Proc. Fla. State Hort. Soc. 100:398. 1987.

ROOT GROWTH & STIMULATION AT TRANSPLANTING AND EFFECTS OF WIRE BASKETS ON TREE ROOTS

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Survival and growth of newly planted landscape trees is dependent on the regeneration of new roots and their subsequent exploration of soil to supply water and nutrients. Adequate soil moisture and optimum digging/planting season are important in tree establishment, particularly for *Tilia cordata* (8, 9). Chemical stimulants, primarily auxins, have been used successfully by several workers (3, 7) to enhance root regeneration at planting. Prior to our work at Guelph (4, 6) most attempts to stimulate root regeneration have been with seedlings or small transplants.

Wire baskets have become an integral part of transplanting landscape trees. The basket functions as support for the root ball and as a means of lifting the tree (2). However, the potential longevity of the wire in the soil has led to concern and speculation about root girdling, tree instability, reduced shoot growth and premature decline as possible effects of trees planted in wire baskets (1). Initial work at Guelph (5) has shown that root tissues reunite after closing around the wire.

Medium (5-15 mm) and large (15-25 mm) diameter roots of 250-300 cm tall nursery-grown, machine-dug *Quercus rubra* treated with 3000 ppm IBA or NAA regenerated more new roots than untreated roots. IBA stimulated more new roots than NAA on large diameter roots. As root diameter increased there was a trend to a greater number of regenerated roots. In other experiments root sprays of 3000 ppm IBA more than doubled the number of roots regenerated from fall-dug *Acer saccharum* and *Q. rubra*. However, there were no difference in the number of regenerated roots from spring-dug *A. saccharum, Betula pendula, Fraxinus pennsylvanica* or *Tilia cordata*. Auxin synergists had a limited effect on enhancing root regeneration.

Fall-dug, fall-planted *Tilia cordata* (250 cm, bareroot) regenerated more new roots that those dug and/or planted at other times in spite of the fact that spring-dug, spring-planted roots contained higher levels of root promoters.

Excavation of root systems growing in wire baskets for as long as 12 years revealed that complete tissue budging of periderm, phloem and xylem occurred after the root enclosed the wire. Xylem vessels were distinctly angled for 1-2 years after the root enclosed the wire but this effect diminished 1-3 years later, revealing apparently normal vascular tissue.

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Proc. Fla. State Hort. Soc. 100:398-405. 1987.

PROGRESS IN NUTRITION OF FLORIDA VEGETABLES DURING THE PAST 100 YEARS

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Additional index words. Macronutrient, micronutrient, soluble salts, polyethylene mulch, trickle irrigation.

Abstract. **Vegetables were grown on about 450,000 acres with a value of $1.2 billion during the 1985-86 season in Florida. Over 40 vegetable crops are grown commercially on soils that, in the native state, are deficient in from one to several macro- and micronutrients. Universally, most of these soils are considered infertile. During the past 100 years, vegetable nutrition programs have progressed from open culture with the use of low analysis, organic fertilizer that resulted in the production of low yields to fertility programs based on extensive research that resulted in 4 to 10 fold increases in yields. Progress to improve crop production has been a gradual process. One of the earliest and most significant findings during the review period was the finding and correction of Cu, Mn, and Zn deficiencies on organic soils in 1927 that opened this soil to crop production. The correction of Mn deficiency on the marl soils in 1930 was of equal importance.**

Florida Agr. Expt. Station Journal Series No. 8823.

Deficiencies of all micronutrients except Mo, Cl, and Fe are common on all native soils used for vegetables. Plant nutrition studies have provided information to prevent micro- and macronutrient deficiencies. These studies are the basis of crop nutrient requirement recommendations made by the Florida Agricultural Extension Service. During the 1950's, damage from excessive soluble salts and their nutritional effects on physiological disorders of vegetables such as blackheart of celery and blossom-end rot of tomato and pepper were identified as important factors limiting vegetable production. The use of high quality irrigation water and proper nutrient rates, ratios, and sources resulted in the elimination of these disorders and an increase in vegetable growth and production. Optimum fertilizer placement was shown to vary with fertilizer rate. With low fertilizer rates, banding was generally more efficient, while at higher fertilizer rates, broadcast application often resulted in higher yields. With very high rates, a combination of broadcast and banded generally resulted in higher yields than with all fertilizer applied either broadcast or banded. In 1958, polyethylene mulch was introduced to the vegetable industry in Florida. Fertilizer program modifications and application of complete soil fumigants resulted in earlier production and dramatic yield increases. Currently, over 25% of Florida vegetables are grown with polyethylene mulch. Trickle irrigation provided an effective method to apply water and nutrients throughout the season under the polyethylene mulch. The use of trickle irrigation and a fertilizer injection wheel have increased the potential of producing multiple crops with polyethylene mulch.

In the native state, soils used for vegetable production in Florida are generally considered infertile and are deficient in some or all of the essential macro- and micronutrients except Cl. Knowledge of the infertility of the coarse-textured sands is widespread. However, as recently as 1927, the currently extremely productive organic soils also were considered to be infertile. Allison et al. (5) stated that "The poor plant response usually associated with raw peat soils has been the consistent experience with practically all types of agricultural plants tested on the raw sawgrass soils at the Everglades Station." Malcolm (80) stated that, "due to fertility problems before 1930, farming on the currently highly productive marl and rock soils of Dade County was more similar to organic gardening than to commercial production." This review covers some of the research conducted by numerous scientists that resulted in the production of vegetables valued at $1.2 billion on 450,000 acres in 1985-86 (37) on soils once considered infertile. As part of the Florida State Horticultural Society's Centennial Meeting, work conducted in Florida during the past 100-year period will be emphasized in an effort to put the work in prospective to current practices and aid in determining directions of future work.

During the early 1900's, Florida vegetable production was located primarily on the mineral soils of Seminole, Manatee, and Putnam Counties and on marl soils of Dade County. In 1916, vegetables ranked as a top commodity in Florida with a farm value of $14,000,000 (84). At that time, macronutrient requirements had been demonstrated. The most common sources of nutrients were animal manures, Peruvian guano, cotton seed meal, fish scraps, superphosphate, and imported potassium chloride (55). By 1900 ammonium sulfate and nitrate of soda became available, and they were the main sources of N used until the 1940's when ammonium nitrate, urea, and ammonium phosphate use became more common (55). During the 1890's to the early 1900's, vegetables were produced *on unlimed* soils without supplemental irrigation and with no effective insecticides and fungicides. Thus, nutrients provided by these materials were adequate for the level of production possible.

Micronutrients, organic-N sources, and lime response

One of the most significant vegetable nutrition findings during this review period was reported in 1927 by Allison, Bryan, and Hunter (5). They were the first in the USA to recognize micronutrients as a limiting factor to crop growth in the field. Applications of 30 lb./acre of copper sulfate on a raw peat soil in Belle Glade tremendously enhanced growth of numerous crops. Responses were also obtained to applications of Zn and Mn. The authors recognized that micronutrients added individually in their study probably would provide further growth enhancement if added in combination. They also stated that the toxic effects of some elements including B added alone may have resulted in increased growth if added at a lower rate or in combination with other elements. Lesser, but good plant growth also was obtained with the application of manure, a material commonly used on mineral soil. This work provided the needed nutritional information necessary to allow vegetable production on the organic soils. Acreages of cabbage, potato, bean, celery, and escarole expanded rapidly after these findings (99). In 1930, Skinner and Ruprecht (98) found that Mn deficiencies were limiting growth on soils in Dade County. At that time, these soils were reported to consist of a mucky layer 6 to 12 inches deep underlaid by calcareous material. At present time, the mucky layer has decomposed or become incorporated in the upper profile of the marl soil. This work opened up the marl and rock land soils to extensive commercial vegetable production. Supplemental micronutrient requirements for vegetables grown on marl and muck soil were described by 1939 (5, 7, 80, 98). During the period of 1930 through 1960, extensive research was conducted on micronutrient requirements of various vegetables grown on the major soil groups used for vegetables and these data were reviewed by Forsee (35) and recently by Locascio and Fiskell (68).

Field grown vegetables have responded to applications of B, Cu, Mn, Mo, Zn, and Fe, all the known micronutrients except Cl. Applications of these micronutrients in small amounts have resulted in substantial yield responses on soils where micronutrients are deficient. On the muck soils, initial application of 10 to 15 lb./acre Cu is required for maximum plant growth and this application is sufficient for several years (35). On virgin mineral soils, responses to Cu have been obtained throughout the state and watermelon requirements are about 4 lb./acre (74). Boron deficiencies have been reported on virgin and non-virgin organic and mineral soils (35) other than marls (80). Boron applied at 0.5 to 3 lb./acre is generally adequate for most vegetables (35, 68). On high pH muck soils, plant uptake efficiency of applied B is decreased, and for high B requiring crops such as some celery cultivars, both soil and foliar applications are required to provide adequate B

(14). Since plant available B is easily leached, yearly applications are required on deficient soils (93).

Iron deficiency on soils used for vegetable production is not as common as some other micronutrients. Deficiencies are rare on vegetables grown on muck soils but occur on alkaline mineral soils, particularly when Fe-sensitive vegetables are grown under stress conditions (8, 9, 107).

Manganese deficiencies occur commonly on muck and on mineral soils of central and south Florida (97). Yearly applications of Mn are generally required to correct deficiencies because plant available Mn is rapidly converted to unavailable forms, particularly in high organic matter and alkaline soil (51).

Applications of Zn are required on most soils in Florida brought into cultivation for vegetables. The need for further application depends on the soil type, crop grown, and fungicide used. The Zn content of some fungicides used for vegetables can be adequate for the crop under most conditions (6). Similar responses to Cu and Mn are obtained from fungicides containing those elements.

Molybdenum was the most recent micronutrient found to be deficient for vegetables in some Florida soils. Eddins et al. (21) reported Mo deficiency on cauliflower in 1952. In 1955, Westgate (108) reported the only other Mo deficiency on vegetables in Florida. In both studies, the deficiency was corrected by liming the soils to pH 6.0 or above, or applying Mo.

Since soil pH influences the availability of nutrients, the pH should be 6.0 or above for most vegetables grown on mineral soils (31, 32, 36, 42). With this soil pH, Mo is adequate for good plant growth. No report of Mo deficiency was found on muck or marl soils; thus, additions of Mo to vegetable fertilizer is not necessary under most conditions.

Organic and inorganic nutrient rates

During the early development of the vegetable industry in Florida, excessively large quantities of organic N containing fertilizer were applied for many vegetables. In 1916, McQuarrie (84) stated that at Sanford, large quantities of fertilizer were left after celery and lettuce harvest and that it was possible to grow a corn crop without additional fertilizer. Because of the potentially high value of vegetables, growers of Florida vegetables have often applied nutrients in large to excessive quantities to prevent deficiencies; a practice that often continues in current vegetable production.

In 1930, Skinner and Ruprecht (98) evaluated the effects of N-P-K rate and sources for celery and lettuce grown on a cultivated Leon fine sand in Sanford and for tomato grown on calcareous Glades soils. They concluded that 8,000 to 10,000 lb./acre of 4.9-.9-6.6 N-P-K (6-2-8 NH_3-P_2O_5-K_2O) fertilizer was required for celery and lettuce. A mixture of sodium nitrate with organic nitrogen materials as cottonseed meal, fish scraps, tankage, and dried blood gave better results than mineral N from a single source. Phosphorus was apparently near adequate from previous applications. In the same report, Skinner and Ruprecht state that "It has been found generally by growers that tomatoes cannot be grown successfully in calcareous Glades soils of Dade County without the presence of manure, regardless of the amount of commercial fertilizer used." They found that application of Mn could replace the need for stable manure. This work is credited with changing crop production from organic gardening to commercial vegetable production on the marl soils (80). In 1939, Beckenbach (7) reported from extensive fertility studies that on Everglades organic soils, excellent celery could be grown with 2,000 to 4,000 lb./acre of 3-2.6-10 N-P-K fertilizer + micronutrient applied broadcast. The higher rates were required on soils that had not previously been cropped heavily.

Since 1940, many studies have been conducted on the various soil groups of Florida with numerous vegetables to determine macronutrient sources, rates, and ratio. This has been the most extensive area of work during the review period, and these studies are the basis of vegetable fertilizer recommendations currently made by the Florida Agricultural Extension Service (54).

Fertilizer application rate for most nutrients other than N should be based on soil test data. Some nutrients such as P and K accumulate with applications over a period of years. A summary of the fertilizer requirements for vegetables was presented by Maynard and Locascio (81). On mineral soils testing low in macronutrients, vegetables that mature in 45 to 90 days, such as bean, sweet corn, cucumber and squash, the basic N-P-K lb./acre requirements range from 67-40-75 for snap bean, to 100-60-112. Generally 50% of the fertilizer is applied at planting and the remainder 4 to 5 weeks later. If excessive precipitation occurs, 1 or 2 supplemental applications of 22-0-19 are made. With slower maturing crops such as bell pepper, potato, tomato and watermelon, somewhat higher base N-P-K rates of 135-80-150 to 180-120-224 plus 1 to 3 supplemental applications of 22-0-19 are required.

Vegetable growers continued to use large amounts of natural, organic-N in the fertilizer into the 1960's. Although N from these sources leached more slowly, Volk showed in 1954 (102) that NO_3-N recovery was much slower than from inorganic N, and that split application of inorganic N was more effective than use of organic-N sources. In 1958, Volk (103) reported that a nutritional leaf roll of potato and tomato was due to excess uptake of excessive NH_4-N and did not occur with application of NO_3-N. Geraldson pointed out in 1961 (43) that in most studies, that the cheaper inorganic-N sources, if utilized properly, were at least equivalent to the organic sources. An exception to this was the 1960 work by Everett (25). On a virgin Immokalee soil, watermelon yields were significantly greater when the fertilizer contained 30% of the N from natural organic sources than when derived from ammonium sulfate, ammonium nitrate, or sodium nitrate. Locascio et. al. in 1964 (78) showed that this response to natural organics was due to their Cu content and that yields were increased with application of Cu or complete micronutrient sources (74). Watermelon responses to Cu and complete micronutrient applications were obtained on several virgin mineral soils throughout the state (74).

The importance of soil testing to determine soil pH and its effects on nutrient requirements, nutrient availability, and crop growth was emphasized in 1942 by Jamison (57) and reviewed by Forsee (36), Fiskell (32) and Geraldson (42). Although lime is generally applied 1 to 2 months before planting, work by Everett et al. (31) showed that lime applied at planting for watermelon was as effective as that applied one month earlier. Their work also showed that complete soil coverage and incorporation of lime was required for best crop growth, and that band placement was ineffective.

For most micronutrients, preplant applications are very efficient in preventing deficiencies. If deficiencies occur early in the crop production sequence, micronutrients can be effectively applied by foliar sprays. Vegetable growers have also shown considerable interest in applying macronutrients by foliar application. However, most studies have shown that soil applications were more efficient than the numerous foliar applications required to apply adequate macronutrients for vegetable production (50, 83, 85).

Nutrient concentration and ratio

Excessive soluble salts (salinity) were first recognized as an important factor limiting vegetable production on mineral soils in Florida by Westgate in 1950 (105). Salinity problems are common in arid regions (94) but were considered uncommon in humid regions such as Florida. However, Westgate found that during the low rainfall winter production period, celery yields at Sanford were reduced by excess soluble salts. Excessive soluble salts resulted from high rates of fertilization and from 2 to 4 tons/acre of soluble salts, mostly NaCl, added per foot of artesian well water applied by sub-irrigation, through tiles placed at the hardpan. Excessive soluble salts delay and reduce seed germination, reduces root and shoot growth, result in leaf necrosis, reduce uptake of some nutrients, and increases the occurrence of a number of vegetable physiological disorders. Soluble salts move upward and accumulate on the soil surface as soil water is lost through evaporation. Injury from soluble salts can be minimized by management of water, fertilizer, and other cultural techniques. These include use of overhead irrigation (95) to move salts out of the root zone, production of more tolerant crops such as tomatoes, cabbage, and broccoli as compared to susceptible beans, celery, and radish (95), use of high quality irrigation water (95), use of plug mix (28, 48, 75), and use of bed shapes to accumulate excessive salts away from the root zone (28, 61). The use of some of these and other techniques have minimized damage from excessive soluble salts.

Physiological disorders of vegetables including blackheart of celery, blossom-end rot on tomatoes and pepper, and blackheart of chicory were severe problems for Florida vegetable growers until the mid-1950's. In 1951, a review by Westgate (106) suggested that blackheart of celery was associated with hot dry weather, high atmospheric humidity, low soil moisture, high soil moisture, unbalanced water relations, heavy fertilization especially N, excessive K, deficient K, low Ca, and high total soluble salts. In his studies (106), the occurrence of celery blackheart increased with fertilizer rate and was higher with a sidedress application of N from either $Ca(NO_3)_2$ or $NaNO_3$ as compared to no side-dressing N. In 1952, Geraldson (38) noted that the incident of blackheart of celery was greater on a soil that contained 7,600 ppm than 5,200 ppm total soluble salt. Celery leaf Ca concentrations were 0.26 and 0.71%, respectively, and he concluded that the disorder was a Ca deficiency or due to the K and Ca ratio. In 1953, (39) Geraldson concluded that blackheart of celery was controlled by application of a Ca solution directly to the heart of the plant. In 1951, Wallace (104) showed that blossom-end rot of tomatoes, a universally occurring problem, was a Ca deficiency. However, blossom-end rot continued to be a serious production problem even in soils that contained large quantities of Ca. In 1955, Geraldson (40) concluded that a number of factors that had been related to blossom-end rot including high total soluble salts, unfavorable soil moisture, and high soil concentrations of Na^+, NH_4^+, and K^+ reduce plant uptake of Ca. To control this disorder, he further concluded that the total soluble salts in the soil should contain 15 to 20% Ca (41) and that excessively high total soluble salt concentrations and high soil concentrations of K, Mg, and NH_4 should be avoided.

These studies showed that vegetable growth can be seriously reduced by the presence of excessive concentrations of soluble salts commonly encountered by Florida vegetable growers. By the use of high quality irrigation water and proper nutrient rate, sources, ratio, and placement, the occurrence of many formerly serious physiological disorders has been eliminated and vegetable growth has been enhanced. Continous cropping often reduced yields due to an accumulation of soluble salts. In the past, growers generally solved this problem by moving to new land.

Fertilizer placement

Proper placement of fertilizer for vegetables has long been a concern of Florida growers. With the adequate to excessive rates commonly applied, soluble salt injury was common even with the low analysis, high organic-N fertilizers used in 1900. In 1908, Robinson (96) reported that for celery and peppers grown on a sandy soil, fertilizer should be applied broadcast, harrowed into the soil and the land thoroughly irrigated 10 days before planting. As recently as 1945, application of fertilizer 2 to 4 weeks before planting cabbage was recommended to avoid injury from fertilizer salts (82). With proper fertilizer rates and placement, nutrient uptake is enhanced without crop injury and should result in increased crop growth and yield. As vegetable growers began to use more commercial fertilizer in the 1930's, fertilizer placement became more critical in its effects on vegetable growth.

In studies conducted from 1931 to 1937 in Florida (20), it was reported that vegetable yields were generally higher with fertilizer placed in a band at each side of the seed row than with fertilizer applied broadcast. In 1941, Jamison (57) reported that on mineral soils, growers commonly applied the fertilizer in a broad band that was covered in the process of making a bed. Yields of seeded bean, cucumber, transplanted cabbage, lettuce, and pepper were generally higher with placement of the fertilizer in bands 2 inches to the side and on the level of the seed as compared to row or broadcast placement. Transplanted tomato and lettuce were less affected by fertilizer placement than the seeded crops. In 1940, Nettles (88) pointed out the danger of injury to seed when fertilizer was placed in contact with the seed. He reported that although in-row placement of fertilizer did not result in decreased yields in wetter years, band placement of fertilizer on each side of the seed resulted in the best yields over a period of years. As a resullt of these studies, fertilizer applications through the 1960's was in bands or by growers that did not have proper equipment for band fertilizer application, in the row.

In 1967, Fiskell et al. (34) reported an interaction between fertilizer rate and placement on watermelon yield. Highest yields were obtained with broadcast than with bands placed on one side of the row, bands on both sides of the row (double bands), or with an in-row broad-band placement of the fertilizer. Also, yields increased linearly to 4,000 lb./acre 6-3.5-6.7 N-P-K with the single band and broadcast placements but only from 1,000 to 2,000 lb./acre fertilizer with the double band placement. With the in-row placement, early plant growth and fruit yields were reduced linearly with an increase in fertilizer rate. The poorer response to the row placement and double band placement was related to increased soluble salt injury with an increase in fertilizer rate. Thus, with proper placment, watermelons responded with increased yield to increased fertilizer rate. Locascio et al. (69) also showed that watermelons responded linearly to increases in Cu and complete micronutrient rates when applied broadcast with the fertilizer as compared to band application.

The efficiency of applied fertilizer may vary with the nutrient, rate applied, placement, soil type, and the crop. On high P fixation soils, P is more efficient if applied banded than broadcast (64). Orth (89), reported that 25 lb./acre P applied in the seed furrow on a calcareous soil was much more effective in stimulating tomato seedling growth than 75 lb./acre mixed in the soil. With high concentrations of soil available P and at higher soil temperatures, this effect of close P placement is minimized (58, 64).

The advantage of split over a single fertilizer application was demonstrated in a number of studies. Rainfall and irrigation patterns were recognized as factors influencing optimum time of fertilizer applications. In drier years, a single fertilizer application was similar to split application (72) while in wetter years, vegetable yields were higher with split fertilizer application on mineral soils (52, 72) and organic soils (47).

In 1970, Locascio and Fiskell (65) reported that use of sulfur-coated urea (SCU) and potassium chloride on watermelons resulted in higher soil soluble salts throughout the season and increased fruit production over use of the noncoated nutrients. In wetter seasons, yields of watermelons were similar with one application of SCU and with split applications of urea (73). The slow release properties of SCU, resin-coated N (Osmocote), and isobutylidene diurea (IBDU) have been evaluated on a number of vegetables including watermelon (23, 65, 73), pepper (29, 70), tomatoes (71, 77), potatoes (22), and with strawberries (2, 3, 4, 63).

Polyethylene mulch and fertilization

Vegetable fertilization practices were dramatically influenced in 1958 with the introduction of black polyethylene mulch to Florida. In the first recorded use of polyethylene mulch in Florida, Thompson (101) reported that strawberry yields were significantly higher with polyethylene mulched than with unmulched strawberries. In 1960, Locascio and Thompson (62) reported that strawberry yields with black polyethylene mulch increased 125% over those with pine straw mulch and 45% over those with no mulch. Fruit yields increased linearly with increased fertilizer rates from 500 to 2,000 lb./ acre 6-3.5-6.7 with all treatments but polyethylene mulch influenced a number of soil factors including reduced nutrient leaching and increased yield. The entire Florida strawberry industry adapted the use of black polyethylene mulch by 1961. Its use resulted in more than a doubling of the statewide yield/acre (86) and was responsible for the survival of the industry. By 1970, growers were commonly using polyethylene mulch for tomato, pepper, and eggplant with large increases in yield. With the introduction of polyethylene mulch, it was apparent that fertilizer and cultural programs previously developed had to be reevaluated. In studies with strawberries, highest fruit yields were obtained with use of 2,000 lb./acre 6-3.5-6.7 fertilizer applied broadcast and mulch applied at planting than with the fertilizer applied part broadcast and part banded or all banded at planting (60). Splitting the fertilizer application and applying the mulch one month after planting resulted in a greater reduction in yield with the broadcast than other placements. In 1962, Geraldson (44) reported that tomato yields were increased 20 to 30% with mulch over that with no mulch, and that the mulch maintained a higher nutrient concentration in the soil throughout the crop growth season. Tomato yields were similar with 1,000 to 4,000 lb./acre 15-0-21 applied under the polyethylene mulch. Bryan and Dalton (12) found that on a loam phase of Rockdale soil, yields of tomato and second-crop butternut squash were higher with broadcast application of fertilizer than banding the fertilizer on the soil surface under the mulch. Yields with 1,500 lb./acre of 8-17.4-13.3 applied broadcast were similar to yields with 3,000 lb./acre of the fertilizer applied 1/3 spread on the soil with 2/3 banded on top of the bed or with all of the fertilizer banded on the soil surface under the mulch. After the tomato crop, adequate fertilizer remained to grow butternut squash (12). Persaud et al. (91) reported yield of mulched tomatoes grown on a Myakka sand with overhead irrigation increased significantly with an increase in N-K from 90-100 lb./acre to 2 times this N-K rate and only a slight yield increase with an increase to 270-300 lb./acre N-K. Fruit yields were lowest with 100% of the fertilizer banded 3 inches below and 3 inches to one side of the plant row and was significantly lower than yields obtained with the fertilizer 100% broadcast, 10% broadcast and 90% banded on the soil surface 3 inches to each side of the plant row, or 10% broadcast and 90% banded 3 inches below and 3 inches to one side of the row. At a second location on a Myakka fine sand with seep irrigation, these N-K rates and placements had no significant effect on tomato yield. Everett (26) reported that yields of mulched tomatoes grown with seep irrigation were similar with N-K rates of 130-157, to 310-364 lb./acre with the fertilizer applied part banded in the soil 3 inches below and 3 inches to each side of the bed center and with the remainder banded on the soil surface 9 inches to each side of the bed center. In a later study, Everett (27) reported that yield of seeded and transplanted tomatoes were highest with starter fertilizer placed 3 inches below the seed or plant and in a 2-foot wide band than placed in two 2-inch wide bands on the soil surface 4 inches to each side of the plant. In 1966, Hayslip and Iley (49) reported that yield of direct-seeded tomato was higher with 200-175-332 lb./acre N-P-K applied in a band and the band cover with a 10-inch wide polyethylene strip than with full bed mulch. Geraldson et al. (46) reported in 1966 that the use of polyethylene mulch, high analysis fertilizer and a complete soil fumigant alleviated, if not eliminated, most of the reasons why farmers moved from old to new agricultural lands.

Studies to determine fertilizer requirements with mulch have been conducted from the early 1960's to the present and some of the extensive work in addition to work with strawberry and tomatoes includes studies with pepper (45, 56, 66, 67), potato (53), cabbage (15), eggplant (1), watermelon (10, 11, 34), cauliflower (17), and lettuce (30).

Irrigation and fertilization

The importance of rainfall and irrigation in the fertility program of vegetables was recognized very early. Early irrigation was by surface and subsurface systems. Overhead irrigation was common in the 1940's. In 1946, Pratt et al. (92) stated that with seep irrigation, heavy fertilization resulted in reduced seed germination in the bed center but that daily overhead irrigation eliminated the "burn". Leaching due to excessive rainfall and/or irrigation of N and K is often a major problem limiting vegetable growth on mineral soils. Because of the uncertainty of rainfall occurrence and intensity, fertilizer applied for unmulched vegetables is commonly applied in split applications to minimize plant nutrient stress.

In 1972, Myers and Locascio (87) reported that strawberry yields with overhead irrigation were similar to those with one-half as much water applied by trickle (drip) irrigation and all of the fertilizer applied at planting. With application of some fertilizer preplant and some N and K applied with the trickle irrigation water, strawberry yield exceeded those obtained with overhead irrigation (76). Rates and timing of fertilizer applications with trickle irrigated crops have been studied with tomato (13, 16, 33, 59, 75, 77, 79, 100), broccoli (16, 18), sweet corn (16), cauliflower (18, 59), and watermelon (24). The use of trickle irrigation and mulch provide a system in which fertilizer can be supplied during the crop season to correspond to crop needs.

Both fertilizer for a second crop and pesticides (90) can be applied under the mulch by trickle irrigation. Where trickle irrigation is not used, Csizinszky et al. (19) has shown that an injection wheel could effectively supply supplemental fertilizer through polyethylene mulch for a second crop of squash and muskmelons following tomatoes.

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Proc. Fla. State Hort. Soc. 100:405-408. 1987.

MARKETING STRATEGIES FOR FLORIDA-GROWN TABLE GRAPES

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Abstract. **The recent introduction of Orlando Seedless has generated much enthusiasm among Florida grape growers. Seedlessness, a characteristic that most consumers insist upon, has long been sought and is now available in a cultivar suited to Florida's growing conditions. Other improved seedless varieties are likely to be available soon. Grower enthusiasm and seedless varieties, however, are not sufficient to assure success in the competitive produce market. Growers will have to develop and implement a marketing plan to enter the competitive realm of the table grape industry. This paper identifies the factors most critical in developing successful marketing strategies for table grapes grown in Florida.**

Overview of the Florida Industry

In 1986, Florida had about 318 acres of muscadine grapes being sold in fresh form and 157 acres being utilized for wine, for a total of 475 acres of muscadines. Bunch grape acreage is reported to be 518 acres based on a survey of grape growers. Fresh market utilization accounted for 128 acres of bunch grapes, with 390 acres going into wine production. Thus, total 1986 Florida grape acreage is estimated to be 993 acres. This represents approximately a 100 percent increase in grape acreage in Florida during the past ten years.

Muscadine varieties currently being sold in the fresh market include Fry, Triumph, Dixie, Cowart, Noble, Higgins, and Carlos. Bunch grape varieties being consumed in fresh form include Orlando Seedless, Conquistador, Stover, Blue Lake, and Blue Emerald. Although the Orlando Seedless is the most recent entry in the Florida bunch grape category, it has rapidly moved to the top of the list.

The Fresh Grape Market

One of the most favorable factors affecting the table grape market in recent years has been the rapidly increasing per capita consumption of fresh grapes. Since the early 1970's, per capita consumption of grape has more than doubled. Today, the average American consumes about five pounds of grapes annually (6). It also appears that Americans' tastes are changing. In many regions of the U.S., sales of seeded, more flavorful grapes have been increasing. For example, a survey conducted in Ohio in 1984 indicated that flavor was the most important characteristic desired in table grapes, cited by 89 percent of the consumers interviewed (1). Seedlessness was mentioned as being important by 68 percent of the sample, and price was mentioned by only 18 percent. Surprisingly, appearance was mentioned by only 17 percent, and size mentioned by only 16 percent. These findings are quite different from the general beliefs of many in the produce industry, and these findings offer promise for Florida grape varieties.

A recent Canadian study found that 89 percent of the general population had consumed light green grapes within the past year, as compared to only 32 percent for red grapes and 26 percent for dark blue (5). However, it is likely that these percentages are shifting somewhat due to the rapidly increasing importance of the red seedless varieties from California.

Marketing Factors

In developing marketing strategies for Florida-grown table grapes, several factors must be considered. In mar-