EFFECTS OF PLANT DENSITY AND NITROGEN LEVELS, AND TEMPERATURE AND WATER STRESS ON YIELD RESPONSES OF CUCUMIS SATIVUS L. cv. 'COUNTY FAIR' CUCUMBER

By

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L. cv. 'COUNTY FAIR' CUCUMBER

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CHAPTER I

INTRODUCTION

The introduction of a new hybrid causes much interest among plant breeders and vegetable growers. Much of the time a variety is tested in various climatic regions of the United States to further determine its full merit. Factors to be considered in the evaluation are: a) yield; b) fruit quality; c) disease and insect resistance; d) adaptation to changes in the environment; e) acceptance by growers, processors, and home gardeners; and f) expected dollar returns per hectare.

Cucumis sativus L., the cucumber, is one vegetable which has undergone an intensive breeding program. Cucumbers are ranked eighth in acreage and tenth in value among the 22 principal crops grown in the United States (35). Florida and the Carolinas are the leading states for fresh market fruit, and Michigan is the leader in the production of pickling-type cucumbers (35).

Two rather broad categories make up the cucumber types. Slicing, or fresh market type, produce a rather long, dark green fruit, and is grown primarily for sale on the fresh market. The pickling type is shorter, a ligher green in color, and these cucumbers are usually grown under contract for pickle companies. The pickling type may be either black or white spined. Although the spines are hardly noticeable, each spine color type exhibit a different appearance at maturation. Black spine varieties turn yellow as the fruit matures, while white spine varieties remain green.

Further subdivision of the cucumber is dependent upon flowering habit. Monoecious varieties produce both male and female flowers on the same plant, with male flowers occurring earlier and being greater in number than female blossoms. Gynoecious cultivars are predominantly female, with male blossoms occasionally at the early nodes.

'County Fair' is a recent introduction of a gynoecious hybrid variety and is a product of modern cucumber breeding objectives. These objectives are: a) to enhance female expression of varieties to further concentrate fruit set and increase yield for once-over mechanical harvest; b) produce 100% gynoecious hybrids (all female blossoms) which are necessary for parthenocarpic (seedless) varieties; and c) provide quality fruits for processing.

'County Fair' is the result of a cross between two breeding lines. These were W744GP x W1082HP. This is a cross between a gynoecious and hermaphroditic parent, which produces the F_1 gynoecious hybrid. Hermaphroditic expression is completely recessive to the gynoecious expression; thus, development of parthenocarpic hermaphroditic lines as pollen parents with a parthenocarpic gynoecious seed parent has resulted in hybrids that are homozygous for parthenocarpy.

Parthenocarpic varieties offer significant improvements over conventional varieties. Some of these are: a) control of bees and other pollination worries eliminated; b) higher fruit counts per plant; c) increased vigor and life; d) greater adaptation to mechanical harvest and post-harvest handling; e) improved culinary characteristics with great attractiveness to consumers; and f) improved seed for growers and home gardeners.

Although there is limited acreage of fresh market and pickling cucumbers, the climatic conditions and soil in much of Oklahoma are well suited to production of a high yielding crop. Dr. C. E. Peterson, in conjunction with the U. S. Department of Agriculture and Wisconsin Agriculture Experiment Station, have chosen Oklahoma State University to further evaluate 'County Fair'.

The objectives of this study were:

a) to determine the effect of different plant spacings on yield,

b) to study the effect of different nitrogen levels on yield,

c) to study the interaction of nitrogen and population and its effects on yield,

d) to determine dollar returns per hectare for each treatment,

e) to observe the effects of season on quality and yield,

f) to study the effects of water and temperature stress on plant growth and sex expression of flowers,

g) to determine the most suitable plant density and nitrogen level for a multiple-pick and once-over mechanical harvest, and

h) to evaluate the variety on the basis of all the above objectives.

CHAPTER II

REVIEW OF LITERATURE

Cucumis sativus L., the cucumber plant, has an extraordinary capacity to set fruit, even under severe nutritional stress. Thus, there are many contradictions between recommendations for application rates of N. Numerous studies have indicated either supplemental N provides insignificant increases in yield, or increases in yield proceed up to a peak, after which only negligible differences may be perceived between high and low rates of N application (3) (5) (15) (22) (27) (31) (36). This presents an enigma for the researcher.

Bishop et al. (3) concluded that although there were yield differences at three locations where increasing rates of N were applied, at two of the locations yield decreases were responsible for the differences. At one of these, visual observations indicated that the two highest rates of N, 112 and 224 kg/ha, delayed germination and resulted in plant stunting. Results indicated no response from N on a high producing field, and studies in Michigan (31) suggested that more than 20 kg/ha of N would be beneficial only on poorly drained soils of low fertility.

McCollum and Miller (22) compared four application rates of N with yield, nutrient uptake, and nutrient removal by pickling cucumbers. The trend for N rates was positive up to and including 80 lb./A (89.6 kg/ha); however, 160 lb./A (179.2 kg/ha) was too much, since yields at this rate were no greater than treatments lacking N. Small differences occurred in yield between treatments. Conclusions supported by fruit-to-vine ratios showed that although well-fertilized plants made more vegetative growth than those with some nutritional stress, the increase in number of fruit set averaged only one per plant.

Miller and Ries (27) reported that approximately two to three times as many marketable fruit were produced by high N than low N plants. Highest yield was exhibited under high N and short day photoperiods. Neither temperature or daylength affected the low N plants. High N and low night temperatures increased the length to diameter ratio of fruit. Daylengths of 11 and 15 hours had no effect on the ratio.

The development of new gynoecious hybrids has brought changes to cultural practices of cucumber (1) (7) (29) (30) (34). Motes (29) reported that hybrid cucumber varieties which mature in 50-60 days display a lower need for N than conventional monoecious varieties which were hand-harvested. The amount of N applied would depend on percentage of organic matter in the soil. Soils containing less than 2% organic matter would need 40-50 lbs. N/A (44.8 - 56 kg/ha), but soils with greater than 2% organic matter, a recommendation of 25-40 lbs. N/A (28 - 44.8 kg/ha) would be made.

Relationships of harvest period and rates of N were examined by Ries (31). Variations in yield between treatments for the different harvest periods indicated that more pickles were harvested early, July 24 to August 5, than during the late harvest, August 9 to August 22, from all treatments receiving N. Only on unfertilized plots was the early yield lower than the late yield, indicating that a lack of N delayed maturity.

Plant Population Effects on Yield

Only minor studies of the effect of population on the yield of pickling cucumbers have been conducted. No consistency has been reached among major production areas on the most advantageous spacing. With the release of more gynoecious varieties, confusion has spread.

Ries (31) conducted studies over a three season period and made observations on the effects of in-row spacings of 6, 12, 18, and 24 inches (15.2, 30.5, 45.7, and 61 cm.) on yield. Comparisons were made between high and low fertility treatments. Highest yield was at the close spacing in the plots receiving supplemental fertilization. Close spacing each year increased the early yield of the pickling cucumbers.

Generally, per plant yields decrease as plant population increases. Cantliffe (6) observed pickling cucumbers under eight population densities. He reported yield increases were associated with increases in plant densities. With plant densities of 50,000 to 100,000, and 250,000 to 500,000 plants/ha, yields increased as density increased. The number of fruit per plant decreased with increasing plant population. Of the two hybrids used in the study, the length to diameter ratios were not significantly affected; however, length to diamter ratios were lower at the lowest plant population. Varying plant populations did not affect the percent off-shape fruit or fruit color (uniformity of green) of either cultivar.

Kretchman (19) stated that each cultivar would differ in response to within-row densities. Based upon dollar values, two hybrid cultivars, 'Earlipik' and 'Perfecto Verde' appeared better adapted to higher plant populations than 'Pioneer', although the dollar value from the highest plant population was significantly greater than that of the lowest for 'Pioneer'. It was postulated that yield and returns from once-over harvest of pickling cucumbers are associated with plant densities, and that when developing programs for mechanization of harvest, the cultivar should be an important consideration.

Research by Morrison and Ries (28) indicated that the rate of fruit development was retarded at the higher plant populations. As plant population increased, the number and weight of fruit per plant decreased. However, as plant population increased, dollar value climbed. It was also noted that the number of plants without fruit increased. In addition to fewer fruits per plant with population increases, the dry weight per plant decreased. This indicated a decreasing capacity of plants to support developing fruit at higher plant densities. Insufficient CO_2, light, nutrients, and combinations of these limit plant growth and fruit set at high populations (4) (24) (28).

Motes (29) recommended 40-50,000 plants per acre (98,800-123,500 plants per ha) on lighter textured soils without irrigation. However, with irrigated fields, plant populations from 70-100,000 plants per acre (173,000-247,000 plants per ha) would be desirable. Intensive management would be top priority at high plant populations. Plant stresses due to insufficient water or nutrients and pest problems would have faster development. This indicates that although growers may expect increased dollars per hectare under high plant density, concentrated management schedules must be followed.

Introduction of gynoecious varieties has brought changes to cucumber plant culture (30). Gynoecious varieties are usually suited to high plant population; thus, with careful attention, yields in excess of

400 bushels/acre (24.5 mt/ha) are possible in once-over harvests.

Bradley et al. (5) conducted studies in Arkansas on fertilization of pickling cucumbers and cantaloupes at two locations over a three season period. These workers were unable to discern differences in firmness or color of brined cucumbers resulting from different fertilizer treatments in any of the three seasons. However, there was a definite tendency in each season for shape to become less desirable as the harvest season progressed on low N treatments.

The USDA (34) reports that as a result of a tendency to set a heavy load of fruit in early nodes, a high incidence of nubby cucumbers will frequently occur following periods of drought, nutrient deficiency, high temperatures, or other stress conditions in Cucumis sativus L. cv. 'County Fair'. Sensitivity to stress indicates a percentage of poor quality fruit would increase under high-density culture for once-over mechanical harvest.

Harvesting Techniques

Cucumber harvesting presents a major obstruction in pickling cucumber production. In Oklahoma and other southern states of the United States, most of the cucumber acreage is hand harvested five to eight times during the season. The high cost and unreliable supply of harvest labor has prompted the development of mechanical harvesting of pickling cucumbers. Research and development of harvesters (2) (7) (8) (9) (16) (17) (23) has classified harvesters into two groups: a) once-over machines that destroy plants during the harvesting process and b) multiple-pick machines which utilize a non-destructive method of fruit removal from the same plant five to ten times in one season.

Both types of harvest machines offer advantages and disadvantages as a solution to the harvest problems of pickling cucumbers (16). Multiple pick machines require fewer and less extensive changes in pre-harvest cultural methods than once-over machines; however, they require engineering which preserves the plant-soil system. Once-over machines require much greater plant population and concentrated fruit set for acceptable economic return. The harvest period is brief and difficult to predict; however, the development of commercial once-over machines is far more advanced than the multiple-pick harvesters.

Pickling cucumber fruit may have a 40% weight increase in 24 hours (7) (10) (29). The value of a field of pickling cucumbers changes as the fruit size increases. Depreciation in values of 5 to 10%, and occasionally 20%, occurs in a 24 hour time span (7) (8) (9) (29). Thus, timeliness becomes a concern when goals of high monetary returns have been set (9).

Trial harvest present a satisfactory means of evaluating the stage of fruit development. The grower moves across the field diagonally, harvesting fruit samples from ten random areas, each 10 square feet in size. This would be an equivalent of 100 square feet or 1/435 acre (14) (16) (27) (29). Hand grading of the samples helps the grower to estimate the most suitable time for harvest. Logically, if fruit samples greater than 2 inch diameter (5.1 cm) are collected, the grower would proceed with once-over or multiple-pick harvest with expediency.

Growth of Cucumber Under Water and Temperature Stress

Cucumbers are grown for the fresh and processing markets in Oklahoma and other southern states (36). The areas of production are subject to both high temperature and moisture stress. Several researchers have reported the separate effect of temperature or water on cucumber growth (11) (12) (13) (20) (21) (32) (33), but not the interaction of these variables.

Friend and Helson (13) conducted studies on the thermoperiodic effects on the growth and photosynthesis of cucumber and other crop plants. A high day temperature of 30°C and low night temperature of 25°C resulted in greater growth than a low day temperature of 20°C and high night temperature of 30°C. Measurements of the mean total plant dry weight per plant were taken and revealed cucumbers had optimum conditions for growth at a mean temperature of 30°C.

Salter (32) reported that irrigation prior to flowering resulted in a yield increase when soil moisture had been reduced to 50% of field capacity. Irrigation maintained at 60-65% of field capacity throughout the growing season significantly reduced test plot yields.

CHAPTER III

METHODS AND MATERIALS

Multiple Harvest Experiment

'County Fair' cucumber seed was planted in the summer and fall of 1978 at the Oklahoma State University Vegetable Research Station near Bixby, Oklahoma. A preliminary soil test on the Reinach silt loam soil revealed a pH of 6.3 with 24.7 kg/ha of residual NO_3-N. Soils were medium in content of P, K, Ca, Mg, Fe, Zn, and Mn.

Weed control was imposed by a preplant application of herbicide. Prefar at 7.2 kg/ha (6 lb. AI/A) and Alanap at 5.2 kg/ha (4 lb. AI/A) were applied during the summer season. For the fall, Sonalan[1] at 1.8 kg/ha (1.5 lb. AI/A) and Prefar at 7.2 kg/ha (6 lb. AI/A) were used for weed control.

The seed was hand-planted on May 26 for the summer crop and August 10 for the fall crop. The in-row spacings for both plantings were 7.5, 15, and 30 cm., which is equivalent to 88,888, 44,444, and 22,222 plants/ha. Experimental design was a randomized complete block with four replications and nine treatments. Plots were 6 by 1.5 m., with a guard row between each plot.

Nitrogen in the form of urea (45-0-0) at 0, 23, and 46 kg/ha was broadcasted over plots at each spacing on June 23 for the summer crop,

[1]Sonalan, manufactured by Elanco, is a herbicide being tested for use on Cucurbits.

and September 9 for the fall crop.

Carbaryl 50 W at 2.24 kg/ha (2 lbs./A) was applied as needed for control of cucumber beetles. Captan 50 W at 4.48 kg/ha (4 lbs./A) was applied once in each season for control of damping off during the cotyledon state of growth.

Cultivation was as needed until vine cover did not permit entrance of machinery into the field.

Irrigation was by means of a trickle system in the summer and conventional sprinkler system in the fall. Plots were irrigated as needed.

Summer plots were hand harvested over a four week period, with a total of 10 harvests. These were July 7, 10, 13, 17, 19, 21, 24, 26, 31, and August 2. Fall plots were harvested on five different dates. These were September 22, 27, 29, October 3, and 9. Yield was determined by market grades of #1's, 2's, 3's, 4's, 5's, 6's, total size 1-3, culls, and total yield. Weights were recorded for each grade and dollar value per hectare computed.

Dollar value was computed as follows: dollar value = $194/metric ton grade 1 + $117/m. t. grade 2 + $68/m. t. grade 3. Grade 1 fruit are 1.9 to 2.9 cm. in diameter, grade 2 fruit are 2.9 to 3.8 cm., grade 3 fruit are 3.8 to 5.1 cm. Dollar values were calculated using Vlasic Foods Hand Pick Pricing Schedule of April, 1976 (25).

Once-Over Harvest Experiment

'County Fair' cucumber seed was planted for once-over harvest during the summer and fall of 1978 at the Oklahoma State University Vegetable Research Station, near Bixby, Oklahoma. Soil testing, weed control, pest control, cultural practices, and irrigation methods were similar to those employed in the multiple-harvest experiment.

The experimental design was a randomized complete block with four replications and nine treatments. Plots were 6 by 2.10 m., with three rows to each plot, 70 cm. apart. In-row spacings were 12.5, 25, and 50 cm., which is equivalent to 114,285, 57,142, and 28,571 plants/ha.

Nitrogen in the form of urea (45-0-0) at 0, 23, and 46 kg/ha was broadcasted over plots June 23 and September 9.

The summer plots were abandoned July 7 due to an excessive number of nubbed fruit, vines of poor vigor, and fruit containing undesirable seed. The failure of these experimental plots was believed to be due to an inadequate irrigation system during the summer. Water flow of the trickle system was not sufficient to supply both the once-over and multiple-harvest plots. High iron content of the water impeded water from moving through the trickle tubing micropores.

On September 26, the fall crop was harvested in a simulated once-over machine harvest. Yield was determined by market grades of #1's, 2's, 3's, 4's, 5's, 6's, total size 1-3, culls, and total yield. Weights were recorded for each grade and dollar values per hectare computed.

Dollar value was computed as follows: dollar value = $102/metric ton fruit grades 1-3. Grade 1 fruit are 1.9 to 2.9 cm. in diameter, grade 2 fruit are 2.9 to 3.8 cm., grade 3 fruit are 3.8 to 5.1 cm. Dollar values were calculated using Vlasic Foods Machine-Harvest contract pricing schedule of April, 1976 (25).

Water and Temperature Stress Experiment

A growth chamber study was conducted in two Sherer Model CEL 37.14 chambers. Two temperature regimes were maintained. The high temperature study was set on 40°C day, 30°C night, while the low temperature study was set on 30°C day, 20°C night. Whitaker and Davis (36) state the optimal temperature for growth of cucumbers is 30°C. The flux density of fluorescent and incandescent lamps was bench level from 08.00 to 22.00 hours.

The cucumber seed were pre-germinated under mist conditions beginning on September 11, 1978. On September 18, the seedlings were transferred to 1-liter, covered, plastic containers, wrapped with aluminum foil, with one seedling per container. A hole was cut in the plastic cover and the seedling secured with cotton. The containers were filled with 800 ml. of half strength Hoagland's nutrient solution at -0.4 bar. Water stress was imposed by adding PEG 6000 in two 1-bar steps on September 23 and 27. One third of the plants were maintained at -0.4 bar; one third at -1.4 bars; and one third at -2.4 bars. The experimental design was a randomized complete block design with five replications and three treatments.

During the experiment, the pots were weighed daily and distilled water was added to replace that lost by transpiration. Resistances of the stomata on the lower leaf surface were measured on September 25, 26, 29, and October 1, and 2, with a stomatal diffusion porometer[1] (18).

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[1]Model LI-60 and Sensor LI-20S, Lambda Instrument Company, Lincoln, Nebraska.

At the termination of the experiment on October 30, growth was determined by measuring leaf area of all leaves on a plant with a leaf-area meter.[2]

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[2]Model LI-3000 Area Meter and LI 3050 A Transparent Belt Conveyor Accessory, Lambda Instrument Company, Lincoln, Nebraska.

CHAPTER IV

RESULTS AND DISCUSSION

Multiple Harvest Experiment

Table I shows the fruit yield and dollar value as affected by plant density and nitrogen fertilization for the summer hand-harvest crop. This interaction displayed significant values for grade size 3 and culls. As displayed in the table, many fluctuations occurred. Similar yield for total size 1-3 were obtained at high density-zero nitrogen, medium density-high nitrogen, and low density-high nitrogen treatments. Dollar values were relatively homogeneous. The greatest total yield and total grade 1-3 was at the high density-zero nitrogen treatment.

The main effects of plant density and nitrogen fertilization are shown in Tables II and III. The effect of plant density on cucumber fruit yield was significant for grade size 3 and culls (Table II and Figure 1). Table III shows that the effects of nitrogen fertilization were not significant for a summer crop.

The climatic condition at the Oklahoma State University Vegetable Research Station was unusually hot and dry. Lack of soil moisture caused fluctuations in yield among treatments.

A preliminary soil test revealed the residual NO_3-N was 24.7 kg/ha. It is feasible that this nitrogen level was optimum, since yield was highest at the zero nitrogen treatment. Yield responses of medium and high applications of nitrogen were similar.

TABLE I

EFFECT OF PLANT DENSITY AND N FERTILIZATION ON YIELD AND DOLLAR VALUE IN A MULTIPLE HARVEST CROP, SUMMER 1978

Plant Density (plts./ha)	N Fertilization (kg/ha)	Yield (mt/ha) Grade Sizes 1	2	3	4	5	6	Culls	Total Grade 1-3	Total	Dollar/ha
88,888	0	1.7	5.9	4.6	.6	.2	.2	3.2	12.3	16.5	2893
	23	1.4	5.1	3.3	.5	.1	0	3.2	9.8	13.7	2320
	46	1.5	4.4	2.7	.3	0	0	3.5	8.6	12.5	2035
44,444	0	1.7	4.8	4.5	.8	.2	.1	1.7	11.1	13.9	2608
	23	1.6	5.3	4.5	1.1	.1	.2	1.8	11.6	14.8	2730
	46	1.7	6.2	4.1	.8	.2	0	1.6	12.0	14.6	2837
22,222	0	1.6	6.0	4.3	.7	.4	0	1.2	11.9	14.2	2807
	23	1.7	5.1	3.8	.6	.2	.2	1.1	10.5	12.7	2486
	46	1.6	5.4	5.3	.5	.2	.1	1.2	12.2	14.4	2887
LSD (.05)		NS	NS	1.3	NS	NS	NS	1.1	NS	NS	NS

Mean separation within columns by protected LSD at 5% level.

TABLE II

EFFECT OF PLANT DENSITY ON CUCUMBER FRUIT YIELD AND DOLLAR VALUE IN A MULTIPLE HARVEST CROP WITH N FERTILIZATION, SUMMER 1978

Plant Density (plts/ha)	Yield (mt/ha) Grade Size									
	1*	2	3	4	5	6	Culls	Total Grades 1-3	Total	Dollars/ha
88,888	1.5 a	5.1 a	3.5 b	.5 a	.1 a	0 a	3.3 a	10.2 a	14.2 a	2416 a
44,444	1.7 a	5.4 a	4.4 a	.9 a	.2 a	.1 a	1.7 b	11.5 a	14.5 a	2725 a
22,222	1.6 a	5.5 a	4.4 a	.6 a	.3 a	.1 a	1.2 b	11.6 a	13.8 a	2727 a
LSD (.05)	NS	NS	.8	NS	NS	NS	1.1	NS	NS	NS

*Mean separation within columns by protected LSD at 5% level.

TABLE III

EFFECT OF NITROGEN FERTILIZATION ON CUCUMBER FRUIT YIELD AND DOLLAR VALUE IN A MULTIPLE HARVEST CROP, SUMMER 1978

Nitrogen Fertilization (kg/ha)	Yield (mt/ha) Grade Size 1*	2	3	4	5	6	Culls	Grade Size 1-3	Total	Dollars/ha
0	1.7 a	5.5 a	4.4 a	.7 a	.2 a	.1 a	2.0 a	11.7 a	14.8 a	2769 a
23	1.6 a	5.2 a	3.9 a	.8 a	.1 a	.1 a	2.0 a	10.6 a	13.7 a	2512 a
46	1.6 a	5.3 a	4.0 a	.6 a	.1 a	.1 a	2.1 a	11.0 a	13.8 a	2727 a
LSD (.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Mean separation within columns by protected LSD at 5% level.

Figure 1. Effect of Plant Density on Cucumber Fruit Yield in a Multiple Harvest Crop, Summer 1978

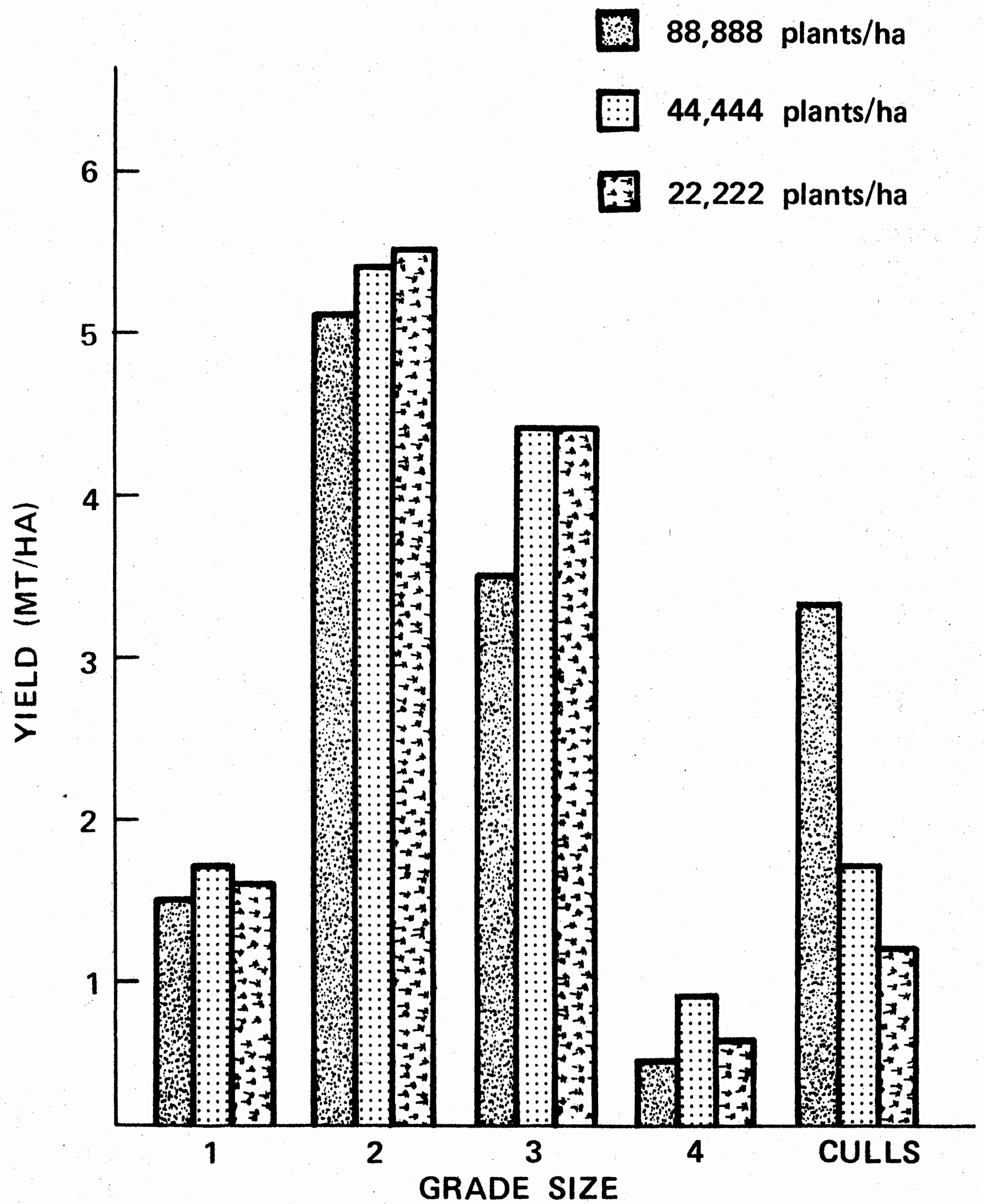

88,888 plants/ha
44,444 plants/ha
22,222 plants/ha
YIELD (MT/HA)
6
5
4
3
2
1
1
2
3
4
CULLS
GRADE SIZE

Table IV shows cucumber fruit yield and dollar values with interactions of the main effects for a fall hand-harvest crop. The interaction between these main effects were significant for grade sizes 1 and 2. The highest value obtained for total yield and dollar value was at the high density-zero nitrogen treatment.

Plant density effects on cucumber fruit yield and dollar value was significant for grade size 2 and culls (Table V and Figure 2). The main effect of nitrogen was not significant for any grade sizes or dollar value (Table VI).

No differences of fruit quality, vine vigor, uniformity of fruit color, and shape could be seen among treatments.

Climatic conditions during the fall were warm and dry. Irrigation with the conventional sprinkler system provided an adequate moisture supply to the plants. Yields were slightly higher at zero nitrogen than medium and high nitrogen treatments, which could be attributed to the improved irrigation system.

The effect of season on cucumber fruit yield and dollar value is shown in Table VII and Figure 3. Significant differences occurred for grade sizes 2, 3, 4, 5, 6, and total yield. Higher yield was obtained in the fall for both total size 1-3 and total yield, indicating conditions were more suitable for production of a hand-harvest crop in the fall.

Once Over Harvest Experiment

Table VIII shows cucumber fruit yield as affected by plant density and nitrogen fertilization on a fall crop for once-over harvest. Significant differences were exhibited for grade size 5. Culls were rare, with

TABLE IV

EFFECT OF PLANT DENSITY AND N FERTILIZATION ON YIELD AND DOLLAR VALUE IN A MULTIPLE HARVEST CROP, FALL 1978

Plant Density (plts/ha)	N Fertilization (kg/ha)	Yield (mt/ha) Grade Size 1*	2	3	4	5	6	Culls	Total Size 1-3	Total	Dollars/ha
88,888	0	1.7	5.1	7.4	2.6	.4	.1	2.8	14.3	20.3	3374
	23	1.3	4.4	5.0	1.7	.6	0	2.1	10.7	15.4	2540
	46	2.0	4.7	6.9	3.0	.9	.3	2.2	13.7	20.2	3226
44,444	0	1.3	3.5	6.1	3.0	.1	.4	1.7	11.0	17.1	2587
	23	1.5	4.4	7.8	2.0	.2	.5	1.6	13.8	18.2	3250
	46	1.5	4.0	6.1	2.2	.2	.1	2.0	11.7	17.1	2760
22,222	0	1.1	4.4	6.3	3.0	.1	1.0	1.3	11.7	17.3	2774
	23	1.8	4.0	5.2	2.6	.4	.6	1.0	11.0	15.8	2602
	46	1.2	3.2	5.7	2.3	.5	.4	1.1	10.2	14.6	2412
LSD (.05)		.6	1.3	NS	NS	NS	NS	NS	NS	NS	NS

*Mean separation within columns by protected LSD at 5% level.

TABLE V

EFFECT OF PLANT DENSITY ON CUCUMBER FRUIT YIELD AND DOLLAR VALUE IN A MULTIPLE HARVEST CROP, FALL 1978

Plant Density (plts/ha)	Yield (mt/ha) Grade Size 1*	2	3	4	5	6	Culls	Total Size 1-3	Total	Dollars/ha
88,888	1.7 a	4.7 a	6.4 a	2.5 a	.7 a	.1 a	2.4 a	12.9 a	18.6 a	3047 a
44,444	1.4 a	4.0 b	6.7 a	2.4 a	.5 a	.6 a	1.8 a	12.1 a	17.5 a	2865 a
22,222	1.4 a	3.9 b	5.7 a	2.6 a	.4 a	.7 a	1.1 b	11.0 a	15.9 a	2596 a
LSD (.05)	NS	.7	NS	NS	NS	NS	.9	NS	NS	NS

*Mean separation within columns by protected LSD at 5% level.

Figure 2. Effect of Plant Density on Cucumber Fruit Yield in a Multiple Harvest Crop, Fall 1978

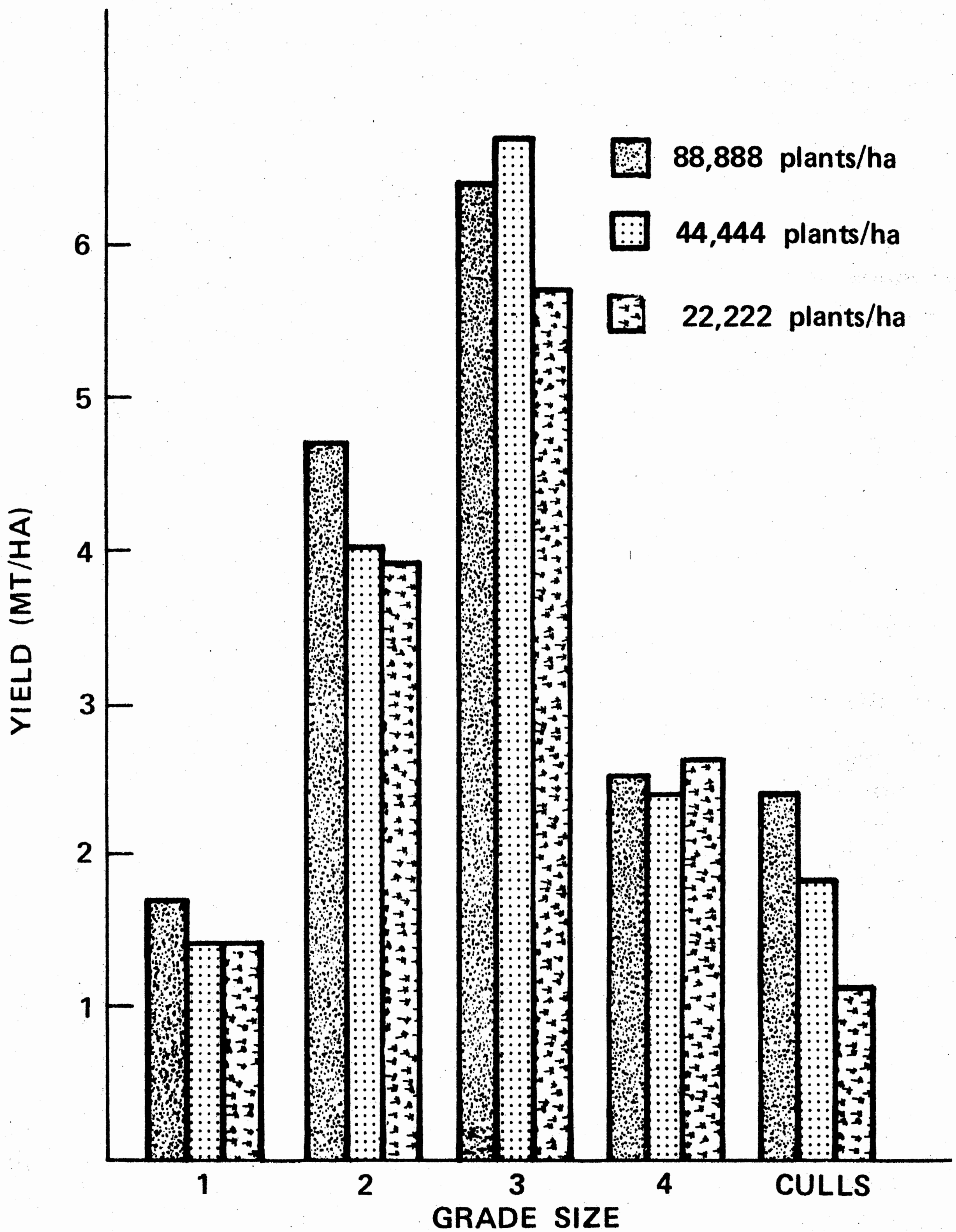

88,888 plants/ha
44,444 plants/ha
22,222 plants/ha
YIELD (MT/HA)
6
5
4
3
2
1
1
2
3
4
CULLS
GRADE SIZE

TABLE VI

EFFECT OF NITROGEN FERTILIZATION ON CUCUMBER FRUIT YIELD AND DOLLAR VALUE IN A MULTIPLE HARVEST CROP, FALL 1978

Nitrogen Fertilization (kg/ha)	Yield (mt/ha) Grade Size									
	1*	2	3	4	5	6	Culls	Total Size 1-3	Total	Dollars/ha
0	1.4 a	4.3 a	6.6 a	2.8 a	.5 a	.5 a	1.9 a	12.3 a	18.2 a	2912 a
23	1.5 a	4.3 a	6.0 a	2.1 a	.4 a	.4 a	1.6 a	11.8 a	16.5 a	2797 a
46	1.6 a	4.0 a	6.2 a	2.5 a	.6 a	.5 a	1.8 a	11.8 a	17.3 a	2799 a
LSD (0.5)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Mean separation within columns by protected LSD at 5% level.

TABLE VII

EFFECT OF SEASON ON CUCUMBER FRUIT YIELD AND DOLLAR VALUE IN A MULTIPLE HARVEST CROP, 1978

Harvest Season	Yield (mt/ha) Grade Size 1*	2	3	4	5	6	Culls	Total Size 1-3	Total	Dollars/ha
Summer	1.6 a	5.3 a	4.1 a	.7 a	.2 a	.1 a	2.0	11.1	14.1 a	2623
Fall	1.5 a	4.2 b	6.3 b	2.5 b	.5 b	.5 b	1.8	12.0	17.3 b	2836
LSD (.05)	NS	.5	.9	.4	.2	.3	NS	NS	1.8	NS

*Mean separation within columns by protected LSD at 5% level.

Figure 3. Effect of Season on Cucumber Fruit Yield, 1978

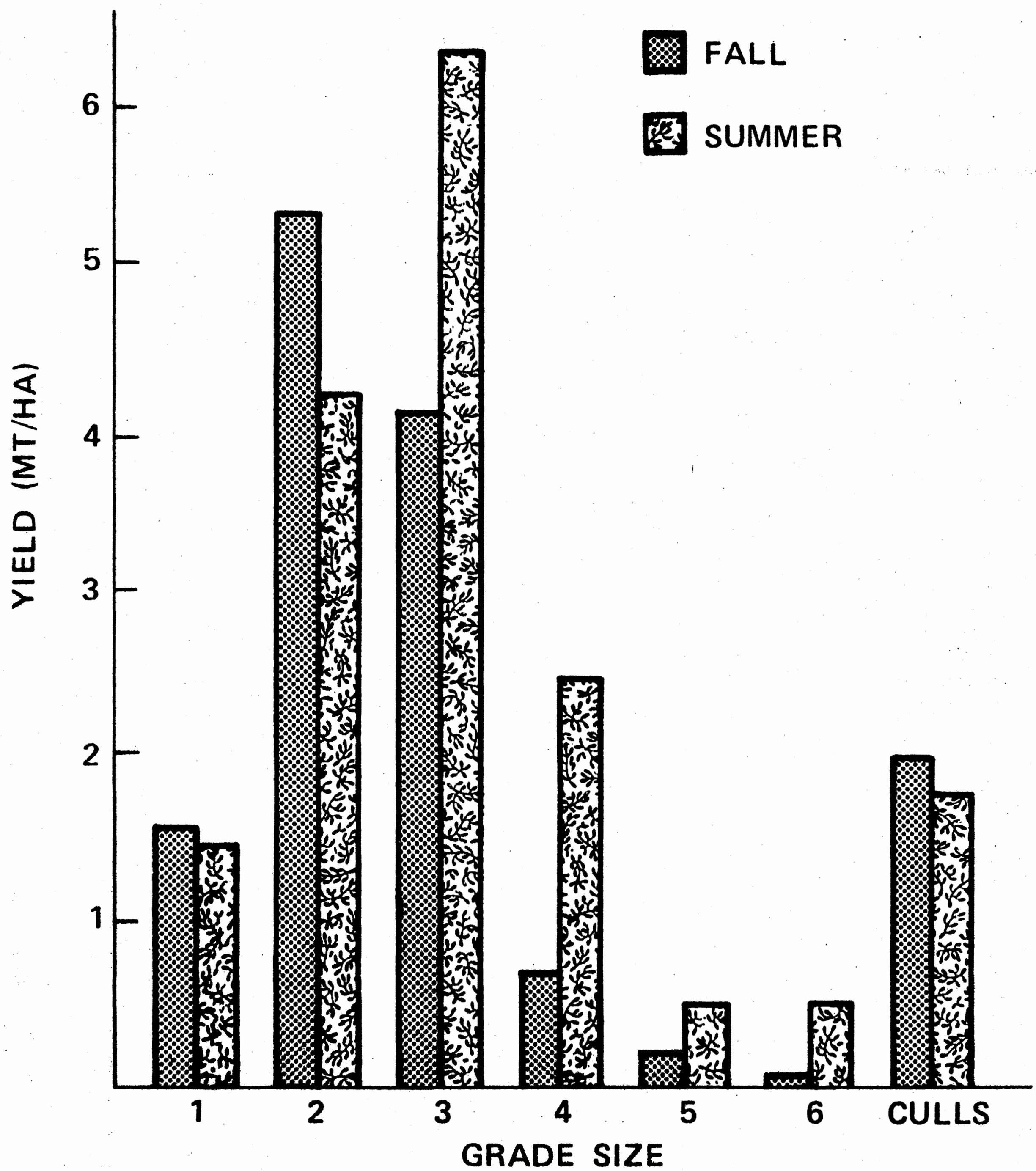

FALL
SUMMER
YIELD (MT/HA)
6
5
4
3
2
1
1
2
3
4
5
6
CULLS
GRADE SIZE

TABLE VIII

EFFECT OF PLANT DENSITY AND N FERTILIZATION ON YIELD AND DOLLAR VALUE IN A ONCE-OVER HARVEST, FALL 1978

Plant Density (plnts/ha)	N Fertilization (kg/ha)	Yield (mt/ha) Grade Sizes 1*	2	3	4	5	6	Culls	Grade Size 1-3	Total	Dollar Value/ha
114,285	0	.7	1.3	4.8	6.7	2.9	.5	0	6.8	17.1	846
	23	.8	1.8	4.6	6.4	1.6	.6	0	7.3	15.9	902
	46	.7	1.5	4.3	6.8	1.3	0	0	6.5	14.7	809
57,142	0	.5	1.0	2.9	5.0	2.3	1.4	0	4.4	13.1	543
	23	.6	.8	2.7	3.6	1.9	.9	0	4.1	10.5	508
	46	.5	.7	2.4	5.8	3.0	1.5	0	3.6	14.1	452
28,571	0	.6	.9	2.9	2.8	1.1	1.0	0	4.4	9.4	549
	23	.4	.6	2.5	4.8	1.9	.2	0	3.5	10.6	441
	46	.6	.7	2.2	2.4	2.0	.6	0	3.5	8.7	442
LSD (.05)		NS	NS	NS	NS	1.3	NS		NS	NS	NS

*Mean separation within columns by protected LSD at 5% level.

mt/ha means reported at decimal placement of 10^{-3} and 10^{-4}. Thus, culls have been reported at zero values.

The effect of plant density on cucumber fruit yield for the fall once-over harvest is shown in Table IX and Figure 4. Significant differences are shown for grade sizes 1, 2, 3, 4, 6, grade size 1-3, total yield, and dollar value. Significant increases in yield were obtained at higher density plant populations. There were no significant differences apparent due to nitrogen fertilization (Table X).

Visual comparisons among treatments were made. No differences of vine vigor, fruit quality, fruit shape, and uniformity of color of fruit could be perceived.

Temperature and Water Stress

Figure 5 shows the stomatal resistance, amount of water added, and leaf area of the plants under the three water treatments and two temperature treatments. Values of stomatal resistance increased with water stress, as expected. However, stomatal resistance was higher in plants exposed to the low temperature compared to that of plants grown with the high temperature. Amount of water added to the pots paralleled stomatal resistance. More water was lost from pots at 30°C than at 20°C due to greater stomatal opening at the high temperature. Water stress had little effect on the leaf area of the plants grown at the high temperature. However, as water potential decreased (stress increased), leaf area of plants grown at the low temperature was decreased. In general, stomatal resistance results were similar to growth results. Plants with a lower resistance grew more than plants with a higher resistance.

TABLE IX

EFFECT OF PLANT DENSITY ON CUCUMBER FRUIT YIELD AND DOLLAR VALUE IN A ONCE-OVER HARVEST, FALL 1978

Plant Density (plts/ha)	Yield (mt/ha)									
	Grade Sizes									
	1*	2	3	4	5	6	Culls	Grade Sizes 1-3	Total	Dollars/ha
114,285	.7 a	1.5 a	4.5 a	6.6 a	1.9 a	.4 b	0	6.8 a	15.9 a	853 a
57,142	.5 b	.8 b	2.6 b	4.8 b	2.4 a	1.3 a	0	4.0 b	12.6 b	501 b
28,571	.5 b	.7 b	2.5 b	3.3 b	1.7 a	.6 b	0	3.8 b	9.5 c	478 b
LSD (.05)	.2	.3	.7	1.6	NS	.6	NS	.9	1.9	116

*Mean separation within columns by protected LSD at 5% level.

Figure 4. Effect of Plant Density on Cucumber Fruit Yield in a Once-Over Harvest, Fall 1978

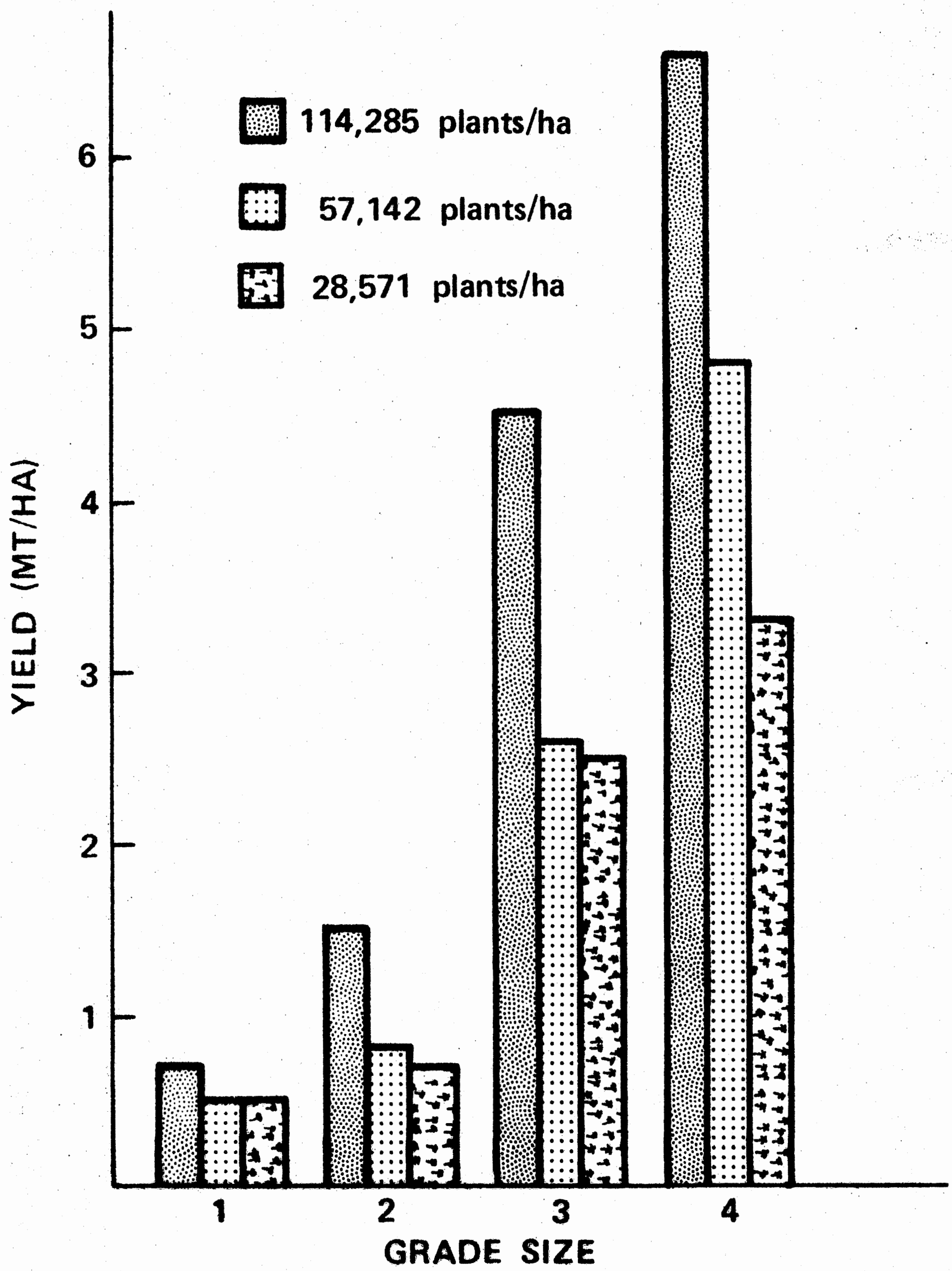

114,285 plants/ha
57,142 plants/ha
28,571 plants/ha
YIELD (MT/HA)
1
2
3
4
5
6
1
2
3
4
GRADE SIZE

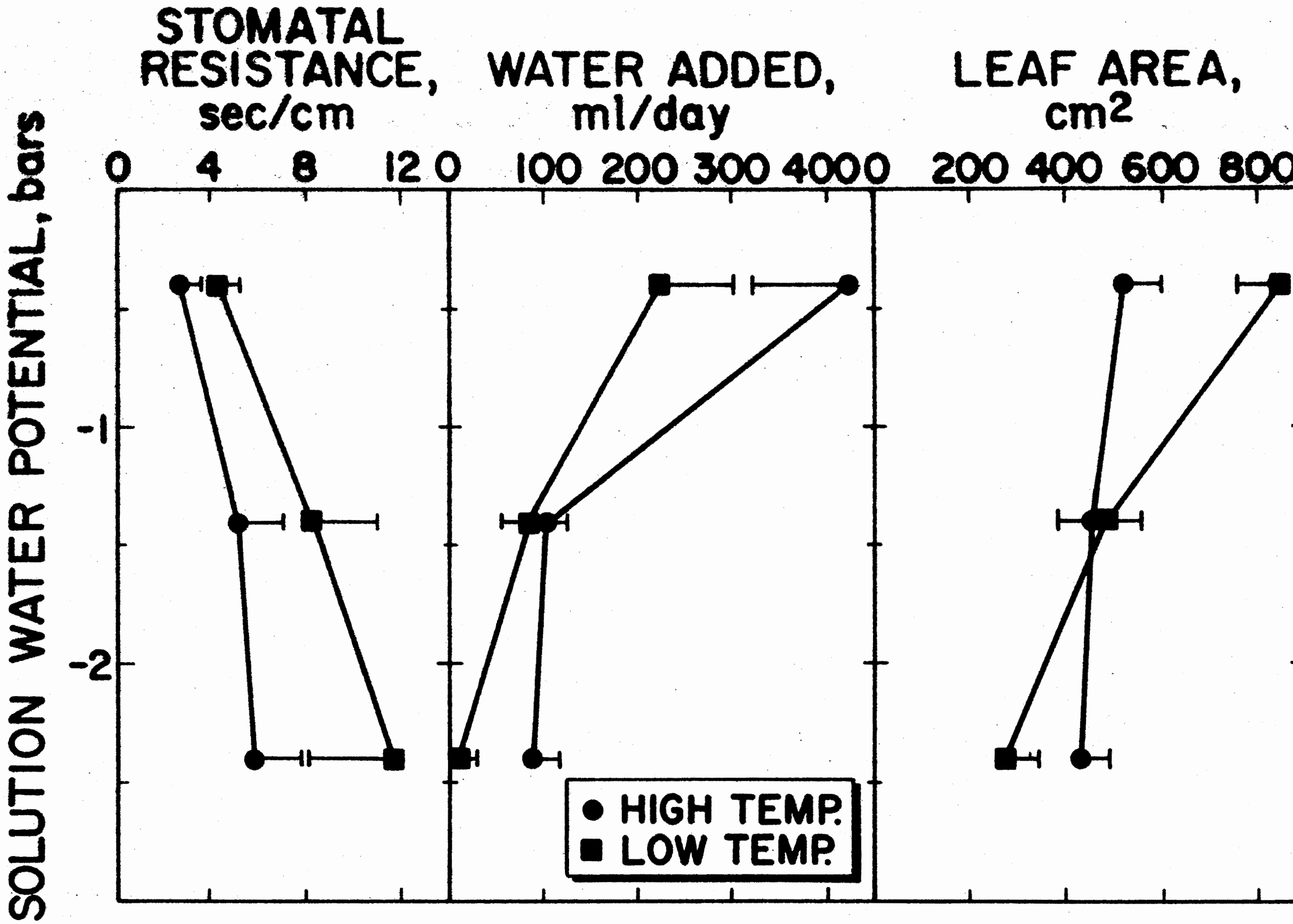
TABLE X

EFFECT OF NITROGEN FERTILIZATION ON CUCUMBER FRUIT YIELD AND DOLLAR VALUE IN A ONCE-OVER HARVEST, FALL 1978

Nitrogen Fertilization (kg/ha)	Yield (mt/ha) Grade Sizes									
	1*	2	3	4	5	6	Culls	Grade Size 1-3	Total	Dollars/ha
0	.6 a	1.0 a	3.5 a	4.8 a	2.1 a	1.0 a	0 a	5.2 a	13.2 a	646 a
23	.6 a	1.1 a	3.2 a	4.9 a	1.8 a	.6 a	0 a	5.0 a	12.3 a	617 a
46	.6 a	1.0 a	2.9 a	5.0 a	2.1 a	.7 a	0 a	4.5 a	12.5 a	568 a
LSD (.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Mean separation within columns by protected LSD at 5% level.

Figure 5. Effect on Stomatal Resistance, Amount of Water Added, and Leaf Area of Plants Under Three Water Treatments and Two Temperature Treatments


STOMATAL RESISTANCE, sec/cm
WATER ADDED, ml/day
LEAF AREA, cm2
0 4 8 12
0 100 200 300 400
0 200 400 600 800
SOLUTION WATER POTENTIAL, bars
-1
-2
HIGH TEMP.
LOW TEMP.

Pistillate flowers developed on plants grown at -0.4 bars in both chambers, but not on plants grown under the other moisture regimes. No staminate flowers developed on any of the plants.

Table XI shows that the greatest leaf growth occurred at low temperature and no moisture stress. Leaf growth decreased as stress increased.

TABLE XI

EFFECT OF TEMPERATURE AND MOISTURE STRESS ON LEAF GROWTH

Leaf Growth	Temperature	Moisture
1 (most)	Low (optimum)	No Stress
2	High	No Stress
3	High	Stress
4 (least)	Low	Stress

It can be concluded that moisture stress with optimal temperature was more detrimental to growth of cucumbers than high temperature with optimal moisture.

CHAPTER V

SUMMARY AND CONCLUSIONS

The major objectives which highlighted this study were: a) to determine the most suitable plant density and nitrogen level for 'County Fair' cucumber in a multiple harvest and once-over harvest situation; b) to study the effects of water and temperature stress on plant growth; and c) to observe the performance of 'County Fair' in a dry region such as Oklahoma.

High density plant populations and low rates of nitrogen produced the highest yields of pickling cucumbers during the summer and fall of 1978. Increased yields were obtained in a fall crop at high plant densities. Nitrogen treatments did not promote significant differences in yield among treatments. Plant density and season proved to be the most significant factors.

Lower quality fruit, lower yield, and lower dollar returns occurred in the summer season. Results from a summer multiple-harvest study suggested that adequate irrigation would be a necessity for a profit-yielding crop.

A growth chamber study was conducted to observe the effects of temperature and water stress. Moisture stress with optimal temperature was found to be more detrimental to growth of cucumbers than high temperature with optimal moisture. Therefore, if a producer had a choice, the results indicated that maintenance of optimal moisture conditions would be more advantageous than optimal temperature conditions. An example would be shading in a greenhouse situation.

'County Fair' has proved itself as an acceptable pickling cucumber for both the ideal climatic conditions of the Great Lakes Region and stress conditions of the southwest; thus, it should gain expeditious appeal among home gardeners and commercial vegetable growers. Yields were average in the fall for multiple and once-over harvests, but high sensitivity to water and heat stress will limit acceptability as a variety grown for once-over harvest.

Based on this study, several inferences can be made. These are: a) this variety will not respond to additional applications of nitrogen if inherent soil fertility is already adequate; b) plant densities equivalent to or greater than 88,888 plants/ha would be most desirable for a multiple harvest crop; c) plant densities equivalent to or greater than 114,000 plants/ha for a once-over crop would be advisable; and d) that yields in fall would be greater than a crop planted in late May.

Some suggestions for future research with 'County Fair' can be made. Because data indicated that yield increases accompanied augmentations in plant density, further field studies could be made to show the effects of even higher plant densities than were used in this research. A recommendation for an earlier planting date in the spring using sprinkler irrigation would allow researchers to make comparisons between seasons more valid.

Vegetable research in the state of Oklahoma will be increasing, as will interest among growers and home gardeners; thus, education among farmers concerning potential of cucumbers and other vegetables as an alternative or supplement to conventional agronomic crops is a challenging possibility for future work.

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VITA 2

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Master of Science

Thesis: EFFECTS OF PLANT DENSITY AND NITROGEN LEVELS, AND TEMPERATURE AND WATER STRESS ON YIELD RESPONSES OF CUCUMIS SATIVUS L. cv. 'COUNTY FAIR' CUCUMBER

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