THE INFLUENCE OF NITROGEN AND PLANT POPULATIONS ON SEVERAL CULTIVARS OF PICKLING CUCUMBERS

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

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1977

ABSTRACT

THE INFLUENCE OF NITROGEN AND PLANT POPULATIONS ON SEVERAL CULTIVARS OF PICKLING CUCUMBERS

By

Christopher John Rajzer

Early and late plantings of several cultivars of pickling cucumbers *Cucumis sativus* L. were evaluated under various levels of preplant N and plant populations. Cultivars responded to treatments differently in fruit yields, sex expression, fruit set, and length to diameter ratios. Increasing nitrogen rates to 67 kg/ha increased yields (metric tons and dollars/ha) in the early planting only, and 101 kg/ha appeared to suppress yields in both plantings. High nitrogen rates (67 and 101 kg/ha) reduced the percent cull fruit in the first planting. Increasing the plant populations increased yields only when N was sufficient. Increasing populations from 99,000 to 296,000 plants/ha increased the percent culls, but oversize fruit decreased with increasing plant populations. Yield was positively correlated to percent pistillate flowers and fruit number per vine.

Cucumber plants and fruit were analyzed at harvest to determine the plant nutrient content and nutrient removal

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by fruit. Factors studied were time of planting, cultivars, N levels, and plant populations. The mean plant nutrient content of N, P, and K was 103, 9, and 147 kg/ha, respectively, with mean nutrient removal of 22, 3, and 38 kg/ha, respectively. The nutrient levels of three cultivars were increased by added N and increasing plant populations. Nitrogen treatments influenced plant nutrient content. Yields and percent cull fruit were also affected. As plant population increased, both total nutrient content in the plants and nutrient removal by fruit decreased. Nutrient removal from a field by cucumber fruit is about 25 percent of the total plant's content at harvest.

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By

Christopher John Rajzer

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Horticulture

1977

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ACKNOWLEDGMENT

I would like to express my sincere thanks and appreciation to Dr. H. C. Price for his counsel, assistance, and support during the course of my graduate program. I am most grateful to Drs. J. E. Motes, A. R. Putnam, M. J. Bukovac and M. M. Warncke for counsel and service on my guidance committee.

My greatest indebtedness is to my wife, Dina, for her patience, understanding, and encouragement throughout my graduate studies.

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Guidance Committee:

The Paper-Format was adopted for this thesis in accordance with Departmental and University regulations. The thesis body was separated into two sections. Both sections are intended for publication in The Journal of the American Society for Horticultural Science.

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INTRODUCTION

There are many factors influencing the yields of pickling cucumbers (*Cucumis sativus* L.). Some of these factors are cultivars, nutrients, or plant populations which are somewhat controllable, or local environmental factors which are variable. Cultivars may respond differently to various fertilizers and plant population. The nutrient concentration of pickling cucumbers varies with application of fertilizers, spacing, and the physiological age of plants.

The invention of a mechanical once-over harvester aroused interest in new cultural practices. Plant populations changed to increase yields. Monoecious cultivars were replaced with earlier maturing cultivars which were predominantly female. Therefore, nutrient requirements and uptake by plants grown under these practices should be different.

The objective of this study was to examine the response of cultivars as well as the influence of plant populations and nitrogen, and how their main effects and interactions may be related to cucumber growth, sex expression, yields, and to evaluate plant and fruit nutrient contents.

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LITERATURE REVIEW

Hoglund (1958) stated that there are many factors that can interact to influence the overall yield of pickling cucumbers. These determinate factors are local environment over which we have little control, cultivars and nutrition, as well as plant populations which man can alter to influence yield.

Before the early 60's most of the pickling cucumbers were harvested by hand several times throughout the growing season. About this time a once-over machine harvester was developed that required higher plant populations and different fertilizer rates to obtain maximum yields. The literature does not provide adequate information on optimum growth determinates and their interaction for machine harvested cucumbers. However, it does describe the responses of the pickling cucumber plants to several growth factors.

Nutritional Requirements of Cucumber

One of the earliest studies on nutritional requirements of pickling cucumbers was by Magrude (1933) in southern Ohio. After a long study, he indicated that cucumbers benefitted from the application of 1.0 T/A of limestone and the application of manure yearly. Magrude did not report on the pH of the soil nor the organic matter content but one might suspect that it was sandy acidic soil. When commercial fertilizers became

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available, researchers compared their effectiveness to established practices. This led to Comin and Bushnell's (1928) work with slicing cucumber. With the application of lime during the early years of their experiment, no increase in yield was observed even though the initial pH was 5.6. A marked increase in yield was recorded with the use of 77 lb/A of N supplemented with superphosphate. With the application of 160 lb/A of N (nitrate of soda) and manure, yields were still greatly increased with no indication of leveling off. K application was not profitable and only small quantities of P were needed. In contrast, two years later, Bushnell (1930) reported that his cucumber crop showed the highest response to K and that this had now become the limiting element.

With the development of complete fertilizers, nutrition studies became more numerous. Seaton et al. (1936) indicated that 16 T/A of manure gave a slightly better yield than 1220 lb of 4-10-4 fertilizer. Two years later in New York, Dearborn (1936) had the foresight to see that commercial fertilizers would some day become an important tool to vegetable growers. He observed that high N levels increased vegetative growth and fruit size of cucumbers.

Anderson (1941) recommended 800 to 1000 lb/A of 6-8-8 for land not previously cropped, and 800 to 1000 lb of 6-8-12 for land already in production. No specific amount of supplementary nitrogen was recommended, although its use was suggested. Later, Anderson (1943) indicated increased yields were received with 500 and 1000 lb/A of 6-8-6 fertilizer with little difference between rates. More recent work by Wittwer and Tyson

(1950) from a fertilizer trial at three locations in Michigan concluded that a band application of 500 lb/A of 3-12-12 would be profitable on fertile soils, and that the application of N was beneficial only on poorly drained soils. They concluded that fertile soils needed smaller amounts of fertilizer, than previously reported, in the area of 500 lb/A of 3-12-12 to obtain yields of 237 Bu/A. Soils of low fertility produced lower yields, however, they could produce up to 200 Bu/A with applications of 800 lb/A of 3-12-12. Where drainage is poor, nitrigication is low, or if sod is plowed down, one should side dress with 200 lb/A of ammonium nitrate, and for better earlier growth and production, band placement of fertilizer should be practiced. For higher late season yields, fertilizer should be broadcasted.

Comparing growth responses to various levels of fertilizer in Maryland, Reynolds (1954) was unable to observe any different responses in yield of pickling cucumbers. In Michigan, Miller (1957) noted that 200 and 400 lb/A of 5-20-20 placed 2 inches under the seed would reduce stand and yields. This was one of the first studies on the effects of fertilizer placement for pickling cucumbers. He also reported that 100 lb/A of K_2O depressed yields. The highest yields were obtained with 100 or 200 lb/A of 5-20-20 fertilizer placed 2 inches to the side and below the seed or with 300 lb/A of 5-20-20 broadcasted before planting.

A more intensified nutritional study by Ries and Carolus (1959) indicated that 20 lb/A of N and 80 to 160 lb/A of P_2O_5

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with 80 lb of K_2O would produce yields of over 400 Bu/A. With 160 lb/A of P_2O_5 compared to 80 lb/A, no reduction in yields was observed. They concluded that soil potassium levels of 150 to 200 lb/A K_2O would be sufficient. Good yields (361 to 440 Bu/A were obtained by broadcasting 400 lb/A of 5-20-20 fertilizer prior to planting.

In the 1960's, the invention of a mechanical once-over harvester aroused interest in new cultural practices. In Canada, Bishop (1960) with a complex study found P is of more relative importance than either N or K. He also found that yields were not always increased but were never decreased by N, P, or K.

By the early 1970's, most of the research dealt with excess minerals decreasing yields. In North Carolina, McCollum and Miller (1971) studied different rates of N, P, and K only to find that few of the yield differences were assignable to treatments. Postitive yield trends from the addition of increasing increments of N and K_2O up to 80 lb/A and for P_2O_5 up to 63 lb/A were observed.

Bishop et al. (1969) reported that at 3 locations there were variable yields without applied N. However, at 2 of these locations, yields were not significantly increased with additional N, but were significantly decreased by more than 56 kg/ha. It is an important observation that yields can be decreased without an observed reduction in plant growth.

At the Piedmont Substation in Alabama, Johnson et al. (1973) concluded that responses to N fertilizer were variable depending on soil area and fertility. Added P_2O_5 provided large

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increases in yield with increasing increments at several different locations. K_2O gave indications of yield increases. Downes and Lucas (1966) have also reported yield responses from applied K which quantitatively is the predominate element in cucumbers according to Ward (1967).

Cantliffe (1977) reported the results of a 3 year study which supported earlier findings. His work dealt only with N applied in the form of urea or ammonium nitrate, side-dressed or broadcasted on plantings for once-over harvesting. The use of N rates of 67 or 134 kg/ha increased yields with no differences between forms. These findings are similar to those of McCollum and Miller (1971) and Bishop et al. (1969) and McCall et al. (1958) who obtained maximum yields with 50 kg/ha and 56 kg/ha respectively of N.

The results of extra side dressing showed basically no benefit as Ries and Carolus (1958) also reported. Cantliffe (1977) concluded that applications of 67 to 134 kg/ha of N broadcasted and incorporated into the soil would produce maximum yields for once-over harvesting of pickling cucumbers.

The nutrient requirements for the gynoecious hybrid pickling cucumbers appear different than those of the monecious cultivars. Motes (1975) indicated that hybrid cucumber cultivars which mature in 50-60 days require less nitrogen than monecious cultivars which were hand harvested over longer periods of time.

There is a variation in fertilizer recommendations and responses of pickling cucumbers. However, we can conclude from these readings that much of the variation is due to the initi

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initial soil fertility, cultural practices, or local environmental effects. Furthermore, N may not be the main limiting factor to yields. It is the one element most commonly over-applied that results in a reduction of yields. If P_2O_5 and K_2O are at adequate levels in the soil, less variation in yields will be observed.

Effect of Plant Population on Cucumber Growth

With the adoption of mechanical harvesting, plant populations have been increased drastically to obtain yields comparable to hand harvesting. Banadyga (1949) summarized research on spacing of hand-picked cucumbers as follows: "Varying results have been obtained with spacing tests. It is recognized that rows should be 5 to 7 ft. apart, but much controversy exists on the spacing of plants in the rows." Three years later, Ware et al. (1953) conducted a spacing trial with rows 3 ft. apart and plants 12, 24, and 36 inches apart in the row. With no supplemental irrigation, the highest yields were obtained from the 12 inch spacing.

A 3 year spacing trial by Ries (1957) reported that with spacings of 6, 12, 18, and 24 inches apart in 5 ft. rows, yields were highest at the 6 inch spacing with no differences between 12 and 18 inches. Yields were lower with the 24 inch spacing. Plots were harvested by hand and higher yields were due primarily to higher earlier yields. In a later planting, there was no effect of plant density on yields.

When even higher plant densities were observed, it seemed as if there was no limit that would result in increased yields.

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Putnam (1963) evaluated populations for once-over harvesting varying from 22,000 to 87,000 plants/A. The highest yields with greatest number of fruit per plant were from a 1 ft. spacing irregardless of the distance between rows. Morrison et al. (1967) with similar work indicated that plant populations of 77,800 plants/A at 9 inch spacing in 9 inch rows consistently produced the highest dollar value. Cantliffe et al. (1975) observed two different cultivars under 8 populations ranging from 50,000 to 850,000 plants/ha. Yields as dollar and tonnage/ha increased with populations of 50,000 to 100,000 and 250,000 to 500,000 plants/ha. Delaying harvest for 4 days doubled the tonnage but did not affect the dollar value with both cultivars reacting similarly. Cantliffe (1977) reported that in a fertilizer study, the mean yield in dollars/ha was higher at 450,000 plants than at 250,000 plants/ha.

With the application of nitrogen, an increase in plant density will increase both tonnage and dollar yield. However, there is much more controversy on the limits one can go with density. It appears there may be interactions between the nitrogen and population levels.

Nutrient Uptake

Some of the first chemical analyses of cucumbers were performed by Wilkins (1917). He showed that Ca was 10 times higher in vines than in the fruit, with Mg only 2 to 3 times higher. P content was slightly higher in the fruit compared to

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to vines whereas K and N levels were similar in both.

Friedrich and Schmidt (1954) analyzed plants every 10 days for N, P, K, Ca and Mg. They found that there was a high Ca content in the leaves. N was stored in leaves as protein, and the fruit contained high amounts of soluble N. There was a large increase in nutrient uptake during the flowering and fruiting phase.

Campbell (1953) found that Ca levels in pickling cucumber vines were not changed by soil applications of Ca, but the K levels would increase with added K. Reynolds (1954) growing cucumbers under varying rates of N, P, K, Ca, and Mg observed significant differences in the amounts of all of these elements except N in the leaves and fruit.

Ries (1957) in a spacing trial, observed an inverse correlation between spacing and concentration of NO_3-N in cucumber petioles. He also observed that P would increase in plant tissue as spacing and N levels decreased. Petiole K levels were higher in low fertilized plots (300 lb/A of 12-12-12 plus side-dressing 100 lb/A of NH_4) than those with a higher fertilization rate. In the higher fertilized plot (300 lb/A of 12-12-12 plus side-dressing 200-275 lb/A of 12-12-12), K increased in the petiole as spacing increased.

Miller (1957) found an inverse relationship between the soluble N and soluble P in cucumbers. Both nutrients increased in the petioles during the season. The largest yields were associated with moderate levels of soluble NO_3-N (892 ppm) and P (59 ppm) in petioles at harvest. Mg increased sharply as th

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as the season progressed.

In a study of the nutrient levels in laminae and petioles of cucumbers grown at low populations for multiple harvesting, Bishop et al. (1969) found the yield response to applied P_2O_5 to be of much greater relative importance than applied N or K_2O. The study indicated that N and K_2O each at 50 kg/ha and P_2O_5 at 100 kg/ha would be adequate. El-Sheikh and Broyer (1970) reported that total N content was less satisfactory than NO_3-N content to determine critical N concentration for optimum growth. Cantliffe (1977) indicated that total N within the blade or petiole of pickling cucumbers did not appear to be a good indicator of yields, but highest yields were obtained when the leaf blade contained from 4 to 5% total N. The concentration of NO_3-N in leaf blade and petiole tissue rapidly decreased during the fruit sizing period. When preplant and side dress N fertilizers were used, this led to an increased tissue concentration of NO_3-N and total N. The source of N fertilizer had little influence on tissue concentration. The tissue concentration of K, Ca, Mg, Fe and Mn were higher in tissue when treated prior to planting with 67 to 207 kg/ha of N.

McCollum and Miller (1971) found that after 72 days the N, P, and K uptake by cucumber plants was 90, 12, and 145 lb/A respectively. The nutrient fruit removal with multiple harvesting was 40 lb N, 6 lb P, and 55 lb K/A with yields of 8.7 to 11.9 T/A. The maximum rate of growth and nutrient accumulation occurred about 50 days after seeding.

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With once-over harvesting, plants generally take only 50 days to obtain maximum dollar yields. If the plants are grown for shorter periods of time, nutrient content and requirements should vary. However, there are no indications of research in this area.

Other Plant Responses to Nutrition

Reynolds and Stark (1953) reported that in comparing growth response to N, Ca, K, and Mg, N levels produced the greatest effect on vegetative growth. The greatest number of fruit occurred on plants receiving a medium supply of N compared to very low or high amounts. Similar results were reported earlier by Dearborn (1936) and Cantliffe (1977), while Tiedjens (1926) found that high N improved fruit shape. Cantliffe (1975) observed that the number of fruit per plant decreased with increasing plant populations. However, varying the population did not affect fruit shape or color.

Miller (1957) in a greenhouse study, found that high amounts of N increased the length to diameter ratio of fruit. Cantliffe et al. (1975) reported that with "Premier" the length to diameter ratio (L/D) was decreased at lower plant populations.

N levels have also been found to affect sex expression of cucumbers. Dearborn (1936) indicated that high N supply produced more pistillate flowers. Miller (1957) reported that both pistillate and staminate flower production were increased. However, the staminate to pistillate ratio was decreased with high N levels. Vaile (1938, 1942) indicated that the set and

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number of marketable fruits were greater under high as compared to low nutrient conditions.

Reynolds and Stark (1953) reported that the dry weight of cucumber plants grown on sand increased with increasing increments of N, but there were more fruit at the medium N level.

Cantliffe (1977) reported that the addition of preplant N up to 134 kg/ha resulted in a greater number of pistillate flowers per plant. However, the percent of off-shape fruits were also highest for the highest N treatment, while L/D ratios were not influenced. Similar results were reported by Lloyd and McCollum (1940). It appears that both nutrient levels and plant populations can influence the quality of the cucumber fruit under different local environmental conditions.

LITERATURE CITED

1. Anderson, W. S. 1941. Growing cucumbers for pickling in Mississippi. Miss. Agr. Exp. Sta. Bul. 355:1-17

2. Anderson, W. S. 1943. Close spacing, medium fertilizer rate most profitable for pickling cucumbers. Miss. Farm Res. 6(3):8, March.

3. Banadyga, A. A. 1949. Cucumbers for Pickles. Nat. Pickle Packers Assoc., Oak Park, Ill. 276 pp.

4. Bishop, R. F., E. W. Chipman and C. R. MacEachern. 1969. Effect of nitrogen, phosphorus and potassium on yields and nutrient levels in laminae and petioles pickling cucumbers. Can. J. Soil Sci. Vol. 49, 297-304.

5. Bushnell, J. 1930. The relative response to fertilizer of cabbage, tomatoes, cucumbers, and sweet corn. Proc. Amer. Soc. Hor. Sci. 27:515-519

6. Bushnell, J. 1941. Fertilizers for early cabbage, tomatoes, cucumbers, and sweet corn. Ohio Agr. Exp. Sta. Bul. 622

7. Campbell, J. D. 1953. Differential cation absorption and yield response by vegetable crops grown at various levels of calcium, potassium and sodium. Ph.D. Thesis. Michigan State College. 163 pages.

8. Cantliffe, D. J. 1977. Nitrogen fertilizer requirements of pickling cucumbers grown for once-over harvest I. Effect on yield and fresh quality. J. Amer. Soc. Hort. Sci. 102(2):112-114.

9. Cantliffe, D. J. and S. C. Phatak. 1975. Plant population studies with pickling cucumbers grown for once-over harvest. J. Amer. Soc. Hort. Sci. 100(5):464-466.

10. Cantliffe, D. J. 1977. Nitrogen fertilizer requirements of pickling cucumbers grown for once-over harvest II. Effect on plant tissue mineral nutrient concentrations. J. Amer. Soc. Hort. Sci. 1-2(2): 115-119.

11. Comin, D. 1938. Early yields of selected truck crops as affected by fertilizer treatments. Proc. Amer. Soc. Hort. Sci. 35:673-677.

12. Comin, D. and J. Bushnell. 1928. Fertilizers for early cabbage, cucumbers, and sweet corn. Ohio Agr. Exp. Sta. Bul. 420.

13. Dearborn, R. B. 1936. Nitrogen nutrition and chemical composition in relation to growth and fruiting of the cucumber plant. Cornell Univ. Agr. Exp. Sta. Mem. 192.

14. Downes, J. D. and R. E. Lucas. 1966. Pickling cucumber yields in relation to NPK fertilization and P-K soil tests. Proc. 17th Int. Hort. Congr. 1, Abstr. No. 456.

15. El-Sheikh, A. M., M. A. Abd El-Hakam and Albert Ulrich. 1970. Critical nitrate levels for squash, cucumber, and melon plants. Comm. in Soil Sci. and Plant Anal. 1:63-74.

16. El-Sheikh, A. M. and T. C. Broyer. 1970. Concentrations of total nitrogen in squash, cucumber and melon in relation to growth and to a Piper-Steenbjerg effect. Comm. in Soil Sci. and Plant Anal. 1:213-219.

17. Friedrich, G. and G. Schmidt. 1954. Untersuchungen uber die Nahrstoffausnahme van Triebhausgurken in Wasserkulturen. (The absorption of nutrients by glass-house cucumber in soilless culture). Arch. Gartenb. 2:319-335. (Hort. Abst.).

18. Hoglund, C. R. 1958. Economics of growing and irrigating pickling cucumbers. Quarterly Bul. Mich. Agr. Exp. Sta. 40(4), 796-805.

19. Lloyd, J. W. and J. P. McCollum. 1940. Fertilizing onion sets, sweet corn, cabbage and cucumbers in a four year rotation. Ill. Agr. Exp. Sta. Bul. 464: 219-236.

20. Johnson, W. A., C. E. Evans, E. L. Mayton, and W. A. Griffey. 1973. Soil Fertility studies with pickling cucumbers in the Piedmont Area of Alabama. Alabama Agr. Exp. Sta. Cir. 211.

21. Magrude, R. 1923. Observations on the effect of liming truck crops in Ohio. Proc. Amer. Soc. Hort. Sci. 29:175-179.

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22. McCall, W. W., R. E. Lucas, C. M. Hansen, and W. C. Hulburt. 1958. Fertilizer placement studies with the pickling cucumber. Mich. Agr. Expt. Sta. Quar. Bul. 40:637-645.

23. McCollum, R. E. and C. H. Miller. 1971. Yield, nutrient uptake and nutrient removal by pickling cucumbers. J. Amer. Soc. Hort. Sci. 96:42-45.

24. Miller, C. H. 1957. Studies on the nutrition and physiology of pickling cucumbers. Ph.D. Thesis, Mich. State Univ. 69 pages.

25. Morrison, F. D. and S. K. Ries. 1967. Cultural requirements for once-over mechanical harvest of cucumbers for pickling. J. Amer. Soc. Hort. Sci. 91:339-346.

26. Motes, J. E. 1975. Pickling cucumbers production-harvesting. Mich. State Univ. Ext. Bul. E-837.

27. Putnam, A. R. 1963. Horticultural aspects concerned with the production of pickling cucumbers for once-over harvest. M.S. Thesis, Mich. State Univ. 59 pages.

28. Reynolds, S. W. 1954. Studies with cucumbers for pickling. Ph.D. Thesis, Univ. of Maryland.

29. Reynolds, C. W. and F. C. Stark. 1953. Growth and fruiting responses of cucumbers to varying levels of Ca, K, Mg and N in sand culture. Assoc. Southern Ag. Workers 50:133.

30. Ries, S. K. 1957. The effect of spacing and supplemental fertilizer applications on the yield of pickling cucumbers. Mich. Agr. Exp. Sta. Quart. Bul. 40(2):375-381.

31. Ries, S. K. and R. L. Carolus. 1958. The effect of nutrient level on growth of pickling cucumbers. Mich. Agr. Exp. Sta. Quart. Bul. 40(3):659-668.

32. Seaton, H. L., R. Hutson and J. H. Muncie. 1939. The production of cucumbers for pickling purposes. Mich. Agr. Exp. Sta. Spec. Bul. 273.

33. Tiedjens, V. A. 1926. Some observations on the response of greenhouse cucumber (Cucumis sativus) to certain environmental conditions. Proc. Amer. Soc. Hort. Sci. 23:184-189.

34. Vaile, J. E. 1938. Ark. Exp. Sta. 50th Ann. Rpt. Bul. 368:82.

35. Vaile, J. E. 1942. Ark. Exp. Sta. 53rd Ann. Rpt. Bul. 417:28.

36. Ward, G. M. 1967. Greenhouse cucumber nutrition: a growth analysis study. Plant and Soil 26:324-332.

37. Ward, G. M. 1967. Growth and nutrient absorption in greenhouse tomato and cucumber. Proc. Amer. Soc. Hort. Sci. 90:335-341.

38. Ware, L. M., C. L. Isbell, H. Harris and W. A. Johnson. 1953. Studies with pickling cucumbers in Alabama. Ala. Agr. Exp. Sta. Cir. 114.

39. Wilkins, L. K. 1917. The high calcium content of some cucurbit vines. N. J. Agr. Exp. Sta. Bul. 310: 1-20.

40. Wittwer, S. H. and J. Tyson. 1950. Yields of pickling cucumbers as influenced by rates of fertilizer application, fertilizer placement, and nitrogen side dressing. Mich. Agr. Exp. Sta. Bul. 32(4):535-539.

SECTION I

THE INFLUENCE OF NITROGEN AND PLANT POPULATIONS ON SEVERAL CULTIVARS OF PICKLING CUCUMBERS

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The Influence of Nitrogen and Plant Populations on Several Cultivars of Pickling Cucumbers I. Fruit Yields.

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Abstract: Early and late plantings of several cultivars of pickling cucumbers (*Cucumis sativus* L.) were evaluated under various levels of preplant N and plant populations. Cultivars responded to treatments differently in fruit yields, sex expression, fruit set, and length to diameter ratios. Increasing the nitrogen rate to 67 kg/ha increased yields (metric tons and dollars/ha) in the early planting only, and 101 kg/ha appeared to suppress yields in both plantings. High nitrogen rates (67 and 101 kg N/ha) reduced the percent cull fruit in the first planting. Increasing the plant populations increased yields only when N was sufficient. Increasing populations from 99,000 to 296,000 plants/ha, increased the percent culls but decreased the percent oversize fruit. Both fresh and dry weight per vine decreased with increasing plant populations. Yield was positively correlated to percent pistillate flowers and fruit number per vine.

INTRODUCTION

Previous studies indicate that there are many factors influencing the yields of pickling cucumbers (*Cucumis sativus* L.)

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Some of these factors are cultivars, nutrients, or populations which are somewhat controllable, or local environmental factors which are variable.

Previous nutritional studies indicated that increased yields of cucumbers were obtained by broadcasting 448 kg/ha of 5-20-20 prior to planting (10). Nitrogen applied side-dressed or broadcasted as urea or ammonium nitrate at rates of 67 or 134 kg/ha produced maximum yields for a once-over harvest on a coarse sandy loam soil (2).

Others (6) have indicated that various rates of N, P, and K, did not significantly increase yields, although, increasing trends were observed with an increase of N and K up to 90 and 71 kg/ha respectively. There are some indications (1, 15) that yields can be increased by addition of various individual elements, although yield increases were not consistent.

Comparing vegetative growth responses, increasing increments of N produced the greatest effects on growth and dry wt. (9). The maximum number of fruit was produced with a median level of N compared to a very low or high rate (2, 4, 9). Fruit per vine decreased with increasing plant populations (3). High N also improved fruit shape (11) in some studies, while others found the percent off-shape fruit and length to diameter ratios (L/D) to be increased (2, 7). Sex expression can be altered by increasing nitrogen levels, forming more pistillate flowers, although the ratio of pistillate to staminate flowers decreased (4, 7). Fruit set and numbers of marketable fruit were greatest under high nutrient conditions (12, 13).

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Other studies (3) with 2 cultivars and 8 populations from 50,000 to 850,000 plants/ha indicated that yields in dollars and tons/ha increased with increasing populations from 50,000 to 100,000 and from 250,000 to 500,000. A delay in harvest of 4 days doubled the tonnage but dollars/ha values did not change.

By increasing plant populations, yields can be increased for once-over harvesting. Highest yields with the greatest number of fruits per vine were obtained from a 30 cm spacing with up to 215,000 plants/ha regardless of the distance between the rows (8).

Most of the published data deals with cucumbers grown in a multiple-harvesting system and examines various levels of controllable factors on yield. The objective of this study was to examine the influence of cultivar, populations, and nitrogen, and how their main effects and interactions may be related to cucumber growth, sex expression, and yields.

MATERIALS AND METHODS

Cucumbers were planted in both early and late season tests in 1976. The May 25 planting consisted of 2 cultivars, Green Star and Premier, grown at 3 plant populations, 99,000, 148,000, and 198,000 plants/ha. The Conover sandy loam soil contained 11.5 kg/ha of residual NO_3-N and 3.0% organic matter. The late planting on July 22 had 3 cultivars, Green Star, Premier, and MSU-76 with plant populations of 99,000, 198,000, and 296,000 plants/ha. The Conover sandy loam soil tested 37.3 kg/ha of

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residual NO_3-N and 2.0% organic matter. The soils for both plantings were medium to high in P, K, Ca, and Mg, with a pH of 5.9. The pollinators for cultivars were adjusted to 7 percent and planted with a Dahlman seeder in rows 40 cm apart, and the appropriate spacing within rows was obtained by thinning at emergence to acheive the desired populations. Seeds were planted in beds 5.5 m long and 2.0 m wide with 4 rows to a bed. Four levels of N (urea) 0, 34, 67, and 101 kg/ha were applied with a Gandy spreader and incorporated preplant along with 62 kg/ha of P and 116 kg/ha of K. The experiment was designed as a split-split plot with cultivars as main plots, N levels as subplots and populations as sub subplots, each replicated 3 times. Chloramben methyl ester at 2.0 kg/ha was applied immediately after seeding for weed control. Carbaryl at 2.0 kg/ha was applied twice in each planting for beetle control. Irrigation of 15 cm was applied during each season. A hive of bees was supplied to insure adequate pollination.

At 35 to 40 days after seeding (DAS), 10 plants per plot were randomly selected and flower type characterized for the first 10 nodes. Forty-five to 50 DAS, fruit set on these nodes was determined by the swelling of the ovary. The early planting was harvested 53 and 55 DAS for Premier and Green Star respectively. The late planting was harvested 53, 54, and 57 DAS for Premier, MSU-76, and Green Star respectively. The cucumbers were harvested by hand simulating once-over mechanical harvesting. Fresh vine weight was recorded, and fruit were graded and weighed. The grade and dollar values were calculated from standards established by the Pickling Cucumber Improvement Committee (PCIC), i.e. less than 2.0 cm diameter ($132/metric ton), 2.7 to 3.8 cm ($66/metric ton), 3.8 to 5.1 cm ($44/metric ton), and over 5.1 cm ($11/metric ton). The percentage of fruit culls, "nubs" and "crooks" was calculated for each plot. L/D ratios were measured on 10 randomly selected fruit between 3.8 and 5.1 cm in length. The fruit dry weight was determined from fruit that were removed and dried at 70°C.

RESULTS AND DISCUSSION

Cultivar Influence

Cultivars responded in only the wt. per vine and L/D ratio for the early planting, with Green Star the more vigorous cultivar (Table 1). Different cultivar responses were observed in the late planting with Green Star being the poorest yielder in both weight and value/ha (Table 2). These lower yields corresponded to lower fruit numbers per vine. Green Star and MSU-76 had the highest number of pistillate flowers but the former cultivar had only 23 percent fruit set versus 39 percent with MSU-76. Either poor pollination or the abortion of the ovary after pollination were 2 possibilities for yield differences between these cultivars in the later planting. In the first planting yields correlated closely with sex expression. As expected, cultivars respond differently when grown under different environmental conditions.

The time of planting had a pronounced effect on the yields of pickling cucumbers. The early planting (May 25) responded differently to both N and populations than the late planting (July 22). These differences may have been related to local environmental factors or the differences in soil NO_3-N.

Differences were noted in vegetative growth between cultivars. In the early planting, the fresh wt. of Green Star was greater than that of Premier, while there was no significant difference in their dry wt. (Table 3). This indicates that Green Star makes more vigorous growth and may have a higher water requirement.

For the late planting, vine wt. and L/D ratio did not differ among cultivars, but Premier and MSU-76 yielded significantly more than Green Star. The percent oversize fruit data does not support the idea of later maturity.

Nitrogen Influence

Nitrogen had its greatest influence on the early planting. Yields increased as N levels increased up to 67 kg/ha after which there was no additional benefit (Table 1). The greatest percent culls were obtained with low rates of N, while less oversize fruit occurred with 0 and 101 kg N/ha. Increased fruit dry wt. was associated with higher rates of N. A significant interaction indicates that both cultivars were not different in fruit dry wt. at 0 and 34 kg N/ha, however, Premier was significantly higher at 67 and 101 kg N/ha. No differences in sex expression were observed in the early planting that could account for a difference in yield (Table 3).

In the late planting, nitrogen affected sex expression but not yields. The lowest number of staminate flowers were produced with 101 kg N/ha. An interaction between cultivars and nitrogen levels for marketable fruit per vine shows Premier and MSU-76 both significantly better at 0 to 67 kg N/ha with only MSU-76 greater at 101 kg N/ha.

Cultivars varied in sex expression, and with more pistillate flowers produced, the yields were increased. Nitrogen increased percent pistillate flowers and fruit set while staminate flowers decreased with increasing increments in the late planting. The lower plant populations did produce more pistillate flowers in the late planting only, but the differerces were so small they may be of no importance.

Increasing rates of preplant N increased dollars and metric tons/ha in the early planting with no significant differences in the late planting. There are indications that at 101 kg N/ha fruit tonnage is depressed. McCollum and Miller (6) observed a positive yield response with increasing increments of N fertilizer up to 90 kg/ha, while Wittwer and Tyson (14) and Ries and Carolus (10) found no benefit of supplemental N, except on low fertility soils.

In these tests, residual NO_3-N for early and late plantings was 11.5 and 37.3 kg/ha, respectively. Cantliffe (2) observed that the percentages of off-shape fruit were greater for higher rates of applied nitrogen, with no effect on L/D ratios. In the early study which was influenced by N, percent culls decreased with 67 and 101 kg N/ha compared to 0 and 34 kg N/ha, with no effect on L/D ratio in either planting.

The differential responses to N between plantings could have been influenced by the daily mean temp. and amount of residual NO_3-N in the soil or nitrification. With the higher temp. that occurred during growth of the early planting, the growth rate was rapid, requiring more N. With lower temp. and higher NO_3-N level in the soil, differences were not noted.

There were indications that increasing increments of N increased both vine fresh and dry wt. when yields were influenced by N. This confirms Reynolds and Stark's (9) work. However, when yields were not changed by N, there were no differences in vine wts.

Population Effects

There were no influences of populations on yield or dollar value for the early planting (Table 1). However, percent culls was increased with an increase in population. Oversize fruit was reduced with 198,000 plants/ha. Green Star fruit size decreased linearly with an increase in population while in Premier size leveled off at 148,000 plants/ha.

There was an inverse relationship between the fresh wt. per vine and population. An interaction indicated that Green Star was a vigorous cultivar producing more fresh wt. at all populations. However, the dry wt. per vine did not differ with changes in populations.

Both marketable and total fruit per vine decreased as populations increased. The greatest effect of population was in the late planting, with yield and dollar values showing similar trends. The highest yields were obtained with 198,000 and 296,000 plants/ha (Table 2). These yield differences attributed to population also correspond to the fruit produced per vine (Table 4). The total fruit per vine varied from 30 to 60% of the actual fruit set which was about one-third of the total pistillate flowers which indicate that yield is not necessarily related to this parameter.

As plant population increased, in the late planting, the percent culls increased (Table 2) while oversize fruit decreased. At 99,000 and 198,000 plants/ha Green Star had the greatest percent of oversize fruit, while MSU-76 had the lowest. There were no cultivar differences at the highest population.

Cantliffe and Phatak (3) reported that increasing the plant populations could increase yields. Yields in both dollars and metric tons/ha increased with increasing populations for the late planting, with no effect observed in the early planting. However, in both plantings increasing the population increased the percent culls and decreased percent oversize fruit. Weights of fresh and dry vines decreased with increasing plant populations, while L/D ratios of fruit were not affected.

Relationships between both fresh and dry wt. per vine and dry wt. of fruit was noted (Table 2). As plant populations increased, the plant and fruit wt. decreased. Populations appeared to have the greatest influence on yields when nitrogen levels were not limiting.

Although increasing the plant population increased the total yield, it decreased marketable and total fruit per vine. Cantliffe and Phatak (3) observed similar results. It also appears that there are differences in sex expression which can be attributed to planting dates and cultivars. N will enhance yield when not present in the soil in abundant supply, however, when the supply is adequate, plant population may then become the factor limiting yield. Although higher plant populations provide less fruit per vine, the net result is increased marketable yield.

Table 1. Effect of plant population, nitrogen and cultivar on vine and fruit characteristics. Early Planting.

Main effects		Wt. per vine (g)		Fruit dry wt per vine (g)	Fruit grade (% by wt.)		Marketable fruit		
		Fresh	Dry		Culls	Oversize	MT/ha	L/D	PCIC ($/ha)
(1) Cultivars;	Green Star	159a[z]	21.4a	4.8a	9.6a	12.5a	7.7a	2.52a	494a
	Premier	104b	16.4a	5.6a	9.5a	14.8a	6.7a	2.44b	413a
(2) Nitrogen; (kg/ha)	0	113m	17.6m	4.1m	18.0m	12.7mn	5.4m	2.45m	346m
	34	122m	18.6m	4.9mn	13.4m	17.8m	6.5mn	2.49m	407mn
	67	145m	17.8m	5.9n	3.6n	15.7m	8.6n	2.47m	541n
	101	150m	21.8m	5.8n	3.3n	8.2n	8.4n	2.50m	520n
(3) Plants/ha; (1000's)	99	168r	19.9r	5.7r	6.8r	15.2r	6.8r	2.48r	424r
	148	127s	19.2r	4.6r	8.6r	15.7r	7.4r	2.47r	461r
	198	104t	17.7r	5.2r	13.4s	10.0s	7.4r	2.48r	473r
(4) Interactions;	1x2	NS	NS	*	NS	NS	NS	NS	NS
	1x3	*	NS	NS	NS	*	NS	NS	NS
	2x3	NS	NS	NS	*	NS	NS	NS	NS
	1x2x3	NS	NS	NS	NS	NS	NS	NS	NS

[z]Mean separation within sets by Duncan's multiple range test at the 5% level

Table 2. Effect of plant population, nitrogen and cultivar on vine and fruit characteristics. Late Planting.

Main effects		Wt. per vine (g)		Fruit dry wt per vine (g)	Fruit grade (% by wt.)		Marketable fruit		
		Fresh	Dry		Culls	Oversize	MT/ha	L/D	PCIC ($/ha)
(1) Cultivars;	Green Star	168a[z]	15.8a	3.1a	5.6a	4.4a	8.5a	2.49a	524a
	Premier	141a	11.3a	4.1a	4.0a	2.9a	11.8b	2.51a	714b
	MSU-76	162a	15.1a	4.4a	3.2a	2.1a	12.5b	2.60a	769b
(2) Nitrogen; (Kg/ha)	0	161m	14.5m	3.7m	3.6m	3.3m	11.6m	2.52m	691m
	34	160m	13.9m	3.9m	4.6m	4.1m	10.4m	2.54m	677m
	67	161m	14.3m	4.1m	4.4m	2.9m	11.3m	2.54m	694m
	101	147m	13.5m	3.7m	4.4m	2.4m	10.5m	2.53m	644m
(3) Plants/ha; (1000's)	99	228r	18.7r	4.8r	2.3r	6.6r	10.0r	2.53r	589r
	198	141s	12.6s	3.7s	4.1s	2.4s	11.5s	2.54r	700s
	296	102t	10.8t	3.1t	6.3t	0.4t	11.3s	2.54r	717s
(4) Interactions;	1x2	NS	NS	NS	NS	NS	NS	NS	NS
	1x3	NS	NS	NS	NS	NS	NS	NS	NS
	2x3	NS	NS	NS	NS	NS	NS	NS	NS
	1x2x3	NS	NS	NS	NS	NS	NS	NS	NS

[z]Mean separation within sets by Duncan's multiple range test at the 5% level

Table 3. Effect on sex expressions and fruiting habits. Early Planting.[y]

Main effects		% Blind nodes	Flowers per 10 nodes		Fruit set per 10 nodes	Fruit per vine	
			Pistillate	Staminate		Marketable	Total
(1) Cultivars;	Green Star	7.9a[z]	7.65a	1.55a	2.63a	1.42a	1.61a
	Premier	5.9b	6.23a	3.18a	3.38a	1.17a	1.34a
(2) Nitrogen;	0	6.6m	7.21m	2.14m	3.08m	1.15m	1.38m
(Kg/ha)	34	7.2m	6.87m	2.41m	3.68m	1.07m	1.31m
	67	7.1m	6.81m	2.48m	2.83m	1.43m	1.58m
	101	6.8m	6.89m	2.43m	3.43m	1.51m	1.62m
(3) Plants/ha;	99	7.0r	6.98r	2.32r	2.95r	1.76r	1.99r
(1000's)	148	6.6r	6.98r	2.36r	3.00r	1.10s	1.28s
	198	7.1r	6.88r	2.41r	3.06r	1.01s	1.15s

[y]No significant interactions

[z]Mean separation within sets by Duncan's multiple range test at the 5% level

Table 4. Effect on sex expression and fruiting habits. Late Planting.

Main effects		% Blind nodes	Flowers per 10 nodes: Pistillate	Flowers per 10 nodes: Staminate	Fruit set per 10 nodes	Fruit per vine: Marketable	Fruit per vine: Total
(1) Cultivars;	Green Star	7.8a[z]	9.03a	0.19a	2.12a	1.05a	1.14a
	Premier	4.6b	8.53b	0.96b	3.35b	1.34b	1.44b
	MSU-76	4.3b	9.25a	0.32a	3.63b	1.38b	1.45b
(2) Nitrogen;	0	5.0m	8.84m	0.59m	2.86m	1.23m	1.31m
(Kg/ha)	34	5.9mn	8.92m	0.48mn	2.99m	1.23m	1.32m
	67	6.0n	8.94m	0.46mn	3.31m	1.32m	1.42m
	101	5.3mn	9.05m	0.43n	2.97m	1.24m	1.32m
(3) Plants/ha;	99	4.8r	9.09r	0.40r	3.19r	1.80r	1.91r
(1000's)	198	5.8s	8.89s	0.51s	3.08rs	1.13s	1.21s
	296	6.0s	8.83s	0.58s	2.83s	0.84t	0.91t
(4) Interactions;	1x2	NS	NS	NS	NS	*	NS
	1x3	NS	NS	NS	NS	NS	NS
	2x3	NS	NS	NS	NS	NS	NS
	1x2x3	NS	NS	NS	NS	NS	NS

[z]Mean separation within sets by Duncan's multiple range test at the 5% level

Literature Cited

1. Bishop, R. F., E. W. Chipman and C. R. MacEachern. 1969. Effect of nitrogen, phosphorus and potassium on yields and nutrient levels in laminae and petioles of pickling cucumbers. Can. J. Soil Sci. Vol. 49, 297-304.

2. Cantliffe, D. J. 1977. Nitrogen fertilizer requirements of pickling cucumbers grown for once-over harvest I. Effect on yield and fresh quality. J. Amer. Soc. Hort. Sci. 102 (2):112-114.

3. Cantliffe, D. J. and S. C. Phatak. 1975. Plant population studies with pickling cucumbers grown for once-over harvest. J. Amer. Soc. Hort. Sci. 100(5):464-466.

4. Dearborn, R. B. 1936. Nitrogen nutrition and chemical composition in relation to growth and fruiting of the cucumber plant. Cornell Univ. Agr. Exp. Sta. Mem. 192.

5. Downes, J. D. and R. E. Lucas. 1966. Pickling cucumber yields in relation to NPK fertilization and P-K soil tests. Proc. 17th Int. Hort. Congr. 1, Abstr. No. 456.

6. McCollum, R. E. and C. H. Miller. 1971. Yield, nutrient uptake and nutrient removal by pickling cucumbers. J. Amer. Soc. Hort. Sci. 96:42-45.

7. Miller, C. H. 1957. Studies on the nutrition and physiology of pickling cucumbers. Ph.D. Thesis, Mich. State Univ. 69 pages.

8. Putnam, A. R. 1963. Horticultural aspects concerned with the production of pickling cucumber for once-over harvest. M.S. Thesis, Mich. State Univ. 59 pages.

9. Reynolds, C. W. and F. C. Stark. 1953. Growth and fruiting responses of cucumbers to varying levels of Ca, K, Mg and N in sand culture. Assoc. Southern Ag. Workers 50:133.

10. Ries, S. K. and R. L. Carolus. 1958. The effect of nutrient level on growth of pickling cucumbers. Mich. Agr. Exp. Sta. Quart. Bul. 40(3):659-668.

11. Tiedjens, V. A. 1926. Some observations on the response of greenhouse cucumber (*Cucumis sativus*) to certain environmental conditions. Proc. Amer. Soc. Hort. Sci. 23:184-189.

12. Vaile, J. E. 1938. Ark. Exp. Sta. 50th Ann. Rpt. Bul. 368:82.

13. Vaile, J. E. 1942. Ark. Exp. Sta. 53rd Ann. Rpt. Bul. 417:28.

14. Wittwer, S. H. and J. Tyson. 1950. Yields of pickling cucumbers as influenced by rates of fertilizer application, fertilizer placement, and nitrogen side dressing. Mich. Agr. Exp. Sta. Bul. 32(4):535-539.

SECTION II

THE INFLUENCE OF NITROGEN AND PLANT POPULATIONS ON SEVERAL CULTIVARS OF PICKLING CUCUMBERS

II. NUTRIENT CONTENT AND REMOVAL

The Influence of Nitrogen and Plant Populations on Several Cultivars of Pickling Cucumbers II. Nutrient Content and Removal

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Abstract: Pickling cucumber (*Cucumis sativus* L.) plants and fruit were analyzed at harvest to determine the plant nutrient content and nutrient removal by fruit. Factors studied were time of planting, cultivars, N levels, and plant populations. The mean plant nutrient content of N, P, and K was 103, 9, 147 kg/ha, respectively, with mean nutrient removal of 22, 3, 38 kg/ha, respectively. The nutrient levels of three cultivars were increased by added N and increasing plant populations. Nitrogen treatments influenced plant nutrient content. Yields and percent cull fruit were also affected. As plant population increased, both total nutrient content in the plants and nutrient removal by fruit increased. Nutrient removal from a field by cucumber fruit is about 25 percent of the total plant's nutrient content at harvest.

INTRODUCTION

Nutrient concn of pickling cucumbers vary with application of fertilizer, spacing, and the physiological age of plants. Inverse relationships between soluble N and soluble P with yield have been reported (10). The total N in the lamina and petioles does not correlate with yields, concn of NO_3-N in the tissue rapidly decreasing during the period of fruit development (4).

With multiple harvesting and moderate yields (9), total N, P, and K uptake was 101, 13, and 163 kg/ha, respectively. At low plant populations, N fertilizer was found to increase tissue concn of N, K, Ca and Mg (2).

An inverse correlation exists between spacing and the concn of NO_3-N in cucumber petioles. P increased as spacing and N levels decreased. K levels were higher in plots receiving low fertilizer levels, but at higher fertilizer rates K increased in petioles as spacing increased (13). The objective of this study was to evaluate nutrient concent and removal with various cultivars, nitrogen levels, populations, and planting dates.

MATERIALS AND METHODS

This is the second part of a two-part paper. The procedures utilized, experimental design, and fruit yields have been previously reported for these experiments (11). Plant tissues were collected at 3 periods throughout the growing season: First at tip-over (6-7 leaves), secondly between tip-over and harvest, and thirdly at harvest, with fruit and plants analyzed separately. Tissue was dried at 70° C, weighed and ground in a Wiley Mill to pass a 20-mesh screen. The tissue (.10g) was assayed for NO_3-N using an Orion nitrate electrode (5). Total N was determined by Macro-Kjeldahl procedure (1), K with the flame spectrophotometer[1], and other elements with the spark emission spectograph[2] (6).

Soil samples were taken at tip-over and analyzed for pH, BpH, P, K, Mg, and Ca by standard techniques. The nutrient content of whole plants and removal by fruit is reported in kg/ha or g/ha, and takes into consideration differences in dry wt. due to treatments and the content of nutrient in the plants/ha, rather than the concn.

RESULTS AND DISCUSSION

Both plantings were made on soils similar in nutrient levels (Table 1). Therefore, any difference in nutrient concn of the plant or fruit are assumed to result from the assigned treatments or local environmental factors.

Cultivar Responses

There were essentially no differences in the nutrient content of fruit (Table 2 and 3) or plants (Table 4 and 5) attributable to cultivars in the early and late plantings. No relationship existed between nutrient content and yields of these same cultivars. Cultivars tested appear to be efficient in their ability to use available nutrients in the soil (Table 4 and 5). However, differences were noted within a cultivar between different planting dates and various N and

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[1]Beckman model B, Beckman Instruments, Inc., South Pasadena, Calif.

[2]Quantograph, Applied Research Laboratories, Glendale, Calif.

population treatments. This could be related to their adaptability to local environmental factors.

Nitrogen Influences

With increasing rates of N in the early planting, N, K, Ca, Mg, Mn, Zn, and NO_3-N content of the plant increased (Table 4), and N, P, K, Ca, Mg, Mn, Fe, B, Zn, and NO_3-N was significantly higher in Green Star at 101 kg/ha than Premier. While an interaction of nutrient removal of N, K, and B, in Premier were significantly higher at 67 kg/ha and 101 kg/ha than Green Star. There was a concurrent increase in the yields and a decrease in the percent culls with increasing increments of N, for the early planting (11).

For the late planting, N had no effect on fruit yields (11) and no influence on the nutrient content of the plant and fruit other than NO_3-N which increased with increasing increments of applied N in the plant tissue. It appears that in plant tissue, NO_3-N does not correlate with yields. El-Sheikh and Broyer (8) found NO_3-N values to be more satisfactory than total N to determine the critical N concn for maximum growth. Comparing both the early and late planting, the total N or NO_3-N values (Table 2 and 3) can not be a satisfactory indicator of growth since there is no consistent relationship with yields, vine weights, culls, or sex expression (11). Cantliffe (3,4) observed that NO_3-N was high in plants receiving high N, but also found it reduced yields. This supports the idea that NO_3-N is not a good indicator of growth.

When N was limited (early planting), uptake of applied N increased linearly. When N levels were adequate (late planting) for growth, then the additional uptake of N was suppressed. Reynolds (12), growing cucumbers under varying rates of N, P, K, Ca, and Mg observed significant differences in the amounts of these elements in the leaves and fruit of all except N. Also, no yield responses were observed when N levels were adequate for growth. This indicates that N may influence the uptake of other elements and become a limiting factor of yields. The mean values of N, P, and K removed by plants for the early and late plantings were 98, 8, 150 and 108, 10, 144 kg/ha, respectively. Nutrient removal by fruit was 20, 2, 39 and 24, 3, 37 kg/ha, respectively.

Higher nutrient content in the late planting compared to the early planting are associated with a higher percentage of pistillate flowers among both cultivars and N treatments. Dearborn (7) and Miller (10) reported similar findings. Tiedjens (14) found that high N improved fruit shape. Considering percent culls as a characteristic of fruit shape, there was a decrease in culls with increased applications of N in the early planting. The shape of cull fruit indicated that pollination was not the cause but that nutritional content can become an influencing factor.

Plant Population Influences

In plant tissue at harvest for both plantings all mineral elements were found to increase with increasing plant populations (Tables 4 and 5) except for NO_3-N in the early planting. The lack of change in NO_3-N could have been the result of rapid growth and metabolism. Ries (13), found an inverse correlation in NO_3-N concn and plant population. This indicated that the plants were not receiving adequate N or that the metabolism of NO_3 was increasing with an increasing population.

Fruit nutrient removal increased in both plantings with increasing populations, with Premier having significantly higher levels of P and Mg at 198,000 plants/ha than Green Star. Nutrient removal had linear relationships between increasing yields (11) and populations in both plantings. When populations increase, the nutrients removed by plants and fruit may increase because of the increase in root to soil surface area. Therefore, higher plant populations require more of the available soil nutrients if higher yields are to be obtained. As populations increase, nutrient content of the fruit becomes about 25 percent of the total plant nutrient content at harvest.

Table 1. Soil analyses at tip-over.

Planting	pH	Bph	P	K	Ca	Mg
			(kg/ha)			
Early	5.8	6.5	208.1	342.4	1554.5	301.6
Late	6.1	6.7	166.9	326.4	1390.0	213.9

Table 2. Nutrient content in fruit removed by harvesting for early planting.

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(kg/ha)					(g/ha)						
(1) Cultivars:	Green Star	18a[z]	2.0a	36a	2.2a	1.8a	16a	111a	13a	10a	16a	127a	0.20a
	Premier	21a	2.4a	43a	2.9a	2.0a	18a	71a	11a	12a	20a	52a	0.50a
(2) Nitrogen: (kg/ha)	0	13m	2.1m	32m	2.0m	1.6m	13m	66m	9m	9m	15m	77m	0.04m
	34	16m	2.2m	36m	2.2m	1.7m	16mn	90mn	12m	11m	17m	105m	0.07m
	67	23n	2.3m	44n	2.6m	2.2n	19n	103n	17m	12m	20m	95m	0.40n
	101	26n	2.3m	44n	3.2m	2.2n	20n	106n	10m	12m	19m	82m	1.00o
(3) Plants/ha:	99	16r	1.6r	30r	2.0r	1.5r	14r	84rs	9r	9r	14r	86r	0.30r
	148	18r	2.0r	36r	2.6r	1.7r	15r	78r	13r	10r	17r	75r	0.30r
	198	25s	3.0s	52s	3.0	2.5s	22s	112s	14	15s	23s	108r	0.50r
(4) Interactions	1 x 2	*	NS	*	NS	NS	NS	NS	NS	*	NS	NS	NS
	1 x 3	NS	*	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
	2 x 3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1 x 2 x 3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table 3. Nutrient content in fruit removed by harvesting for late planting.[y]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(kg/ha)					(g/ha)						
Cultivars:	Green Star	20a[z]	2.2a	30a	3.6a	2.2a	18a	82a	8a	8a	13a	94a	1.5a
	Premier	24a	2.9a	40a	3.6a	2.5a	22a	82a	11a	10ab	14a	83a	2.0a
	MSU-76	27a	3.3a	42a	4.2a	2.7a	26a	93a	12a	11b	17a	97a	2.2a
Nitrogen:	0	23m	3.1m	37m	3.9m	2.6m	22m	85m	10m	10m	15m	96m	1.7m
	34	25m	3.0m	38m	3.7m	2.5m	23m	87m	11m	10m	15m	90m	1.9m
	67	24m	2.8m	38m	3.8m	2.5m	24m	93m	10m	9m	15m	102m	2.0m
	101	24m	2.4m	36m	3.7m	2.4m	20m	77m	11m	9m	14m	77m	2.0m
Plants/ha:	99	16r	1.9r	25r	2.6r	1.7r	14r	61r	8r	6r	9r	69r	1.3r
(1000's)	198	25s	2.9s	38s	3.9s	2.5s	24s	89s	11s	10s	16s	93s	1.9s
	296	31r	3.6r	48t	4.9t	3.2t	27t	107t	13s	12t	18t	111t	2.5t

[y]No significant interactions.
[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table 4. Plant nutrient content at harvest for early planting.

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(kg/ha)					(g/ha)						
(1) Cultivar	Green Star	104a[z]	8.7a	164a	81a	27a	248a	2028a	124a	100a	228a	3214a	17.9a
	Premier	93a	8.1b	136a	65a	20a	183a	1445a	86a	73a	204a	2387b	11.5a
(2) Nitrogen (kg/ha)	0	70m	8.4m	127m	64m	20m	159m	1613m	107m	83m	181m	2671m	1.6m
	34	83mn	9.1m	140m	67m	22m	189mn	1804m	101m	86m	198m	3083m	6.4m
	67	102n	7.7m	151m	72m	25m	228no	1572m	97m	82m	205m	2529m	17.7n
	101	138o	8.5m	184n	88m	28m	285o	1958m	116m	96m	279m	2919m	33.1o
(3) Plants/ha (1000's)	99	73r	6.0r	108r	52r	17r	150r	1486r	86r	61r	153r	2309r	10.6r
	148	100s	8.4s	158s	74s	24s	220s	1610r	105rs	87s	215s	2712r	18.3r
	198	122t	10.9t	185t	93t	30t	276t	2113s	125s	112t	279t	3381s	15.2r
(4) Interactions	1 x 2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
	1 x 3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2 x 3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	1 x 2 x 3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z]Mean separation within sets by Duncan's Multiple Range test at the 5% level.

Table 5. Plant nutrient content at harvest for late planting.[y]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(kg/ha)					(g/ha)						
Cultivars:	Green Star	108a[z]	9.3a	152a	86a	29a	228a	1531a	102a	79a	178a	2352a	28.6a
	Premier	94a	8.2a	126a	67a	22a	181b	992a	82a	57a	139a	1382a	25.8a
	MSU-76	122a	11.4a	155a	90a	27a	247a	1195a	72a	78a	202a	1630a	31.3a
Nitrogen: (kg/ha)	0	104m	10.6m	149m	84m	29m	207m	1321m	92m	76m	178m	1971m	17.2m
	34	108m	9.5m	146m	80m	24m	211m	1209m	87m	71m	188m	1696m	26.8mn
	67	110m	9.8m	149m	81m	27m	230m	1197m	83m	72m	171m	1672m	33.2n
	101	110m	8.6m	136m	78m	26m	226m	1230m	79m	67m	156m	1813m	37.3o
Plants/ha: (1000's)	99	80r	6.8r	104r	60r	19r	160r	1012r	65r	52r	133r	1516r	22.0r
	198	109s	9.8s	145s	82s	26s	221s	1202r	82s	72s	170s	1707r	29.3s
	296	135t	12.3t	185t	101t	34t	275t	1504s	108t	91t	217t	2141s	34.4s

[y]No significant interactions.
[z]Mean separation within sets by Duncan's multiple range test at the 5% levels.

Literature Cited

1. Anonymous. 1970. Methods of Analysis of the Association of Official Agricultural Chemists. Eleventh ed. Washington, D. C.

2. Bishop, R. F., E. W. Chipman and C. R. MacEachern. 1969. Effect of nitrogen, phosphorus and potassium on yields and nutrient levels in laminae and petioles of pickling cucumbers. Can. J. Soil Sci. Vol. 49, 297-304.

3. Cantliffe, D. J. 1977. Nitrogen fertilizer requirements of pickling cucumbers grown for once-over harvest I. Effect on yield and fresh quality. J. Amer. Soc. Hort Sci. 102(2):112-114.

4. Cantliffe, D. J. 1977. Nitrogen fertilizer requirements of pickling cucumbers grown for once-over harvest II. Effect on plant tissue mineral nutrient concentrations J. Amer. Soc. Hort. Sci. 1-2(2):115-119.

5. Cantliffe, D. J., G. E. MacDonald, and N. H. Peck. 1970. The potentiometric determination of nitrate and chloride in plant tissue. New York's Food and Life Sci. Bul. No. 3.

6. Carpenter, P. N. 1964. Spectograph analysis of plant tissues. Main Agr. Exp. Sta. Misc. Publ. 666.

7. Dearborn, R. B. 1936. Nitrogen nutrition and chemical composition in relation to growth and fruiting of the cucumber plant. Cornell Univ. Agr. Exp. Sta. Mem. 192.

8. El-Sheikh, A. M., M. A. Abd El-Hakam and Albert Ulrich. 1970. Critical nitrate levels for squash, cucumber, and melon plants. Comm. in Soil Sci. and Plant Anal. 1:63-74.

9. McCollum, R. E. and C. H. Miller. 1971. Yield, nutrient uptake and nutrient removal by pickling cucumbers. J. Amer. Soc. Hort. Sci. 96:42-45.

10. Miller, C. H. 1957. Studies on the nutrition and physiology of pickling cucumbers. Ph.D. Thesis, Mich. State Univ. 69 pages.

11. Rajzer, C. J. 1977. The influence of nitrogen and plant population on several cultivars of pickling cucumbers I. Fruit yields. (Proposed ASHS)

12. Reynolds, C. W. 1954. Studies with cucumbers for pickling. Ph.D. Thesis, Univ. of Maryland.

13. Ries, S. K. 1957. The effect of spacing and supplemental fertilizer applications of the yields of pickling cucumbers. Mich. Agr. Exp. Sta. Quart. Bul. 40(2):375-381.

14. Tiedjens, V. A. 1926. Some observations on the response of greenhouse cucumber (*Cucumis sativus*) to certain environmental conditions. Proc. Amer. Soc. Hort. Sci. 23:184-189.

APPENDICES

Table A-1. Early planting: Weight (MT/ha) of fruit.

Main effects		Grades								
		1A	1B	2A	2B	3A	3B	4's	Culls	Total
Cultivars:	Green Star	0.4a^{z}	0.8a	0.9a	1.1a	3.8a	1.3a	1.4a	0.8a	10.6a
	Premier	0.2a	0.6a	0.8a	0.9a	3.5a	1.1a	1.5a	0.8a	9.4a
Nitrogen:	0	0.3m	0.6m	0.6m	0.6m	2.7m	0.9m	1.1mn	1.2m	8.1m
(kg/ha)	34	0.3m	0.6m	0.8mn	0.8mo	3.5m	1.1m	2.1m	1.3m	10.3m
	67	0.3m	0.9m	1.1n	1.3n	4.3m	1.4m	1.8m	0.4n	11.5m
	101	0.3m	0.8m	1.1n	1.2no	4.1m	1.3m	0.8n	0.4n	10.1m
Plants/ha:	99	0.2r	0.6r	0.8r	0.9r	3.4r	1.3r	1.6r	0.6r	9.5r
(1000's)	148	0.3r	0.7r	0.9rs	1.0r	3.9r	1.2r	1.6r	0.9s	10.4r
	198	0.3r	0.8s	1.0s	1.0r	3.6r	1.1r	1.1s	1.0s	10.1r

^{z}Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-2. Early planting: Fruit wt(g).

Main effects		Grade						
		1A	1B	2A	2B	3A	3B	4's
Cultivars:	Green Star	10.2a[z]	18.1a	42.5a	67.1a	111.9a	153.4a	196.3a
	Premier	4.0a	14.6a	37.8b	60.4a	108.4a	153.9a	215.4b
Nitrogen:	0	4.0m	15.4m	37.7m	59.5m	109.6m	143.2m	183.0m
(kg/ha)	34	7.7m	15.9m	40.0n	63.0mn	108.0m	148.0m	189.5m
	67	4.8m	17.5n	42.0o	65.6n	112.2m	163.2m	205.6m
	101	12.0m	16.5mn	40.9no	67.1n	110.7m	160.2m	245.3m
Plants/ha:	99	4.0r	16.4r	40.2r	63.0r	108.2r	155.5r	197.3r
(1000's)	148	12.6r	17.0r	40.1r	65.2r	113.0r	160.3r	239.6r
	198	4.8r	15.6r	40.1r	63.2r	108.9r	145.1r	180.6r

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-3. Early planting: Other plant parameters at harvest.

Main effects		Vine length (cm)	Fresh vine wt. (MT/ha)	Percent fruit of biomass	Culls fruit/vine
Cultivars:	Green Star	99.9a[z]	22.0a	30.7a	.14a
	Premier	86.9b	15.1b	36.6a	.12a
Nitrogen: (kg/ha)	0	92.4m	15.8m	32.0m	.19m
	34	92.6m	17.3m	35.3m	.17m
	67	94.2m	20.4m	35.3m	.09n
	101	94.4m	20.7m	32.1m	.08n
Plants/ha: (1000's)	99	92.6r	16.6r	35.1r	.16r
	148	93.3r	18.5s	34.7r	.13s
	198	94.3r	20.5t	31.3s	.11s

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-4. Early planting: Pistillate flowers per node.

Main effects		Node location										
		1	2	3	4	5	6	7	8	9	10	Mean
Cultivars:	Green Star	.29a[z]	.83a	.77a	.69a	.62a	.71a	.84a	.92a	.98a	.99a	.76a
	Premier	.36a	.69a	.55a	.52b	.52a	.62a	.64a	.74b	.78a	.83a	.62a
Nitrogen: (kg/ha)	0	.32m	.78m	.67m	.65m	.65m	.66m	.79m	.85m	.92m	.93m	.72m
	34	.37m	.78m	.66m	.58m	.53m	.66m	.69m	.80m	.87m	.92m	.69m
	67	.32m	.73m	.64m	.56m	.57m	.68m	.73m	.83m	.86m	.90m	.68m
	101	.29m	.75m	.67m	.62m	.53m	.67m	.76m	.83m	.88m	.89m	.69m
Plants/ha: (1000's)	99	.32r	.76r	.67r	.62r	.59r	.66r	.74r	.82r	.88r	.91r	.70r
	148	.33r	.75r	.68r	.64r	.57r	.66r	.76r	.81r	.86r	.90r	.70r
	198	.32r	.76r	.63r	.55r	.56r	.68r	.73r	.85r	.90r	.91r	.69r

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-5. Early planting: Staminate flowers per node.

Main effects		Node location										
		1	2	3	4	5	6	7	8	9	10	Average
Cultivars:	Green Star	.06a[z]	.10a	.22a	.30a	.35a	.28a	.14a	.08a	.01a	.01a	.16a
	Premier	.15a	.26a	.44a	.47b	.48a	.38a	.35a	.26b	.22a	.17a	.32a
Nitrogen: (kg/ha)	0	.14m	.16m	.32m	.33m	.34m	.34m	.21m	.14m	.08m	.07m	.21m
	34	.06m	.17m	.33m	.41m	.43m	.33m	.28m	.20m	.12m	.08m	.24m
	67	.11m	.18m	.34m	.44m	.42m	.32m	.27m	.17m	.14m	.10m	.25m
	101	.11m	.20m	.32m	.37m	.47m	.32m	.23m	.17m	.12m	.11m	.24m
Plants/ha: (1000's)	99	.09r	.17r	.33r	.38r	.40r	.33r	.26r	.18r	.11r	.09r	.23r
	148	.12r	.18r	.31r	.34r	.43r	.33r	.23r	.18r	.14r	.10r	.24r
	198	.10r	.18r	.36r	.44r	.42r	.32r	.25r	.15r	.10r	.09r	.24r

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-6. Early planting: Blind flowers per node.

Main effects		Node location 1	2	3	4	5	6	7	8	9	10	Mean
Cultivars:	Green Star	.64a[z]	.08a	.01a	.02a	.02a	.01a	.01a	.01a	.01a	.00a	.08a
	Premier	.49a	.05a	.01a	.01a	.01a	.01a	.01a	.01a	.00a	.00a	.06b
Nitrogen: (kg/ha)	0	.54m	.06m	.01m	.02m	.01m	.01m	.01m	.01m	.00m	.00m	.07m
	34	.57m	.06m	.01m	.01m	.03m	.02m	.02m	.00m	.01m	.00m	.07m
	67	.57m	.09m	.01m	.01m	.01m	.01m	.01m	.01m	.00m	.00m	.07m
	101	.60m	.05m	.01m	.01m	.00m	.01m	.01m	.00m	.00m	.00m	.07m
Plants/ha: (1000's)	99	.58r	.07r	.01r	.01r	.02r	.01r	.00r	.01r	.01r	.00r	.07r
	148	.55r	.07r	.01r	.02r	.01r	.01r	.01r	.01r	.00r	.00r	.07r
	198	.58r	.06r	.01r	.01r	.02r	.01r	.02r	.00r	.00r	.00r	.07r

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-7. Early planting: Soil analyses.

Main effects		pH	BpH	P	K	Ca	Mg
				(kg/ha)			
Cultivars:	Green Star	5.8a[z]	6.5a	211.2a	324.3a	1513.4a	302.9a
	Premier	5.8a	6.5a	205.0a	360.4a	1595.5a	300.3a
Nitrogen: (kg/ha)	0	6.0m	6.6m	221.1mo	359.2m	1584.3m	298.9m
	34	5.9mn	6.6m	246.8m	350.9m	1569.4m	310.3m
	67	5.8n	6.5mn	187.1no	336.6m	1517.0m	301.7m
	101	5.6o	6.4n	177.5n	322.8m	1547.0m	295.6m
Plants/ha: (1000's)	99	5.8r	6.5r	213.9r	350.1r	1552.6r	306.8r
	148	5.8r	6.5r	199.8r	340.6r	1525.8r	299.3r
	198	5.8r	6.5r	210.6r	336.6r	1575.0r	298.6r

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-8. Dry weights (g) for early planting.

Main effects		Vines plus fruit		Vines	Fruit
		July 1[z]	July 9	July 17-19[y]	July 17-19[y]
Cultivars:	Green Star	4.2a[x]	12.0a	21.4a	4.8a
	Premier	3.5a	10.0b	16.4a	5.6a
Nitrogen:	0	3.7m	9.7m	17.6m	4.1m
(kg/ha)	34	4.0m	11.1m	18.6m	4.9mn
	67	4.0m	11.5m	17.8m	5.9n
	101	3.7m	11.6m	21.8m	5.8n
Plants/ha:	99	3.8r	10.5r	19.9r	5.7r
(1000's)	148	3.8r	11.8r	19.2r	4.6r
	198	3.9r	10.5r	17.7r	5.2r

[z]Tipover.
[y]Harvest.
[x]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-9. Nutrient analyses on July 1, for early planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(%)					(ppm)						
Cultivars:	Green Star	4.1a[y]	.31a	4.8a	2.3a	.69a	68a	807a	34a	23a	64a	1398a	13.1a
	Premier	4.0a	.29a	4.2a	2.2a	.69a	64a	884a	31a	20a	67a	1450a	11.4a
Nitrogen: (kg/ha)	0	3.7m	.31m	4.6m	2.1m	.64m	53m	802m	36m	22m	62m	1360m	6.6m
	34	4.0n	.34m	4.4m	2.3m	.73n	63mn	813m	31m	22m	62m	1510m	9.6m
	67	4.2o	.30mn	4.5m	2.3m	.70n	70no	857m	31m	22m	66m	1458m	16.0n
	101	4.2o	.26n	4.6m	2.3m	.70n	78o	910m	33m	21m	72m	1369m	16.8n
Plants/ha: (1000's)	99	4.1r	.30r	4.4r	2.3r	.70r	66r	907r	32r	21r	65r	1547r	11.9r
	148	4.1r	.30r	4.5r	2.3r	.69r	68r	850rs	35r	21r	67r	1429rs	12.6r
	198	3.9s	.31r	4.7r	2.2r	.68r	64r	780s	31r	22r	64r	1296s	12.3r

[z]Tipover
[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-10. Nutrient analyses on July 9, for early planting.

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(%)					(ppm)						
Cultivars:	Green Star	3.4a[z]	.26a	5.0a	2.1a	.69a	67a	564a	36a	24a	60a	1067a	8.6a
	Premier	3.3a	.27a	4.6a	2.1a	.67a	62a	571a	34a	22a	64a	1043a	7.5a
Nitrogen: (kg/ha)	0	3.5m	.29m	4.7m	1.8m	.59m	49m	538m	36m	23m	56m	990m	1.3m
	34	3.1m	.30m	4.6m	2.2n	.70n	58m	543m	35m	23m	58m	1106m	4.9m
	67	3.6mn	.25n	4.7m	2.2n	.71n	71n	597m	32m	23m	63m	1132m	9.8n
	101	4.0n	.22n	5.1m	2.3n	.72n	80n	592m	36m	23m	73m	992m	16.2o
Plants/ha: (1000's)	99	3.4r	.27r	4.8r	2.1r	.68r	61r	580r	35r	23r	61r	1070r	9.2r
	148	3.3r	.26r	4.8r	2.2r	.69r	66r	592r	35r	23r	64r	1116r	7.6r
	198	3.3r	.26r	4.8r	2.1r	.67r	66r	532r	34r	22r	62r	978r	7.3r

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-11. Nutrient analysis in vines only on July 17 - 19, for early planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(%)					(ppm)						
Cultivars:	Green Star	2.7a[y]	.22a	4.1a	2.5a	.81a	74a	634a	36a	29a	67a	1046a	5.3a
	Premier	2.9a	.23a	3.9a	2.5a	.74a	65a	567a	30a	25a	72a	965a	4.2a
Nitrogen:	0	2.2m	.25m	3.6m	2.4m	.68m	56m	622m	38m	28m	64m	1056m	0.5m
(kg/ha)	34	2.5m	.26m	4.0mn	2.4m	.75mn	62mn	628m	32m	27m	64m	1097m	2.4m
	67	3.0n	.20n	4.1n	2.6m	.87no	78no	562m	30m	26m	69m	946m	6.6n
	101	3.5o	.20n	4.3n	2.7m	.81o	82o	589m	33m	26m	82m	922m	9.6o
Plants/ha:	99	2.9r	.22r	4.0r	2.5r	.78r	67r	679r	36r	26r	69r	1094r	5.1r
(1000's)	148	2.8r	.23r	4.3s	2.5r	.77r	71r	534s	32r	27r	69r	937r	5.7r
	198	2.7r	.23r	3.8r	2.5r	.78r	70r	587rs	32r	28r	72r	986r	4.6r

[z]Harvest.
[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-12. Nutrient analyses in fruit on July 17 - 19, for early planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
				(%)						(ppm)			
Cultivars:	Green Star	2.6a[y]	.28a	5.2a	.32a	.26a	23a	164a	16a	15a	23a	189a	0.3a
	Premier	2.6a	.30a	5.2a	.35a	.25a	21a	88a	15a	14a	24a	69b	0.5a
Nitrogen:	0	2.2m	.34m	5.2m	.33m	.26m	21m	108m	16m	15m	24m	126m	0.1m
(kg/ha)	34	2.3m	.30n	5.2m	.32m	.25m	22m	127m	17m	15m	25m	146m	0.2m
	67	2.7n	.27n	5.2m	.31m	.26m	22m	129m	19m	14m	23m	122m	0.4n
	101	3.1o	.27n	5.2m	.38m	.26m	22m	140m	11m	14m	22m	121m	1.0o
Plants/ha:	99	2.7r	.30r	5.3r	.35r	.28r	23r	149r	16r	15r	25r	161r	0.4r
(1000's)	148	2.6rs	.29r	5.2rs	.35r	.25r	21r	113s	16r	14r	23r	109r	0.4r
	198	2.4s	.29r	5.1s	.30r	.25r	21r	116s	14r	14r	22r	116r	0.4r

[z]Harvest.
[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-13. Nutrient analyses of vines and fruit on July 17 - 19, for early planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(%)					(ppm)						
Cultivars:	Green Star	5.4a[y]	.51a	9.3a	2.9a	.81a	97a	798a	52a	44a	90a	1235a	5.7a
	Premier	5.4a	.54a	9.2a	2.8a	.74a	86a	654a	46a	39a	96a	1033a	4.7a
Nitrogen: (kg/ha)	0	4.4m	.59m	8.9m	2.7m	.68m	76m	730m	53m	43m	88m	1182m	0.6m
	34	4.8m	.56m	9.2m	2.7m	.75mn	84m	755m	49m	42m	89m	1243m	2.6m
	67	5.7n	.47n	9.2m	3.0m	.87no	100n	691m	49m	41m	92m	1068m	7.0n
	101	6.6o	.47n	9.5m	3.1m	.81o	104n	729m	45m	40m	104m	1044m	10.6o
Plants/ha: (1000's)	99	5.6r	.53r	9.3r	2.9r	.78r	90r	828r	52r	42r	94r	1254r	5.5r
	148	5.4rs	.52r	9.5r	2.8r	.77r	92r	648s	48r	41r	92r	1046r	6.2r
	198	5.1s	.52r	8.9s	2.8r	.78r	92r	703s	46r	42r	95r	1103r	4.0r

[z]Harvest.
[y]Mean separation within sets by Duncan's multiple range test at the 5% level

Table A-14. Nutrient content on July 1, for early planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(kg/ha)					(g/ha)						
Cultivars:	Green Star	25a[y]	1.9a	30a	14a	4.3a	42a	476a	21a	14a	39a	841a	8.4a
	Premier	21a	1.5a	22a	12a	3.6a	33a	450a	16a	11a	35a	742a	6.1a
Nitrogen: (kg/ha)	0	20m	1.6m	24m	11m	3.4m	28m	412m	18m	11m	33m	700m	3.5m
	34	23m	2.0m	27m	14m	4.3m	38n	472m	18m	13m	38m	874m	5.8m
	67	25m	1.8m	27m	14m	4.2m	41n	480m	18m	13m	39m	834m	9.6n
	101	24m	1.5m	27m	13m	3.9m	43n	489m	19m	12m	40m	757m	10.0n
Plants/ha: (1000's)	99	15r	1.2r	16r	8r	2.6r	24r	325r	12r	8r	24r	577r	4.2r
	148	23s	1.7s	26s	13s	4.0s	39s	471s	20s	12s	38s	806s	7.6s
	198	30t	2.4t	37t	17t	5.3t	50t	593t	24t	17t	50t	991t	9.9t

[z] Tip-over
[y] Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-15. Nutrient content on July 9, for early planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(kg/ha)					(g/ha)						
Cultivars:	Green Star	60a[z]	4.5a	86a	39a	12a	121a	999a	63a	43a	107a	1904a	15a
	Premier	49a	3.9a	68a	31a	10a	94b	843a	50a	32b	97a	1552a	12a
Nitrogen: (kg/ha)	0	36m	3.9m	68m	26m	8m	70m	744m	52m	32m	79m	1373m	2m
	34	51n	4.9m	76m	36n	12n	98n	875m	56m	38m	94mn	1805m	7m
	67	62no	4.2m	79m	38n	12n	123o	1056m	54m	40m	108no	2028m	17n
	101	70o	3.9m	87m	40n	12n	141o	1012m	62m	40m	127o	1706m	27o
Plants/ha: (1000's)	99	36r	2.8r	51r	22r	7r	64r	606r	36r	24r	64r	1125r	10r
	148	58s	4.6s	83s	39s	12s	118s	1048s	61s	41s	112s	2015s	14s
	198	70t	5.3t	99t	44t	14t	141t	1111s	71s	47t	130t	2044s	16s

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-16. Nutrient content in vines only on July 17 - 19, for early planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(kg/ha)					(g/ha)						
Cultivars:	Green Star	86a[y]	6.7a	128a	79a	25a	232a	1917a	112a	90a	212a	3088a	18a
	Premier	72a	5.7b	94a	62a	18a	165a	1374a	75a	61b	184a	2335b	11b
Nitrogen:	0	57m	6.3m	95m	63m	18m	146m	1547m	98m	74m	166m	2595m	2m
(kg/ha)	34	67m	7.0m	104m	65m	20m	173mn	1713m	89m	75m	180m	2978m	6m
	67	79m	5.4m	106m	70m	23m	209no	1469m	80m	70m	185m	2435m	17n
	101	111n	6.2m	140n	85m	26m	266o	1853m	106m	84m	260m	2837m	32o
Plants/ha:	99	57r	4.4r	78r	50r	16r	136r	1403r	77r	53r	139r	2224r	10r
(1000's)	148	82s	6.4s	123s	71s	22s	205s	1533r	92rs	77s	199s	2638r	18r
	198	97s	7.9t	132s	90t	28t	254t	2000s	111s	98t	256t	3273s	15r

[z]Harvest

[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-17. Late planting: Weights (MT/ha) of fruit.

Main effects		Grades								
		1A	1B	2A	2B	3A	3B	4's	Culls	Total
Cultivars:	Green Star	0.1a[z]	0.8a	1.5a	1.7a	4.2a	0.7a	0.5a	0.6a	10.2a
	Premier	0.2a	0.9a	2.1b	2.8b	6.0a	0.6a	0.4a	0.6a	13.6a
	MSU-76	0.1a	0.9a	2.4b	3.7b	5.8a	0.4a	0.3a	0.5a	14.2a
Nitrogen:	0	0.1m	0.8m	1.9m	2.8m	5.9m	0.8m	0.5m	0.5m	13.4m
(kg/ha)	34	0.2m	1.0m	1.8m	2.6m	5.1m	0.4m	0.5m	0.6m	12.1m
	67	0.2m	0.9m	2.2m	3.0m	5.2m	0.6m	0.4m	0.6m	13.0m
	101	0.1m	0.8m	2.1m	2.7m	5.0m	0.5m	0.3m	0.5m	12.1m
Plants/ha:	99	0.1r	0.6r	1.5r	2.2r	5.3rs	0.9r	0.8r	0.3r	11.8r
(1000's)	198	0.1r	0.9s	2.0s	2.9s	5.8r	0.6s	0.3s	0.5s	13.2s
	296	0.2r	1.1s	2.5t	3.2t	4.9s	0.2t	0.1t	0.8t	13.0s

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-18. Late planting: Fruit wt (g).

Main effects		Grade						
		1A	1B	2A	2B	3A	3B	4's
Cultivars:	Green Star	5.3a[z]	15.8a	38.3a	63.4a	102.3a	117.5a	105.6a
	Premier	6.6a	15.5a	39.8a	63.5a	101.2a	124.8a	117.5a
	MSU-76	6.8a	18.2a	39.6a	63.1a	100.9a	128.3a	126.1a
Nitrogen: (kg/ha)	0	5.9m	16.2m	39.6m	63.6m	102.4m	131.8m	106.4m
	34	6.5m	17.3m	39.6m	64.0m	100.7m	116.7m	136.9m
	67	6.3m	15.5m	38.5m	63.2m	102.5m	140.9m	114.5m
	101	6.2m	17.1m	39.2m	62.6m	100.3m	104.8m	107.8m
Plants/ha: (1000's)	99	6.4r	17.2r	39.6r	63.7r	104.5r	150.8r	164.2r
	198	6.4r	16.4r	38.6r	63.3r	102.7r	131.4r	132.1r
	296	5.8r	15.9r	39.4r	63.0r	97.2s	88.5s	52.9s

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-19. Late planting: Other plant parameters at harvest.

Main effects		Vine length (cm)	Fresh vine wt. (MT/ha)	Percent fruit of biomass	Culls fruit/vine
Cultivars:	Green Star	102.1a^{z}	29.2a	25.6a	.08a
	Premier	99.6a	24.5a	35.5a	.08a
	MSU-76	98.0a	27.2a	34.1a	.06a
Nitrogen: (kg/ha)	0	101.6m	27.5m	32.0m	.07m
	34	99.4m	27.2m	31.6m	.07m
	67	99.8m	27.3m	31.9m	.08m
	101	98.8m	25.7m	31.6m	.08m
Plants/ha: (1000's)	99	100.8r	22.6r	34.1r	.08r
	198	101.1r	27.9s	31.9s	.07r
	296	97.8r	30.4t	29.3t	.07r

^{z}Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-20. Late planting: Pistillate flowers per node.

Main effects		Node location 1	2	3	4	5	6	7	8	9	10	Mean
Cultivars:	Green Star	.24a[z]	.96a	.93a	.93a	.99a	1.00a	1.00a	.99a	1.00a	.99a	.90a
	Premier	.56b	.98a	.73b	.51b	.87b	.99a	.99a	.99a	.99a	.99a	.85b
	MSU-76	.58b	.96a	.91a	.86a	.95a	1.00a	.99a	1.00a	1.00a	.99a	.92a
Nitrogen: (kg/ha)	0	.51m	.95m	.79m	.73m	.95m	1.00m	1.00m	1.00m	1.00m	.99m	.88m
	34	.44m	.96m	.88n	.76mn	.94m	.99m	1.00m	.99m	.99m	.97m	.89m
	67	.43m	.97m	.88n	.76mn	.94m	1.00m	.99m	.99m	1.00m	1.00m	.89m
	101	.48m	.97m	.87n	.82n	.93m	1.00m	.99m	.99m	1.00m	.99m	.90m
Plants/ha: (1000's)	99	.54r	.96r	.89r	.80r	.96r	.99r	1.00r	1.00r	.99r	.99r	.91r
	198	.44s	.96r	.85rs	.76rs	.93r	1.00r	.99r	.99r	1.00r	.99r	.89s
	296	.42s	.96r	.83s	.73s	.93r	.99r	.99r	.99r	1.00r	.99r	.88s

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-21. Late planting: Staminate flowers per node.

Main effects		Node location										
		1	2	3	4	5	6	7	8	9	10	Mean
Cultivars:	Green Star	.01a[z]	.01a	.07a	.06a	.01a	.00a	.01a	.01a	.01a	.01a	.02a
	Premier	.01a	.02a	.27b	.49b	.13a	.01a	.01a	.01a	.01a	.01a	.10b
	MSU-76	.01a	.03a	.09a	.14a	.05a	.01a	.01a	.01a	.00a	.01a	.03a
Nitrogen: (kg/ha)	0	.02m	.03m	.21m	.27m	.05m	.01m	.01m	.00m	.00m	.01m	.06m
	34	.00m	.02m	.11n	.23mn	.06m	.01m	.01m	.01m	.11m	.02m	.05mn
	67	.00m	.01m	.12n	.24mn	.06m	.01m	.01m	.01m	.00m	.00m	.05mn
	101	.00m	.02m	.13n	.18n	.07m	.00m	.01m	.01m	.00m	.01m	.04n
Plant/ha: (1000's)	99	.00r	.02r	.11r	.20r	.04r	.01r	.01r	.01r	.01r	.01r	.04r
	198	.01r	.02r	.15rs	.23rs	.07r	.00r	.01r	.01r	.01r	.01r	.05s
	296	.01r	.02r	.16s	.26s	.07r	.01r	.01r	.01r	.00r	.01r	.06s

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-22. Late planting: Blind flowers per node.

Main effects		Node location										
		1	2	3	4	5	6	7	8	9	10	Average
Cultivars:	Green Star	.74a[z]	.02a	.01a	.01a	.00a	.00a	.00a	.00a	.00a	.00a	.08a
	Premier	.44b	.02a	.01a	.01a	.00a	.00a	.00a	.00a	.00a	.00a	.05b
	MSU-76	.41b	.02a	.00a	.00a	.00a	.00a	.00a	.00a	.00a	.00a	.04b
Nitrogen: (kg/ha)	0	.47m	.02m	.00m	.01m	.00m	.00m	.00m	.00m	.00m	.00m	.05m
	34	.56m	.02m	.01m	.01m	.00m	.00m	.00m	.00m	.00m	.00m	.06mn
	67	.57m	.03m	.01m	.00m	.00m	.00m	.00m	.00m	.00m	.00m	.06n
	101	.52m	.01m	.00m	.00m	.00m	.00m	.00m	.00m	.00m	.00m	.05mn
Plants/ha: (1000's)	99	.46r	.01r	.01r	.01r	.00r	.00r	.00r	.00r	.00r	.00r	.05r
	198	.56s	.02r	.00r	.01r	.00r	.00r	.00r	.00r	.00r	.00r	.06s
	296	.57s	.02r	.01r	.01r	.00r	.00r	.00r	.00r	.00r	.00r	.06s

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-23. Late planting: Soil analyses.

Main effects		pH	BpH	P	K	Ca	Mg
				(kg/ha)			
Cultivars:	Green Star	6.0a^{z}	6.7a	145.5a	333.4a	1375.1a	218.4a
	Premier	6.0a	6.6a	168.6a	302.4a	1412.5a	212.6a
	MSU-76	6.0a	6.6a	186.8a	343.5a	1382.5a	210.8a
Nitrogen: (kg/ha)	0	6.1m	6.7m	165.5m	304.1m	1365.2m	216.5m
	34	6.0mn	6.6m	180.6m	333.8m	1245.5m	193.8m
	67	6.0mn	6.7m	166.4m	333.6m	1484.6m	225.1m
	101	5.9n	6.6m	155.4m	334.4m	1464.8m	220.2m
Plants/ha: (1000's)	99	6.0r	6.7r	161.2r	316.1r	1412.5r	212.1r
	198	6.0r	6.7r	164.8r	329.4r	1390.0r	217.5r
	296	6.0r	6.6r	174.8s	334.0r	1367.6r	212.1r

^{z}Mean separation within sets by Duncan's multiple range test at th 5% level.

Table A-24. Dry weights (g) for late planting.

Main effects		Vines plus fruit		Vines	Fruit
		August 24^{z}	Sept. 1	Sept. 13-17^{y}	Sept. 13-17^{y}
Cultivars:	Green Star	4.8a^{x}	10.4a	15.8a	3.1a
	Premier	4.6a	10.9a	11.3a	4.1a
	MSU-76	5.2a	11.6a	15.1a	4.4a
Nitrogen: (kg/ha)	0	4.8m	11.0m	14.5m	3.7m
	34	5.0m	10.9m	13.9m	3.9m
	67	4.8m	11.2m	14.3m	4.1m
	101	4.9m	10.5m	13.5m	3.7m
Plants/ha: (1000's)	99	5.8r	14.1r	18.7r	4.8r
	198	4.7s	10.0s	12.6s	3.7s
	296	4.0t	8.6t	10.8t	3.1t

^{z}Tip-over.
^{y}Harvest.
^{x}Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-25. Nutrient analyses on August 24, for late planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(%)					(ppm)						
Cultivars:	Green Star	3.9a[y]	.23a	4.5a	2.7a	.88a	71a	419a	14a	20.4a	50a	637a	9.6a
	Premier	3.9a	.25a	4.1a	2.7a	.92a	74a	470a	16a	19.4a	50a	761a	9.3a
	MSU-76	3.9a	.25a	4.1a	2.8a	.89a	71a	380a	12a	19.5a	52a	560a	8.0a
Nitrogen: (kg/ha)	0	3.8m	.25m	4.2m	2.6m	.93m	66m	453m	16m	19.4m	47m	728m	7.9m
	34	3.9m	.25m	4.4m	2.7m	.85m	67m	395m	12m	19.7m	53m	588m	8.9mn
	67	3.9m	.25m	4.2m	2.8m	.92m	73n	419m	12m	19.7m	51m	632m	9.2n
	101	4.0m	.24m	4.2m	2.8m	.90m	82o	425m	15m	20.1m	52m	662m	9.2n
Plants/ha: (1000's)	99	4.0r	.27r	4.3r	2.8r	.89r	72r	479r	14r	20.4r	52r	764r	9.2r
	198	3.9s	.24s	4.2r	2.8r	.91r	73r	396s	13r	19.6s	51r	597s	8.6r
	296	3.7t	.23s	4.2r	2.6s	.89r	71r	394s	15r	19.3s	49r	597s	9.1r

[z]Tip-over
[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-26. Nutrient analyses on September 1, for late planting.

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(%)					(ppm)						
Cultivars:	Green Star	3.9a[z]	.29a	4.5a	2.9a	.93a	76a	528a	14a	23.2a	56a	758a	10.9a
	Premier	4.0a	.33a	4.2a	3.1a	.94a	76a	518a	17a	21.6a	60a	752a	11.0a
	MSU-76	4.1a	.35a	4.3a	3.0a	.95a	79a	475a	15a	22.6a	63a	649a	9.3a
Nitrogen:	0	3.7m	.34m	4.3m	2.9m	.97m	69m	522m	15m	22.2m	53m	746m	6.3n
(Kg/ha)	34	4.1m	.32m	4.4m	2.9m	.86m	73mn	466m	15m	22.2m	65n	630m	10.3n
	67	4.0m	.32m	4.3m	3.1m	.97m	80no	507m	16m	22.7m	61n	720m	12.0no
	101	4.2m	.31m	4.3m	3.0m	.96m	88o	533m	15m	22.7m	59mn	784m	13.0o
Plants/ha:	99	4.2r	.34r	4.2r	3.1r	.92r	76r	595r	16r	22.9r	60r	902r	11.2r
(1000's)	198	4.0s	.32s	4.2r	3.0r	.94r	81s	484s	15r	22.5rs	61r	659s	9.8r
	296	3.9t	.31s	4.5r	2.9r	.96r	75r	443s	15r	22.0s	57r	600s	10.3r

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-27. Nutrient analyses in vines only on September 13 - 17, for late planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
				(%)						(ppm)			
Cultivars:	Green Star	3.2a[y]	.24a	4.2a	3.0a	1.01a	77a	525a	33a	25.4a	59a	816a	10.2a
	Premier	3.4a	.25a	4.2a	3.1b	.96a	81a	460a	35a	23.1a	62a	663a	11.7a
	MSU-76	3.5a	.27a	4.1a	3.1b	.90a	87a	421a	21a	24.4a	67a	590a	10.9a
Nitrogen:	0	3.1m	.27m	4.2m	3.0m	.98m	73m	484m	32m	24.7m	62m	744m	6.5m
(kg/ha)	34	3.4n	.25m	4.2m	3.1m	.91m	82m	468m	31m	24.4m	68m	665m	10.6n
	67	3.4n	.27m	4.3m	3.0m	.97m	84m	449m	28m	24.5m	61m	647m	12.6no
	101	3.5n	.24m	4.0m	3.0m	.95m	88m	472m	28m	23.6m	58m	704m	14.1o
Plants/ha:	99	3.5r	.26r	4.1r	3.1r	.92r	82r	533r	31r	24.2r	66r	812r	10.9r
(1000's)	198	3.4s	.26r	4.2r	3.1r	.97s	81r	445s	29r	24.4r	60r	645s	11.1r
	296	3.3s	.25r	4.2r	3.0r	.97s	82r	428s	30r	24.3r	61r	613s	10.7r

[z]Harvest.
[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-28. Nutrient analyses in fruit on September 13 - 17, for late planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
				(%)						(ppm)			
Cultivars:	Green Star	3.6a[y]	.40a	5.4a	.64a	.39a	33a	160a	15a	14a	23a	193a	2.7a
	Premier	3.3a	.41a	5.3a	.49b	.34b	29a	112a	15a	13a	18a	120a	2.7a
	MSU-76	3.4a	.43a	5.4a	.52b	.34b	31a	120a	16a	14a	22a	124a	2.8a
Nitrogen:	0	3.3m	.43m	5.4m	.56m	.37m	30m	129m	15m	14m	23m	148m	2.4m
(Kg/ha)	34	3.5m	.43m	5.3m	.52m	.34m	31m	129m	15m	14m	21m	143m	2.7mn
	67	3.5m	.41m	5.4m	.55m	.35m	34m	146m	15m	14m	21m	172m	2.8n
	101	3.5m	.38m	5.3m	.56m	.35m	30m	119m	17m	13m	21m	121m	2.9n
Plants/ha:	99	3.4r	.41r	5.4r	.55r	.35r	29r	139r	16r	14r	20r	163r	2.7r
(1000's)	198	3.5r	.42r	5.4r	.55r	.35r	34s	129r	16r	14r	23s	141rs	2.6r
	296	3.4r	.41r	5.3r	.54r	.36r	30t	123r	15r	13r	20r	133s	2.8r

[z]Harvest.
[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-29. Nutrient analyses of vines and fruit on September 13 - 17, for late planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(%)					(ppm)						
Cultivars:	Green Star	6.9a[y]	.64a	9.6a	3.6a	1.40a	110a	686a	48a	39a	82a	1010a	13.0a
	Premier	6.7a	.66a	9.5a	3.6a	1.30a	110a	572a	50a	36a	80a	783a	14.4a
	MSU-76	6.9a	.70a	9.4a	3.6a	1.24a	118a	541a	38a	38a	88a	714a	13.7a
Nitrogen: (kg/ha)	0	6.5m	.70m	9.5m	3.6m	1.36m	103m	614m	46m	39m	82m	893m	9.1m
	34	6.9n	.67m	9.5m	3.6m	1.26m	113m	597m	46m	38m	89m	807m	13.3n
	67	6.9n	.68m	9.7m	3.6m	1.32m	118m	595m	43m	38m	83m	819m	15.3no
	101	7.0n	.62m	9.3m	3.6m	1.31m	118m	591m	45m	37m	79m	824m	17.0o
Plants/ha: (1000's)	99	6.9r	.66r	9.5r	3.6r	1.27r	112r	672r	47r	38r	85r	974r	13.7r
	198	6.8r	.68r	9.5r	3.6r	1.32r	115r	574s	45r	38r	83r	786s	13.8r
	296	6.7r	.66r	9.5r	3.6r	1.33r	112r	553s	44r	38r	81r	747s	13.6r

[z]Harvest.
[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-30. Nutrient content on August 24, for late planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	$N\theta_3$-N
		(kg/ha)							(g/ha)				
Cultivars:	Green Star	34a[y]	2.1a	40a	23a	7.4a	59a	343a	12a	17a	43a	512a	8.5a
	Premier	34a	2.3a	36a	24a	8.0a	62a	388a	15a	17a	45a	619a	8.2a
	MSU-76	38a	2.5a	41a	27a	8.6a	66a	355a	12a	19a	52a	513a	7.5a
Nitrogen:	0	33m	2.2m	36m	23m	8.0m	55m	372m	15m	17m	41m	586m	6.8m
(kg/ha)	34	37m	2.5m	42m	25m	7.6m	61mn	351m	12m	18m	51m	515m	8.2m
	67	35m	2.3m	38m	25m	8.1m	62mn	355m	11m	17m	46m	530m	8.2m
	101	36m	2.2m	38m	26m	8.4m	72n	369m	14m	18m	49m	560m	9.1m
Plants/ha:	99	24r	1.6r	25r	16r	5.0r	39r	270r	8r	12r	31r	428r	5.3r
(1000's)	198	37s	2.3s	40s	26s	8.5s	66s	362s	12r	18s	49s	537r	8.0s
	296	45t	2.9t	52t	31t	10.6t	82t	453t	18s	23t	60t	678s	10.9t

[z]Tipover.
[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-31. Nutrient content on September 1, for late planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(kg/ha)					(g/ha)						
Cultivars:	Green Star	73a[z]	5.6a	86a	54a	17a	139a	928a	26a	43a	104a	1306a	20a
	Premier	78a	6.5a	81a	60a	19a	148a	963a	33a	42a	120a	1367a	21a
	MSU-76	86a	7.4a	92a	64a	20a	164a	973a	32a	48a	133a	1320a	20a
Nitrogen:	0	72m	6.8m	86m	57m	19m	135m	1003m	30m	44m	105m	1425m	12m
(kg/ha)	34	80m	6.6m	86m	58m	17m	139m	885m	30m	44m	131m	1183m	20m
	67	81m	6.6m	87m	64m	20m	160m	976m	33m	46m	124m	1379m	24m
	101	82m	6.0m	85m	60m	19m	167m	954m	29m	43m	117m	1338m	25m
Plants/ha:	99	58r	4.9r	60r	43r	13r	103r	797r	23r	32r	85r	1193r	16r
(1000's)	198	79s	6.5s	84s	60s	19s	157s	958s	30s	45s	125s	1313rs	19s
	296	99t	8.2t	114t	74t	24t	190t	1109t	39t	56t	148t	1487s	26t

[z]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-32. Nutrient content in vines only on September 13 - 17, for late planting.[z]

Main effects		N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Al	NO_3-N
		(kg/ha)					(g/ha)						
Cultivars:	Green Star	88a[y]	7.1a	122a	82a	27a	209a	1449a	93a	72a	166a	2258a	27a
	Premier	70a	5.3a	87a	63a	20a	159b	910a	70a	48a	126a	1299a	24a
	MSU-76	95a	8.0a	113a	85a	25a	222a	1102a	59a	67a	184a	1533a	29a
Nitrogen:	0	82m	7.5m	111m	80m	26m	186m	1235m	82m	66m	164m	1875m	16m
(kg/ha)	34	83m	6.5m	107m	76m	21m	188m	1122m	76m	61m	172m	1606m	25mn
	67	86m	7.0m	110m	78m	25m	206m	1104m	72m	62m	156m	1570m	31no
	101	86m	6.1m	100m	74m	23m	206m	1153m	67m	58m	142m	1736m	35o
Plants/ha:	99	64r	4.9r	79r	57r	17r	145r	951r	57r	45r	124r	1446r	21r
(1000's)	198	84s	6.8s	106s	78s	24s	197s	1113r	71rs	62s	154s	1614r	27s
	296	105t	8.7t	136t	96t	31t	248t	1397s	95s	79t	198t	2030s	32t

[z]Harvest.
[y]Mean separation within sets by Duncan's multiple range test at the 5% level.

Table A-33. Daily extreme and mean temperature data recorded from the Horticulture Research Station, East Lansing, MI.

	Date	Max.	Min.	Mean
May	15	73	59	66
	16	66	60	63
	17	69	54	62
	18	57	50	49
	19	60	35	48
	20	64	46	55
	21	76	49	62
	22	69	39	54
	23	63	41	52
	24	60	38	49
	25	62	43	53
	26	64	43	54
	27	68	42	55
	28	74	52	63
	29	72	59	66
	30	65	57	61
	31	74	59	67
June	1	74	58	66
	2	70	47	59
	3	73	45	59
	4	76	53	65
	5	80	50	65
	6	81	52	67
	7	83	56	70
	8	85	55	70
	9	86	59	73
	10	89	63	76
	11	88	68	78
	12	88	56	72
	13	84	65	75
	14	89	67	78
	15	90	73	82
	16	80	61	71
	17	73	52	63
	18	78	55	67
	19	85	62	74
	20	72	48	60
	21	78	56	67
	22	73	62	68
	23	79	57	68
	24	80	60	70
	25	73	65	69
	26	76	60	68
	27	85	62	74
	28	85	66	76
	29	82	62	72
	30	78	56	67
July	1	65	55	60
	2	75	53	64
	3	76	52	64
	4	73	54	64
	5	84	55	70
	6	85	60	73
	7	86	61	74
	8	85	60	73
	9	79	55	67
	10	81	68	75
	11	89	78	84
	12	89	56	73
	13	76	48	62
	14	78	58	68
	15	94	64	79
	16	90	65	78
	17	75	52	64
	18	85	58	72
	19	83	57	70
	20	85	66	76
	21	84	64	74
	22	80	58	69
	23	83	63	73
	24	84	64	74
	25	80	57	69
	26	84	61	73
	27	87	67	77
	28	86	57	72
	29	80	65	73
	30	71	57	64
	31	76	63	70

Table A-33. Daily extreme and mean temperature data recorded from the Horticulture Research Station, East Lansing, MI

Date		Max.	Min.	Mean
August	1	71	50	61
	2	73	48	61
	3	70	44	57
	4	80	49	65
	5	78	62	70
	6	80	59	69
	7	72	50	61
	8	72	48	60
	9	77	48	63
	10	81	52	67
	11	85	65	75
	12	84	70	77
	13	86	68	77
	14	82	62	72
	15	68	50	59
	16	72	44	58
	17	73	46	60
	18	80	48	64
	19	85	50	68
	20	88	57	73
	21	88	58	73
	22	87	57	72
	23	90	56	73
	24	82	56	69
	25	85	57	71
	26	84	61	73
	27	85	63	74
	28	86	65	76
	29	80	49	65
	30	70	38	54
	31	69	51	60
Sept.	1	86	60	73
	2	68	40	54
	3	72	50	61
	4	83	62	73
	5	79	47	63
	6	67	39	53
	7	78	52	65
	8	88	61	75
	9	92	61	77
	10	72	48	60
	11	67	52	60
	12	80	55	68
	13	83	52	68
	14	84	58	71
	15	87	57	72
	16	59	58	59
	17	68	59	64
	18	74	52	63
	19	76	49	63
	20	79	58	69