5	76.1
	50%	110.8	3.1	6.3	74.3
	Mean	108.3	3.2	6.5	75.8
Sumter	10%	102.3	3.2	5.2	84.1
	25%	111.3	3.2	5.0	86.3
	50%	119.0	3.2	5.3	86.3
	Mean	110.9	3.2	5.2	85.6
	LSD (5%)	14.9	0.4	0.9	8.9
	CV (%)	12.4	9.7	12.2	40.0

[z]Data are means of 2 yr, two seasons, five replications, and four planting densities. Plant density did not influence the quality traits listed. L/D ratio using 10 grade 2 fruits; fruit skin color rated 1 to 9 (1 to 3 = light green, 4 to 6 = medium green, 7 to 9 = dark green); and skin toughness measured with a punch tester in Newtons (N). Least significant difference (LSD) presented to compare cultivar means.

Recommended cultural practices (Schultheis 1990) and pest control practices (College of Agricultural and Life Sciences 1990) were followed through the completion of harvest. First-year plantings (spring and summer 1990) were in a Norfolk or an Orangeburg loamy sand (both are fine loamy, siliceous, thermic Paleudults), while second-year plantings (spring 1990) were in a Goldsboro loamy sand (fine loamy, siliceous, thermic aquic Paleudults) or (summer 1990) in an Orangeburg loamy sand.

Traits evaluated included vine length (determined for main stem, soil surface to apical bud using five plants per plot), sex expression (determined by counting the number of pistillate flowers on the first five nodes from five plants in a plot), fruit color (rated 1 to 9, with 1 to 3 = light green, 4 to 6 = medium green, 7 to 9 = dark green), seedcell size (rated 1 to 9, with 1 to 3 = large, 4 to 6 = medium, 7 to 9 = small), seed size (rated 1 to 9, with 1 to 3 = large, 4 to 6 = medium, 7 to 9 = small), firmness of the fruit skin (measured with a punch tester [McCormick fruit firmness pressure tester, model FT 3-27, Yakima, Washington] in Newtons (N) using an 8 mm diameter tip), length to diameter (L/D) ratio using 10 grade 2 fruits, total yield (t ha^{-1}), and dollar value ($ ha^{-1}). Fruits were harvested based on the three targeted harvest stages and were graded according to North Carolina standards. Grades 1, 2, 3, and 4 consisted of fruits 0 to 27 mm, 28 to 38 mm, 39 to 51 mm, and greater than 51 mm in diameter, respectively (Wehner 1986). Culls were oversize or misshapen (dogbone, nubbin, crooks, etc.) fruit. Fruits were weighed and dollar value was calculated as: (wt. grade 1 × $352) + (wt. grade 2 × $176) + (wt. grade 3 × $106) + (wt. grade 4 × $0). Dollar value was determined using industry values (P. Denlinger, 1996, Mt. Olive Pickle Co., NC, personal communication, 1996).

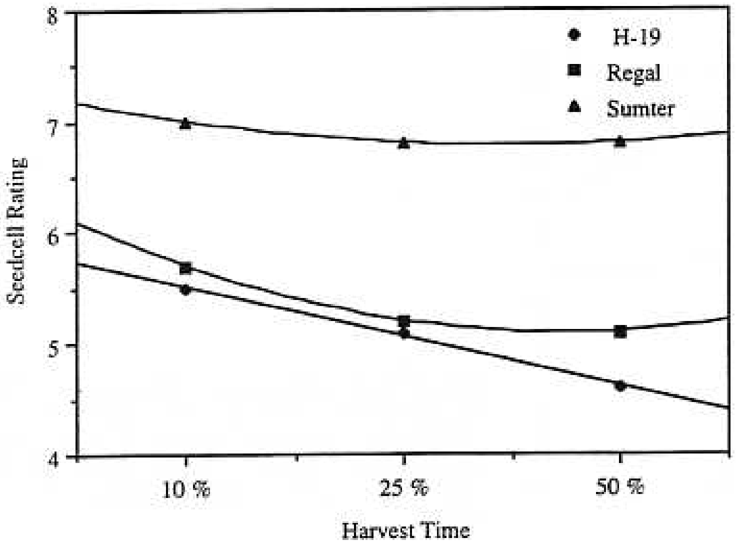

Fig. 1. Relationship between seedcell rating and harvest stage was linear for H-19 [$y = 5.97 - 0.45(x)$, $r^2 = 1.0$]; and quadratic for Regal [$y = 6.60 - 1.10(x) + 0.20(x)^2$, $R^2 = 1.0$], and Sumter [$y = 7.40 - 0.50(x) + 0.10(x)^2$, $R^2 = 1.0$].

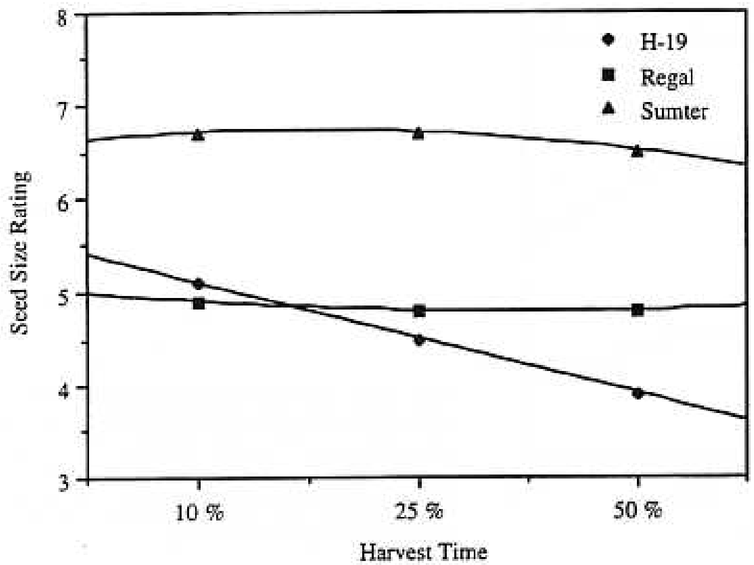

Fig. 2. Relationship between seed size rating and harvest stage was linear for H-19 [$y = 5.70 - 0.60(x)$, $r^2 = 1.0$]; and quadratic for Regal [$y = 5.10 - 0.25(x) + 5.00(x)^2$, $R^2 = 1.0$], and Sumter [$y = 6.50 + 0.30(x) - 1.00(x)^2$, $R^2 = 1.0$].

Data were analyzed using regression, analysis of variance, and least significance difference where appropriate; regression analysis was used to determine the optimum plant density for both yields and crop dollar value (SAS Institute, Inc. 1989).

RESULTS AND DISCUSSION

Analysis of variance indicated that cultivar traits were similar between seasons, but variable over years. Means for cultivar, harvest stage, and plant density are presented over seasons and years.

Based on fruit weight, the overall harvest stage means were within 4 to 6% of targeted stages. The percentage of oversized fruits (based on weight) averaged 13.8, 31.3, and 46.3% for the 10, 25, and 50% oversize harvest stages, respectively.

VINE LENGTH. Vine length increased with harvest stage for H-19, Sumter, and Regal (Table 1), but vine length was not affected by plant density (data not shown). Differences between cultivars were detected. Average length of H-19 vines was less than Sumter, but not Regal. This suggests that H-19 may be more acceptable for once-over harvest than the other cultivars evaluated because of its shorter vines. However, the advantage of the shorter primary vine may be negated by its dense plant canopy (Goode et al. 1980).

PISTILLATE FLOWERS. The percentage of pistillate flowers produced differed among the three cultivars with Regal, Sumter, and H-19 producing 43, 14, and 4%, respectively (data not shown). The percentage of pistillate flowers produced by monoecious cultivars, H-19 and Sumter, was not affected by plant density. However, in Regal (a predominantly gynoecious hybrid), the percentage of pistillate flowers decreased by 13, 17, and 26% at densities of 75 000, 150 000, and 300 000 plants ha^{-1}, respectively, compared with the lowest density (37 000 plants ha^{-1}). This effect of

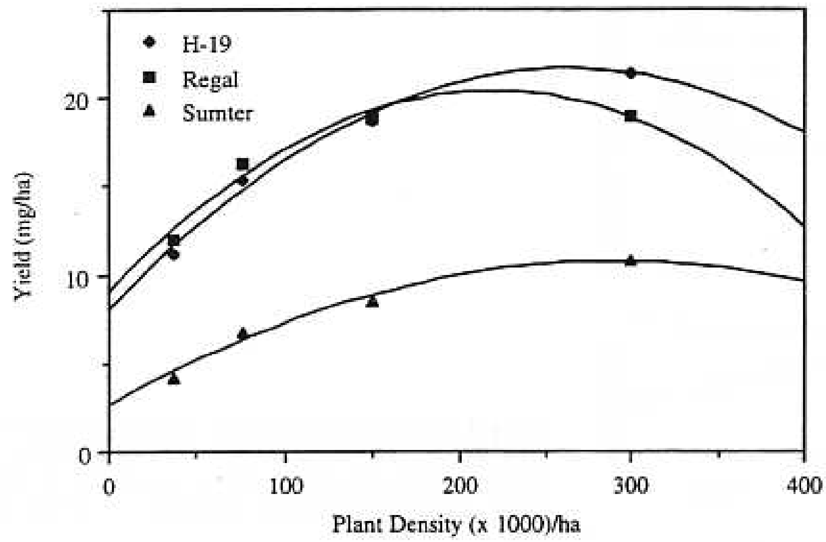

Fig. 3. A. Relationship of yield (tonne/ha) and plant density at the 10% oversize harvest stage: H-19 [$y = 7.94 + 0.10(x) - 0.0002(x)^2$, $R^2 = 0.99$]; Regal [$y = 8.93 + 0.10(x) - 0.0002(x)^2$, $R^2 = 0.97$]; and Sumter [$y = 2.56 + 0.06(x) - 0.0001(x)^2$, $R^2 = 0.98$].

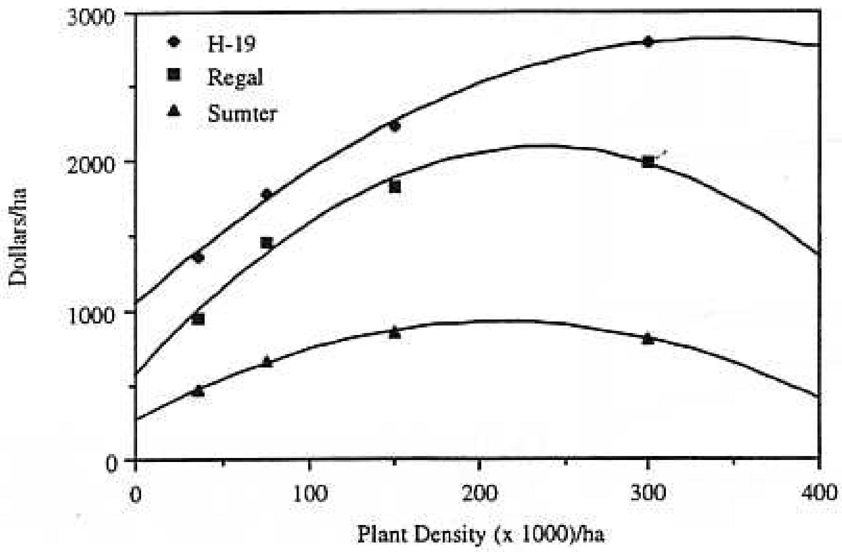

Fig. 3. B. Relationship of dollar value ($/ha) and plant density at the 10% oversize harvest stage: H-19 [$y = 1035.7 + 10.4(x) - 0.015(x)^2$, $R^2 = 1.0$]; Regal [$y = 562.3 + 12.9(x) - 0.027(x)^2$, $R^2 = 0.98$]; and Sumter [$y = 261.6 + 6.1(x) - 0.014(x)^2$, $R^2 = 1.0$].

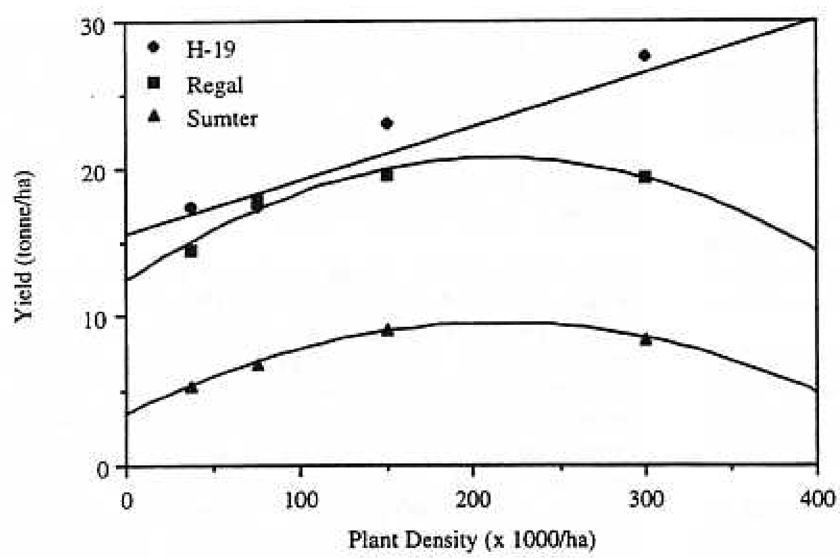

Fig. 3. C. Relationship of yield (tonne/ha) and plant density at the 25% oversize harvest stage: H-19 [$y = 15.47 + 0.04(x)$, $r^2 = 0.96$]; Regal [$y = 12.25 + 0.08(x) - 0.0002(x)^2$, $R^2 = 0.93$]; and Sumter [$y = 3.42 + 0.06(x) - 0.0001(x)^2$, $R^2 = 1.0$].

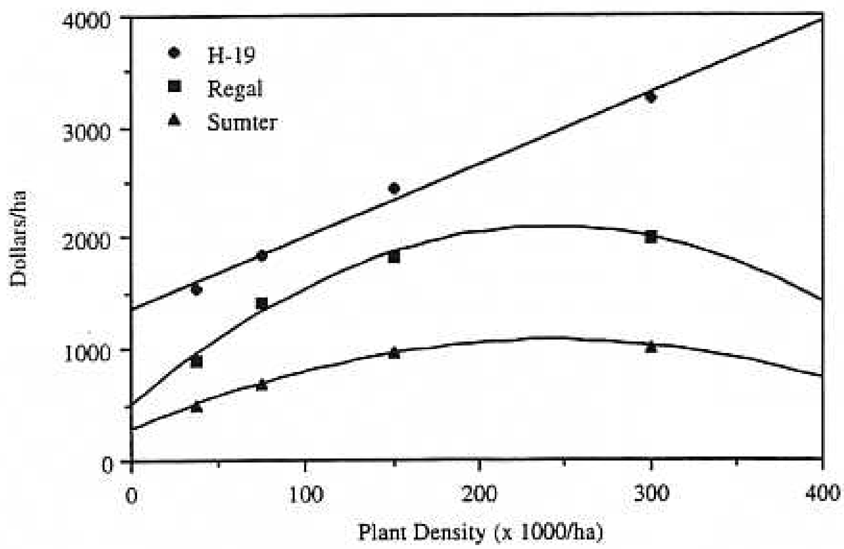

Fig. 3. D. Relationship of dollar value ($/ha) and plant density at the 25% oversize harvest stage: H-19 [$y = 1352.3 + 6.5(x)$, $r^2 = 0.99$]; Regal [$y = 494.8 + 13.1(x) - 0.027(x)^2$, $R^2 = 0.98$]; and Sumter [$y = 270.6 + 6.6(x) - 0.014(x)^2$, $R^2 = 1.0$].

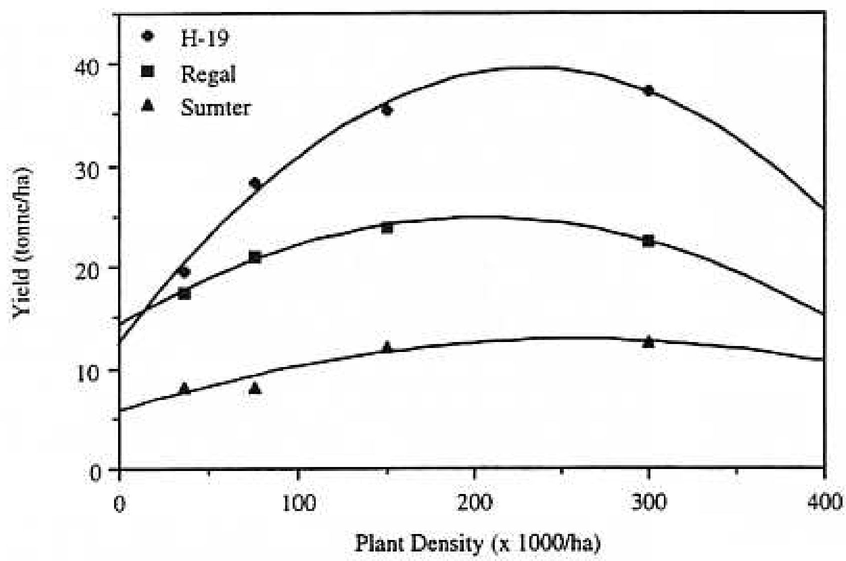

Fig. 3. E. Relationship of yield (tonne/ha) and plant density at the 50% oversize harvest stage: H-19 [$y = 12.34 + 0.23(x) - 0.0005(x)^2$, $R^2 = 0.99$]; Regal [$y = 14.23 + 0.10(x) - 0.0003(x)^2$, $R^2 = 0.98$]; and Sumter [$y = 5.57 + 0.06(x) - 0.0001(x)^2$, $R^2 = 0.89$].

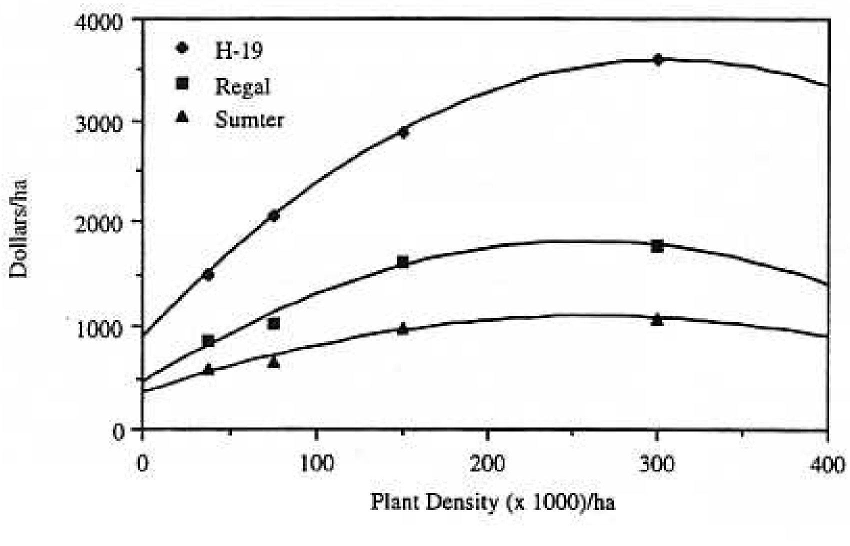

Fig. 3. F. Relationship of dollar value ($/ha) and plant density at the 50% oversize harvest stage: H-19 [$y = 885.5 + 17.7(x) - 0.029(x)^2$, $R^2 = 1.0$]; Regal [$y = 447.1 + 10.6(x) - 0.020(x)^2$, $R^2 = 0.97$]; and Sumter [$y = 351.2 + 5.6(x) - 0.011(x)^2$, $R^2 = 0.97$].

plant density on gynoecious expression has been reported previously by Lower et al. (1983) and Nienhuis et al. (1984) who found that increased plant density reduced pistillate flower numbers while increasing numbers of staminate flowers. It appears that as the plant-to-plant competition with gynoecious or predominantly gynoecious types becomes greater at higher densities, physiological responses occur in response to that stress, resulting in the reduction of pistillate flowers.

FRUIT LENGTH TO DIAMETER RATIO. The L/D ratio of the three cultivars evaluated was not affected by plant density (data not shown), similar to results reported by Cantliffe and Phatak (1975). The L/D ratio also did not differ among cultivars or harvest stages of cultivars (Table 1).

FRUIT SKIN COLOR. Fruit of Regal were darker than Sumter, while those of H-19 were generally intermediate in color (Table 1). Plant density did not influence the fruit skin color of the cultivars, and fruit color of Regal and Sumter was not affected by the harvest stage (data not shown). However, there was a significant ($P \le 0.05$) cultivar × harvest stage interaction; the two later harvests (25 and 50% oversize fruit) of H-19 were different from the first harvest stage (10% oversize fruit) for fruit color (Table 1). An average fruit skin color rating of 6.8, 5.5 and 5.6 was obtained for the 10, 25, and 50% harvest stages, respectively. All are acceptable fruit skin color ratings, but ratings greater than 7 (dark green) are preferred by the cucumber processing industry. For H-19, the combined percentages of grades three and four were 56, 74, and 75% for the 10, 25, and 50% harvest stages, respectively. Less acceptable color in H-19 was caused by the lighter color of larger fruits.

FRUIT SKIN TOUGHNESS. Plant density or harvest stage did not affect the skin toughness of Sumter, Regal, or H-19. However, Sumter had tougher skin (85.6 N) than Regal (75.8 N) (Table 1); H-19 also had tough skin (83.3 N), but fruit toughness was not statistically different from Regal.

SEEDCELL SIZE. Seedcell size is an important trait of pickling cucumbers, since a large seedcell separates more than a small seedcell during the processing of products such as spears and chips. In the cultivars tested, seedcell size was not affected by plant density (data not shown). However, the seedcell size increased linearly in H-19 and quadratically in Regal and Sumter with harvest stage (10 to 50% oversize fruit) (Fig. 1). The overall ratings were 6.9 for Sumter, 5.4 for Regal, and 5.1 for H-19, which had the largest seedcell size. Even though H-19 produced the largest seedcell of the cultivars tested, the size falls within the acceptable range for the cucumber processing industry (a seedcell size rating of 4 to 6 is acceptable, but 7 to 9 is preferred).

SEED SIZE. A large seed size is undesirable because small soft immature seeds are preferred by consumers. The seed size rating of Sumter, Regal, and H-19 were not affected by plant density (data not shown). However, the seed size increased linearly in H-19 (smaller number corresponds to larger seed size) and quadratically in Regal and Sumter with harvest stage (Fig. 2). A slight effect on seed size could be attributed to harvest stage for Regal and Sumter. A larger seed size was observed in all cultivars, especially in H-19, as the harvest stage was delayed from 10% oversize fruit to 50% oversize fruit (Fig. 2). Sumter had a superior seed size rating compared to the other two cultivars. The overall average seed size ratings for Sumter, Regal, and H-19 were 6.6, 4.9, and 4.5, respectively. As with seedcell size, the first harvest stage (10% oversize fruit) was best to obtain the smallest seed size possible, particularly with H-19.

TOTAL YIELD. Over all harvest stages and plant densities, total fruit yields of H-19 (22.7 t ha^{-1}) and Regal (18.5 t ha^{-1}) did not differ significantly, but were greater than Sumter (8.4 t ha^{-1}). Fruit value ($ ha^{-1}) was $2270 ha^{-1}, $1469 ha^{-1}, and $767 ha^{-1} for H-19, Regal, and Sumter, respectively. Thus, Sumter (typically used as a pollenizer in cucumber blends) would not be utilized in a once-over harvest system as the primary cultivar since it has low yields compared with predominantly gynoecious hybrids.

Plant density and harvest stage affected total fruit weight (t ha^{-1}) and dollar value ($ ha^{-1}). Plant density had a similar effect on total yield and dollar value at all harvest stages (no harvest stage × density interaction). However, there were interactions ($P \le 0.05$) of cultivar with both density and harvest stage for total fruit weight and value.

10% OVERSIZE HARVEST STAGE. At 10% oversize fruits, fruit weight and value increased quadratically for all cultivars as plant density increased (Figs. 3A and 3B). The best plant densities per hectare for fruit weight (Fig. 3A) were approximately 225 000 for Regal, 260 000 for H-19, and 280 000 to 290 000 for Sumter. At the 10% oversize stage, fruit dollar value was optimum for H-19 at 330,000 plants ha^{-1}, but for Regal and Sumter it was at 200 000 to 250 000 plants ha^{-1} (Fig. 3B).

25% OVERSIZE HARVEST STAGE. At 25% oversize fruits, yield and dollar value were described best by linear regression models for H-19 and quadratic regression models for Regal and Sumter (Figs. 3C and 3D). H-19 did not reach a peak for plant density as more than 300 000 plants ha^{-1} would be needed to obtain optimum yields and dollar value. For Regal and Sumter, between 200 000 and 250 000 plants ha^{-1} were the densities for optimum fruit weight and dollar value which was similar to the optimal density at the 10% oversize harvest stage.

50% OVERSIZE HARVEST STAGE. At 50% oversize fruits, maximum fruit weight was produced for all three cultivars between 200 000 to 250 000 plants ha^{-1} (Fig. 3E). Maximum fruit value for H-19 was obtained at 300 000 plants ha^{-1} and for Regal and Sumter at 250 000 plants ha^{-1} (Fig. 3F). Many additional oversized fruits that had no monetary value were harvested at the 50% compared with the 10 or 25% oversize stages, resulting in the handling of more fruits with little or no financial return.

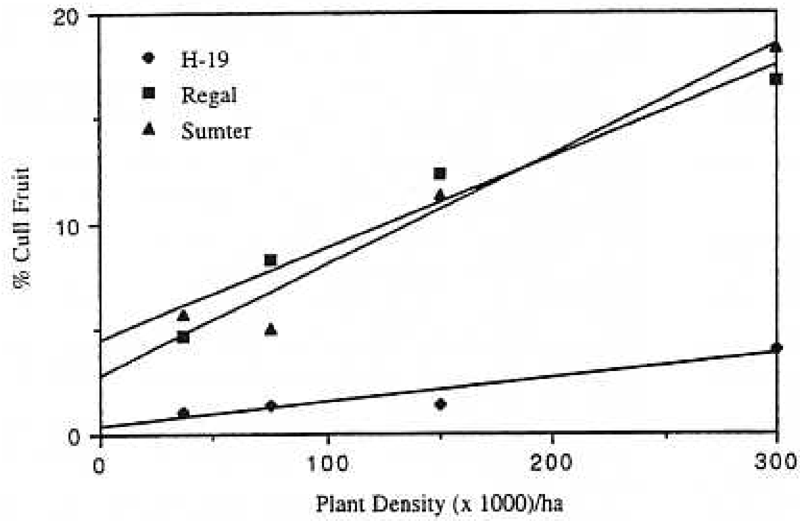

Fig. 4. Relationship between percentage cull fruit and plant density was linear for all cultivars evaluated: H-19 [$y = 0.30 + 0.0114(x)$, $r^2 = 0.89$]; Regal [$y = 4.37 + 0.0434(x)$, $r^2 = 0.89$]; and Sumter [$y = 2.77 + 0.0520(x)$, $r^2 = 0.96$].

CULL FRUIT. The percentage of cull fruit increased linearly with increasing plant density for all cultivars (Fig. 4). Plant density influenced the percentage of cull fruit produced for H-19 much less than Sumter or Regal. The increased competition in Sumter and Regal at 300 000 plants ha^{-1} reduced the percentage of marketable fruits by over 10% compared with 37 000 plants ha^{-1} density. The low percentage of cull fruits (2 to 3%) produced by H-19 could have been due to several factors. H-19 is parthenocarpic (i.e., fruit development with no pollination). Pollination may have been more difficult with increased plant density for Sumter and Regal, which are not parthenocarpic, as the excess foliage may have hindered bee visitation. Genotypic variation between H-19 and Sumter or Regal for fruit development may also explain the percentage of cull fruit differences. Fruit of H-19 enlarge slowly and, thus, do not produce many oversized fruits (Cook et al. 1991). The amount of cull fruit increases with increasing plant density and should concern growers when growing cucumbers at a high plant density since there would be more fruit to handle with little or no value.

SUMMARY

Similar yield responses for each cultivar with respect to plant density at the various harvest stages were found. Most responses were best described by quadratic regression models, which suggest that optimal plant densities had been reached. However, increased yields did not always coincide with increased dollar returns per hectare because at the later harvest stages, grade 4 fruit contributed more to weight but had no dollar value. The best fruit quality and dollar return was achieved at the 10% harvest stage for all cultivars. However, optimum plant density differed with cultivar at this harvest stage. Maximum dollar value was obtained with approximate densities of 330 000, 200 000, and 240 000 plants ha^{-1} for H-19, Sumter, and Regal, respectively. H-19 had higher yields at all densities and harvest stages compared with the other cultivars. However, fruit quality of H-19 worsened as percentage oversized fruits increased. The harvest stage influenced fruit skin color, seed size, and seedcell size. Considering both quality and yield traits, the 10% harvest stage at 330 000 plants ha^{-1} would be the optimal stage and density for once-over harvest of H-19 in North Carolina.

Crop genotype plays an important role in affecting the yield of cucumbers at various plant densities. The optimum plant density of cucumber was genotype dependent. Van Wann (1993) found that the optimum plant density of cucumber cultivars ranged from 160 000 to 270 000 plants ha^{-1} depending upon plant genotype. Optimum yields in a once-over harvest system of H-19 was previously reported to occur between 59 000 and 98 340 plants ha^{-1}, and a little-leaf hybrid was found to produce optimum yields at 94 570 plants ha^{-1} (Cook et al. 1991). Staub et al. (1992) reported that optimum yields of a determinate little-leaf line (WI 5047G) was similar at 242 000 and 272 000 plants ha^{-1}, but lower at 109 000 plants ha^{-1}. However, in our study, more than 300 000 plants ha^{-1} gave optimum fruit weight and value of H-19.

The little-leaf cucumber fruit was inferior to that of the normal-leaf types tested because of increased seed size, increased seedcell size, and a lighter fruit skin color. However, H-19 had higher yields which make it attractive for processors if the quality problems can be overcome through breeding.

ACKNOWLEDGMENTS

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