HS-755

A Summary of N, P, and K Research with Watermelon in Florida[1]

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Florida watermelon production in the 1996-1997 season totaled 7,500,000 hundred weight (cwt) of which 80% were shipped out of the state in May through July. Crop value was $55,000,000 from 33,000 planted acres (30,000 harvested acres) largely in north Florida (Fla. Dept. of Agr. and Cons. Serv., 1998). Statewide fertilizer costs were approximately 9% of the crop value, or $4,700,000 (Smith and Taylor, 1996).

Statistics on statewide application of nitrogen (N) fertilizer amounts applied to watermelon crops in 1994 met the current IFAS recommendation of 150 lb/acre N (Fla. Agr. Statistics Serv., 1995; Hochmuth and Hanlon, 1995). The average application rates of 123 lb/acre P_2O_5 and 182 lb/acre K_2O were similar to the maximum recommended rates of 150 lb/acre for each P_2O_5 and K_2O. Current P and K fertilizer recommendations are based on high crop yielding requirements. In most soils in Florida, P is retained and accumulates with successive applications. Excess applied K leaches readily and should not be applied at rates greater than crop requirements.

More than forty years of watermelon fertilization research has been conducted in Florida. During this time, many changes have occurred in watermelon production practices, including changes in cultivars, and introduction of new cultural systems such as polyethylene mulch and drip irrigation. The purpose of this publication is to summarize fertilization research, documenting experiments that led to the current University of Florida watermelon fertilization recommendations and highlighting topics needing additional research. Since nutrient and water management on the farm are linked, fertilization research is summarized by irrigation method.

Data Summary Method

To evaluate watermelon yield responses to variable rates of fertilizer, a method was needed to standardize the numerous units used for quantifying statewide yield results such as pounds/acre, tons/acre, metric tons/hectare, or hundred-weight/acre (cwt/acre). In addition, vegetable yields varied depending on season, cultivar, and location in the state. Relative yield (RY), a calculated percentage, was chosen as the unit to express watermelon yield

1. This document is HS-755, one of a series of the Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date April 2000. Reviewed October 2008. Visit the EDIS Web Site at http://edis.ifas.ufl.edu.
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responses to fertilization. The highest yield for each fertilizer experiment was assigned a 100% value, and other yields were expressed as a percentage of the highest yield. The actual yield corresponding to 100% RY was presented in cwt/acre units. The RYs were plotted against rates of nutrient to determine how watermelon yields responded to fertilizer in Florida. The RY presentation allowed data from a variety of experiments to be included in the graphical summary of yield responses. For most studies, RYs of 95 to 100% were not significantly different.

Fertilizer rates are expressed on a per-acre basis (amount of fertilizer used on a crop growing in an area of 43,560 sq ft). Changes in bed spacing often lead to needed changes in fertilizer amounts. [For example, to maintain the same amount of fertilizer in the bed for a crop on 6-foot bed spacing as a crop with 4-foot bed spacing would mean an increase by a factor of 1.5, in the "per acre" rate of fertilizer for the crop growing in beds spaced 4-foot on center.] The important aspect is to have the same amount of fertilizer per linear-bed-foot. This linear-bed-foot system is used by the University of Florida Extension Soil Testing Laboratory to express fertilizer rates. The concept is explained by Hanlon and Hochmuth (1989) and by Hochmuth (1996). Fertilizer rate expressions used in this summary and its figures are those rates presented by the various authors in their research papers. Most authors express rates on a per-acre basis, irrespective of variations in bed spacings among reports or experiments. Authors of a few reports chose to use the linear-bed-foot system to standardize fertilizer rate expressions across experiments and planting patterns. We attempt to specify planting patterns and fertilizer rates for each experiment as far as we can determine from each report.

Nitrogen Mixed Fertilizer Trials

Mixed fertilizers were often used in early watermelon experiments to establish crop nutrient requirements. Attributing crop response to a single nutrient, however, could not be done with certainty from research with a blended N-P-K material. Since N is usually the most limiting major nutrient in sandy soils, yield responses in mixed studies are considered here as responses to N. Polyethylene mulch was not used in these studies unless specified.

Watermelons planted at the Horticultural Research Unit near Gainesville and the Suwannee Valley Research and Education Center in Live Oak received either 30 or 60 lb/acre N from a 6 N-8P_2O_5-8K_2O commercial mix (Nettles and Lundy, 1958). Overhead irrigation was applied once in Gainesville. No irrigation was used in Live Oak.

Researchers indicated additional N may have maximized watermelon yields in these 1958 trials, where optimum yields were obtained with 60 lb/acre N (262 and 147 cwt/acre, 100% RYs at Gainesville and Live Oak, respectively). Relative yields with 30 lb/acre N were 70 and 85%, respectively. An increase in applied N from 30 to 60 lb/acre resulted in 8% greater early yields and a 5% increase in average fruit weight to 25 lb/fruit at Gainesville. Fruit weight was not presented for Live Oak. Yields in Gainesville increased only 6% (230 cwt/acre) with fertilizers containing 25% organic material from caster pomace and tankage over yields with inorganic sources alone. The inorganic fertilizer blend resulted in greater yields when applied entirely at preplant than when applied in two applications.

Subsurface irrigation was used on 90% of southwest Florida watermelon fields at the time of an early research project in Immokalee in 1959-1960 (Everett, 1960). Watermelon crops often extended through 8 to 10 harvests and required frequent topdressings of N and K which were generally applied by aircraft at two-week intervals. Watermelon yield responses were evaluated for varying N rates from 90 to 325 lb/acre and for N sources, NH_4NO_3, $(NH_4)_2SO_4$, $NaNO_3$, and a 30% organic-N commercial fertilizer. Experiments were conducted in 1958, 1959, and 1960 at the South Florida Field Laboratory near Immokalee. Mixed fertilizers, 4-8-8 or 6-8-8 (N-P_2O_5-K_2O), were banded on both sides of the row and beneath the level of the row in three applications: at planting, when vines were 12 to 18 inches in length, and when vines were 3 feet in length. Topdressing fertilizer applications were broadcast to simulate airplane application. One topdressing application was made in 1958, three in 1959, and four in 1960. Rows were spaced 10 feet apart.

Marketable watermelon yields responded to fertilization with 100% RY at higher N rates each year. High yields occurred with 124 and 324 lb/acre N (306 and 458 cwt/acre, 100% RY) in 1958 and 1960, respectively. Yields were not significantly affected by increasing N rates in 1959. The authors noted that N rates higher than 150 lb/acre were required in 1960, a dry season, when frequent irrigations likely leached N.

Consistent and significant positive yield responses were observed for organic versus inorganic N sources over the three seasons (Everett, 1960). Plants grown in 1959 with the commercial 30% organic-N mix, 4N-8 P_2O_5-8K_2O, applied at 90 lb/acre N yielded 25% more marketable fruit (720 cwt/acre) than the average high yields over N rates of 110, 150, and 200 lb/acre from plots fertilized with the inorganic source, 6N-8P_2O_5-8 K_2O, or $(NH_4)_2SO_4$. The same organic N mixed fertilizer applied at three N rates, 80, 160, and 240 lb/acre in 1960 resulted in average yields of 788 cwt/acre, double the average yields with the same rate of $(NH_4)_2SO_4$. Research did not establish yield response to trace elements within the organic mix. Nitrogen sources leading to high yields also resulted in the highest NH_4 to NO_3 ionic ratios from soil samples taken throughout the season. The NH_4 to NO_3 ratio was 1.09 with the $(NH_4)_2SO_4$ fertilizer and 0.37 with the organic mixed fertilizer, both of which led to high watermelon yields. Lower yields and lower ionic ratios, 0.19 and 0.11, occurred with NH_4NO_3 and $NaNO_3$, respectively. Advantages of the organic mix were a more constant supply of NH_4 and NO_3-N with decomposition, reduced N leaching due to rain or irrigation, and 75 and 65% of yields harvested early (for best prices) as opposed to an average 55 and 28% with inorganic sources (1959 and 1960, respectively).

In 1964, researchers found that copper was the yield- enhancing micronutrient present in organic fertilizer (Locascio et al., 1964). Copper deficiency symptoms, resulting in failure to set fruit in cases of severe deficiency, were observed in plants in Gainesville. All plants were fertilized with 120 lb/acre N from 4N-8P_2O_5 -8K_2O. Plants fertilized without the addition of copper, including a gypsum-containing treatment, resulted in yields significantly lower (38 cwt/acre) than plants with treatments containing copper (56 cwt/acre) from either inorganic sources (Cu EDTA and Frit 503) or an organic source (Chicago sludge). Plants were spaced 5 feet apart and rows 9 feet apart in a 1964 Immokalee experiment. Yields increased linearly as copper concentrations in mature leaves taken at fruit maturity increased from 4 to 10 ppm. Higher leaf-tissue copper concentrations (7 to 8 ppm) resulted with inorganic copper sources applied at 3 lb/acre copper. Fruit yields with these inorganic copper sources were 800 cwt/acre of watermelon compared to 653 cwt/acre with organic sources of applied copper (rows 10 feet apart). Additional research (Locascio et al., 1966; Locascio and Fiskell, 1966) confirmed the importance of copper at 3 lb/acre, derived from the soil or from fertilizer, for the production of high-yielding watermelon crops.

Experimentation with fertilizer placement in 1967 resulted in significant changes in fertilizer application practices with watermelon (Fiskell et al., 1967; Locascio et al., 1970a). A6N-8P_2O_5-8K_2O fertilizer was applied with N rates of 60,120, and 240 lb/acre at four overhead-irrigated sites. Soils at three sites were Immokalee, Leon, and Lakeland fine sands; soil type at the fourth site was not specified. Treatments were three applications of single- or double-banded fertilizer; a broad-band application with 80% of the fertilizer placed in a 10-inch- wide band 2.5 inches below the seed; and broadcast fertilizer, half at preplant and half at early-runner stage. Plastic mulch was applied at the fourth site, with the 240 lb/acre N treatment, while the remaining sites were unmulched. Plant rows were spaced 9 to 10 feet on center.

Yields were generally highest with 120 lb/acre N, averaging 96% RY. High yields ranged from 174 to 476 cwt/acre with this N rate (Fiskell et al., 1967). Yields increased 100% RY with 240 lb/acre N, at two locations, but were reduced to 90 and 67% RY with 240 lb/acre N at the remaining locations. The recommended N rate for watermelon production at the time of this research was 120 lb/acre.

A significant result of this study was improved yields with modified broadcast fertilizer placement compared to band placement. Yields with broadcast fertilizers averaged over four experiments and three N rates were 33% higher than yields where single-and double-banded fertilizer application was used, and 53% higher than where fertilizer was placed in a broad-band at bed center. The latter placement method was the most commonly used technique at that time. After harvest, soil-soluble salt levels were correspondingly lowest with the broadcast treatment. Single- and double-band-placed fertilizers resulted in equal yields, while broad-band- placed fertilizers resulted in the lowest yields. Seed germination failure, seedling mortality, and delayed maturity combined to reduce yields with broad-band treatments due to soluble-salt concentrations two and three times higher than with other placement methods three months after planting. Yields with plastic mulch were similar to yields with no mulch at the fourth site.

Experimentation with blended 6N-8P_2O_5-8K_2O fertilizer led to yield-comparison studies with sulfur-coated urea (SCU) compared to uncoated urea and sulfur-coated KCl compared to uncoated KCl (Locascio and Fiskell, 1970). Nitrogen rates used in the study were 30, 60, and 150 lb/acre on beds spaced 9 feet on center. Trials were conducted near Gainesville on Leon fine sand with factorial arrangements of the above treatments applied broadcast/incorporated-preplant. In a fifth treatment, equal amounts of uncoated urea and KCl were side-dressed at preplant, at thinning, and at early runner stage.

Despite heavy rainfall, nine inches, in the second month after planting, and a dry third month requiring three acre-inches of water from overhead irrigation, high yields resulted with 150 lb/acre N (524 cwt/acre, 100% RY). Preplant SCU applications resulted in 15% higher average yields by weight (458 cwt/acre) than with preplant uncoated urea (400 cwt/acre), significant at the 10% level. High yields correlated positively with high soil nitrate levels, which were 72 ppm higher with SCU than with uncoated 6N-8P_2O_5-8K_2O three months after fertilization. Combined average yields with coated or uncoated 6N-8P_2O_5-8K_2O applied preplant were similar, however, to yields with uncoated 6N-8P_2O_5-8K_2O applied in three split applications. Sulfur-coated fertilizers reduced pH from 5.81 to 5.26 within one month of fertilization, but had no lasting effect five months after fertilization.

In further research at Gainesville and Live Oak, preplant 6N-8P_2O_5-8K_2O was broadcast and incorporated at 10, 30, 50, 70, and 90% of N rates 90 and 180 lb/acre (Fiskell et al., 1970; Locascio et al., 1970b). The remaining fertilizer was banded in two equal side-dressings, once at thinning and again at early runner stage, to evaluate sustained nutrient supply for a 100-day watermelon crop. Beds were spaced 9 feet on center in two-year experiments at Gainesville and Live Oak, including a wet year (1970) and a dry year (1969).

Early growth was limited by greater amounts of band-placed fertilizer and accelerated by greater amounts of broadcast-placed fertilizer. Researchers cited soil- soluble salt levels nine times higher with banded fertilizer treatments, which likely discouraged early growth. Several weeks after fertilization, soil-soluble salt levels and growth equilibrated, resulting in similar yields with both placement treatments with 90 lb/acre N. With N rates to 180 lb/acre, yields with broadcast-placed fertilizer were 20% higher than yields with the band placed fertilizer (406 versus 342 cwt/acre). Optimum yields were obtained with 180 lb/acre N, averaged over all placement methods in 1969, a dry season, and 1970, a wet season (300 and 450 cwt/acre, 100% RY, respectively). Researchers concluded that three equal 6N -8P_2O_5-8K_2O fertilizer applications totaling 180 lb/acre N, the first application broadcast and incorporated, resulted in the best yields. During the first dry season, yields were unaffected by the percentage of preplant- applied fertilizer, while peak yields were obtained with 30% preplant fertilizer during the wet season.

The same N rates, 90 and 180 lb/acre, from a mixed 12N-16P_2O_5-16K_2O fertilizer were evaluated for yield response in factorial experiments involving different row spacings, fertilizer application methods, and mulch (Brinen et al., 1979). Experiments were conducted in Leesburg and Gainesville on overhead-irrigated plots. Row spacing and mulch interacted in their effects on yield at Leesburg. Watermelon yields on mulched beds increased as plant spacing decreased from 15 to 5 feet (260 to 420 cwt/acre, respectively). Without mulch, yields were highest with the ten-foot spacing (410 cwt/acre). Mulch and fertilizer rates significantly affected yields and mean fruit weights in the Gainesville spring 1977 trial. Yields, averaged over mulched and unmulched treatments, increased 14% from 90 to 180 lb/acre N (590 cwt/acre, 100% RY). Significant (5% level) yield effects occurred with mulch treatments, resulting in 10% more fruit production (580 cwt/acre) with mulched than with unmulched plants. Mean fruit weight was also significantly (1% level) higher, 25 compared to 24 lb, with mulched than unmulched watermelons, respectively.

Controlled-release (CR) sources of N and K were compared with soluble sources in a spring 1993 trial at Live Oak, (Hochmuth and Hochmuth, 1994). The IFAS recommended N rate of 150 lb/acre was applied as soluble N (NH_4NO_3 and KNO_3), or 50% CR-N (polymer coated urea) with soluble K, or 50% CR-N and K (50:50 polymer-coated urea and KNO_3). Fertilizers were either all broadcast/incorporated preplant or applied in three equal applications, preplant (broadcast), banded at four-leaf, and banded at early runner stage. Fields were mulched with clear plastic during fumigation; then the mulch was removed before Royal Sweet watermelons were transplanted. Beds were spaced on 7.5-foot centers, and N rates were expressed on an 8-foot row spacing. Overhead irrigation was used to keep soil moisture at -10 centibars, measured by a tensiometer with the ceramic tip placed 6 inches deep in the root zone.

Since N and K rates were combined, yield response to N rate alone could not be evaluated. Average marketable yields over two independent K rates, 100 and 150 lb/acre K_2O, were 22% higher (340 hundred weight, cwt/acre) with CR 50:50 N and K sources than with soluble sources (278 cwt/acre) when both were applied preplant. Conversely, soluble sources resulted in yields 6% greater than CR 50:50 when both were split applied. Leaf N concentrations were above sufficiency levels at early-runner-stage sampling.

Nitrogen

Subsurface Irrigation

Two cultivars were evaluated for response to N rates of 130 and 320 lb/acre, at the Gulf Coast Research and Education Center in Bradenton (Maynard, 1995). Fertilizer was broadcast uniformly at 130-60-180 lb/acre N-P_2O_5-K_2O and incorporated in beds spaced 9 feet apart. Additional N and K were banded for total N-P_2O_5-K_2O treatments of: 320-60-180, 130-60-360, and 320-60-360 lb/acre, followed by mulching with black polyethylene. Average marketable yield responses with 130 and 320 lb/acre N were similar, resulting in 95 and 100% RY (655 cwt/acre), respectively. Leaf-tissue N concentrations were high (>3.0%) at both fruit set and first harvest for both cultivars. High yields and tissue N concentrations were obtained with 130 lb/acre N, near the current IFAS recommendation of 150 lb/acre N.

Drip Irrigation

Drip-irrigated watermelons on deep Apopka fine sands at Leesburg yielded twice the early yields of plants with overhead sprinkler irrigation (111 and 50 cwt/acre, respectively); (Elmstrom et al., 1981). Early yield represented 40% of the total yield with drip-irrigated plants in Leesburg, as opposed to 17% of the total yield with overhead irrigation. At Gainesville, early watermelon yields were similar with both irrigation methods. Total yields at both locations were not affected by the method of irrigation. Soils used for the Gainesville experiment were more fine textured and on a higher water table than soils at the Leesburg site. Variations in soil type and water table resulted in similar total yields on irrigated or unirrigated plots in Gainesville, but unirrigated Leesburg plants produced only 44% of the fruit produced by irrigated plants. Plant rows were spaced 10 feet apart at both locations.

In a dry spring at Gainesville and Leesburg (spring 1981), water use was reduced 36 and 44%, respectively, with drip irrigation compared to overhead irrigation. Although total yields were not affected by irrigation method, the benefits of drip irrigation were numerous, reduced water use, fewer weeds with restricted water application area versus general water application over cropped and non-cropped areas with overhead irrigation, reduced plant stress periods due to equipment limitations with once-weekly overhead water applications, reduced occurrence of disease, and greater early melon yield on deep dry soils.

Fertilizer placement was an additional factor studied in this unmulched irrigation study (Elmstrom et al., 1981). Nutrients, 150-200-200 lb/acre N, P_2O_5, K_2O, were applied one-third at preplant and two-thirds fertigated in both an overhead and drip-irrigated treatment. In a second overhead irrigated experiment, two-thirds of the fertilizer was applied preplant and one-third was applied at early runner stage. Total yields were similar regardless of the fertilizer split application and regardless of the irrigation method used.

Standard and icebox watermelons were grown on Lakeland fine sandy soils, spring 1988, at the Suwannee Valley AREC near Live Oak (Hochmuth et al., 1992). Beds on five-foot centers were used for the smaller icebox watermelons along with N rates of 0, 40, 80, and 120 lb/acre N (NH_4NO_3). The "standard" size Crimson Sweet watermelons were grown on 7.5-foot centers with 0, 40, 80, 120, 160, and 200 lb/acre N from urea. Mehlich-1 soil tests revealed high P and low K soil indices. Phosphorus was not applied based on IFAS recommendation and 50 lb/acre K_2O from potassium magnesium sulfate was applied, a rate 100 lb/acre K_2O lower than the current recommended rate for soils testing low in K. Fertilizers were hand-applied across the bed center, based on higher yielding results with this application method (Fiskel et al., 1967), as opposed to band fertilizer placement. Beds were then cultivated to incorporate the fertilizer and mulched with black polyethylene. Drip irrigation and tensiometers were used to maintain soil moisture at -10 centibars.

Yields of standard watermelon increased quadratically through 120 lb/acre N, (380 cwt/acre, 100% RY). Early yields, with 120 lb/acre N, were 40% of the total yields. Researchers noted heavy reliance on drip irrigation during this extremely dry spring season. Yields of icebox watermelon did not change with N rates from 40 to 120 lb/acre N (392 cwt/acre with 40 lb/acre N). Researchers noted high yields with lower N rates for icebox watermelon, but indicated additional trials were needed to determine the optimum N rate for this type of watermelon.

Researchers noted a positive yield response with the highest N rate (180 lb/acre N) in another experiment at Suwannee Valley Agriculture Research and Education Center, Live Oak (Hochmuth et al., 1994). Fertilizers were mixed, broadcast in a three-foot swath across the row, and incorporated at rates as follows: 0, 60, 120, and 180 lb/acre N from NH_4NO_3. Fertilizers were calculated based on an 8-foot row spacing but, the actual rows were spaced 7.5 feet apart. The crop was drip irrigated to maintain soil moisture at -10 centibars as measured by tensiometer. Beds were mulched with black polyethylene and Royal Sweet watermelon transplants were set out on March 29, 1993. Marketable yields increased linearly between 0 and 180 lb/acre N, doubling from 265 to 555 cwt/acre (100% RY) with 65% of the total yield from the first two harvests. Average fruit weight also increased linearly from 11.9 to 18.0 lb with increasing N rates from 0 to 180 lb/acre. Researchers attributed part of the increased demand for N to a severe watermelon mosaic virus infection. Leaf N concentrations of plants with the check treatment were very high, 6.2 and 5.7% (>3.5% is adequate) at first flower and early fruit, respectively, this indicated abundant N available from mineralization early in the season from soils with 1.8% organic matter. Fresh petiole sap nitrate-N concentrations were below the adequate range only at the half-mature fruit stage. Apparently yield suffered from inadequate N late in the season.

Watermelon research continued the following spring in Live Oak with further monitoring of petiole sap N and K concentrations (Hochmuth and Hochmuth, 1996). Fertilizers, including 120 lb/acre K_2O from KCl and 0, 60, 120, or 180 lb/acre N from NH_4NO_3, were broadcast in a 30-inch swath and tilled. Beds were spaced 7.5 feet apart. Drip irrigation was used to keep the soil moisture in the root zone at -8 to -12 centibars in beds mulched with black polyethylene.

Total yield, early yield, and average fruit weight increased with N rate to 120 lb/acre N, (433 cwt/acre, 100% RY). Early harvest accounted for 72% of the total yield and average fruit weight was 18.0 lb. Yield was reduced with 180 lb/acre N (410 cwt/acre, 95% RY) with early yield reduced to half of the total yield and average fruit weight reduced to 15.2 lb. Regression analysis established 130 lb/acre N as the optimum N rate. Petiole nitrate-N concentrations from plants fertilized with 120 lb/acre N were 2000 (high), 880 (low), and 720 (adequate) at early, mid-season, and harvest sampling, respectively (Hochmuth, 1994). Sap N on the first sampling (April 22) correlated best (r = 0.94) with total marketable yield. Whole-leaf tissue N concentrations were generally above sufficiency ranges.

Irrigation Unknown

Irrigation method was not cited in this early 1970s study. Based on the predominant form of irrigation used at the time and location of this study, overhead irrigation was the presumed irrigation method.

Sulfur-coated urea and urea fertilizer sources, fertilizer placement methods, mulch types, and N rates, zero through 200 lb/acre, were evaluated in factorial experiments near Gainesville and Live Oak in 1971 through 1973 (Locascio et al., 1973). In all trials, plants received 170 lb/acre P_2O_5 and 150 lb/acre K_2O in broadcast or banded applications, depending on the mulch treatment used. Broadcast fertilizer was spread over a 5-foot area on beds spaced 9 feet apart and tilled, while banded fertilizer was hand applied 3 inches deep to one side of the seed area, and split fertilizer applications were broadcast three times, first across the bed, then in eight to 18 inch broad bands to either side of the plant row.

Yield responses to N rate, averaged for Gainesville and Live Oak sites in 1971, were quadratic for this season and during 1973 at Live Oak, resulting in high yields with 125 lb/acre N (356 and 376 cwt/acre, respectively, 100% RY). With 200 lb/acre N, corresponding RYs were reduced at these locations to 97 and 80% RY, respectively (Locascio et al., 1973). Yields were not significantly different at Live Oak in 1972 with N rates from 0 to 200 lb/acre. Yield optimized this season with 50 lb/acre N (352 cwt/acre, 100% RY). Watermelon yields were always optimized with 125 lb/acre N. Heavy cover cropping prior to watermelon planting may have reduced the need for additional N in some of these experiments.

Nitrogen sources did not affect yields or tissue N concentrations at Gainesville and Live Oak in 1971, but were a factor in yield responses in Live Oak trials during 1972 and 1973. The highest yields in 1972 resulted from plants fertilized with urea banded with strip mulch (400 cwt/acre), followed by plants fertilized with broadcast sulfur-coated-urea (SCU)-30 (% dissolution in 7 days), urea broadcast in three applications, and SCU-44 (% dissolution in 7 days); (360 cwt/acre). Winds removed 50% of the strip and paper mulch in 1973, reducing yields with these mulched treatments. Equal yields of 380 cwt/acre were produced with broadcast isobutylidene diurea (IBDU), NH_4NO_3 - broadcast in three applications, or urea broadcast under polyethylene mulch. A lower yield of 360 cwt/acre was produced with SCU- 41 broadcast. Best N fertilizer sources overall were single broadcast applications of SCU-30 and 44 (% dissolution in 7 days), IBDU, urea under polyethylene, or three broadcast applications of urea or NH_4NO_3.

Nitrogen Summary

In 83% of the combined mixed fertilizer and N-only response trials, optimum yields (95 to 100% RY) were reached between 120 and 180 lb/acre N largely on overhead irrigated fields. In studies where only mixed fertilizers were used, representing 60% of watermelon research, best yields resulted with 120 through 240 lb/acre N in 70% of these trials (Fig. 1). In later studies that isolated yield response to only N, optimum yields were achieved with lower N rates, 120 to 130 lb/acre N (Fig. 2) in 78% of these trials. Yields were increased when fertilizer was broadcast/incorporated instead of banded on overhead irrigated fields and when cover crops were grown prior to planting. Yield response to higher N rates resulted when disease occurred on drip irrigated fields and during wet or dry seasons on subsurface irrigated fields. Drip irrigation often resulted in similar total yields as with overhead irrigation, but early yields were consistently higher (from 35 to 70% of total yields) when drip-irrigated trials were conducted on deep, dry sandy soils.

Research results with N fertilization support the current N recommendation of 150 lb/acre for planting patterns using beds on 8-foot centers. More research is needed with drip irrigated watermelon to determine optimum N management schemes such as proportion of N to apply preplant to the soil and proportion of N to inject. In addition, information is needed to guide the scheduling of N injection through the season.

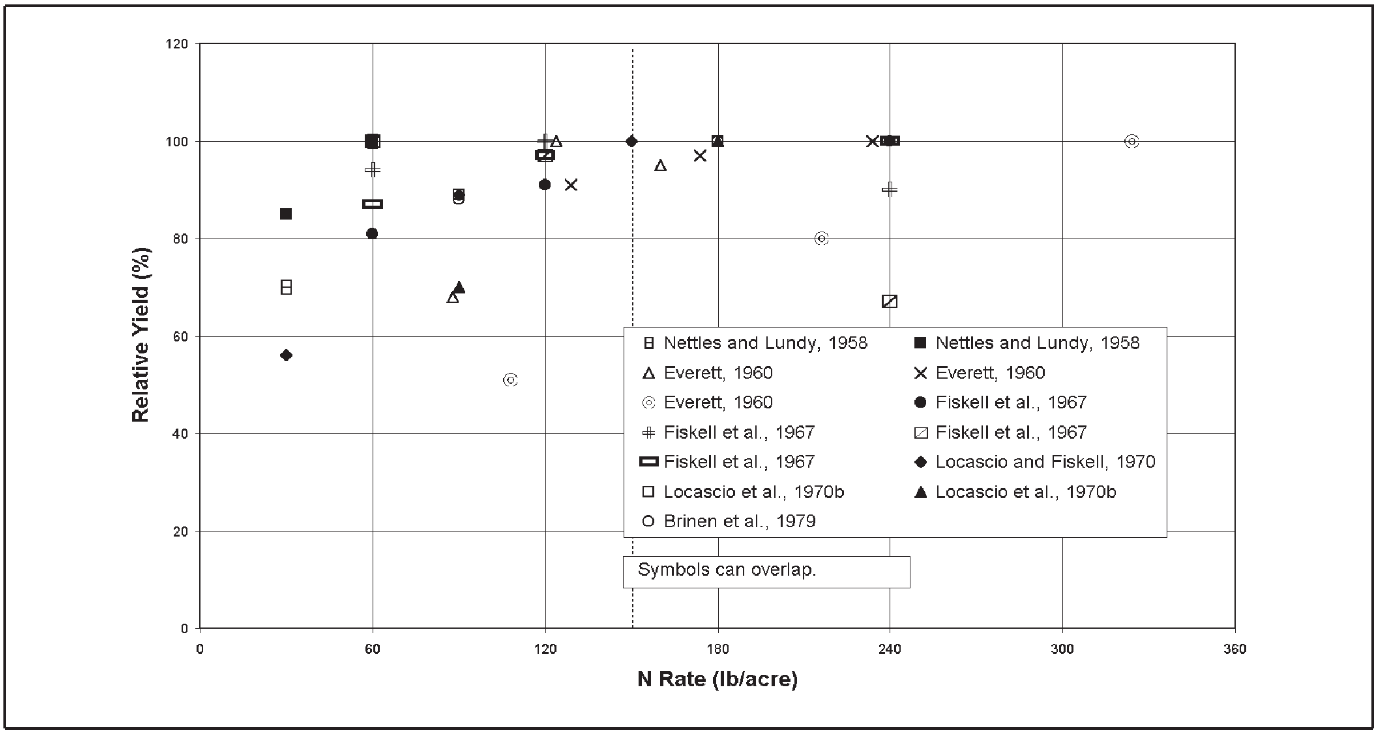

Figure 1. Relative yield of watermelon for experiments, years, and seasons as a function of added N (mixed fertilizer).

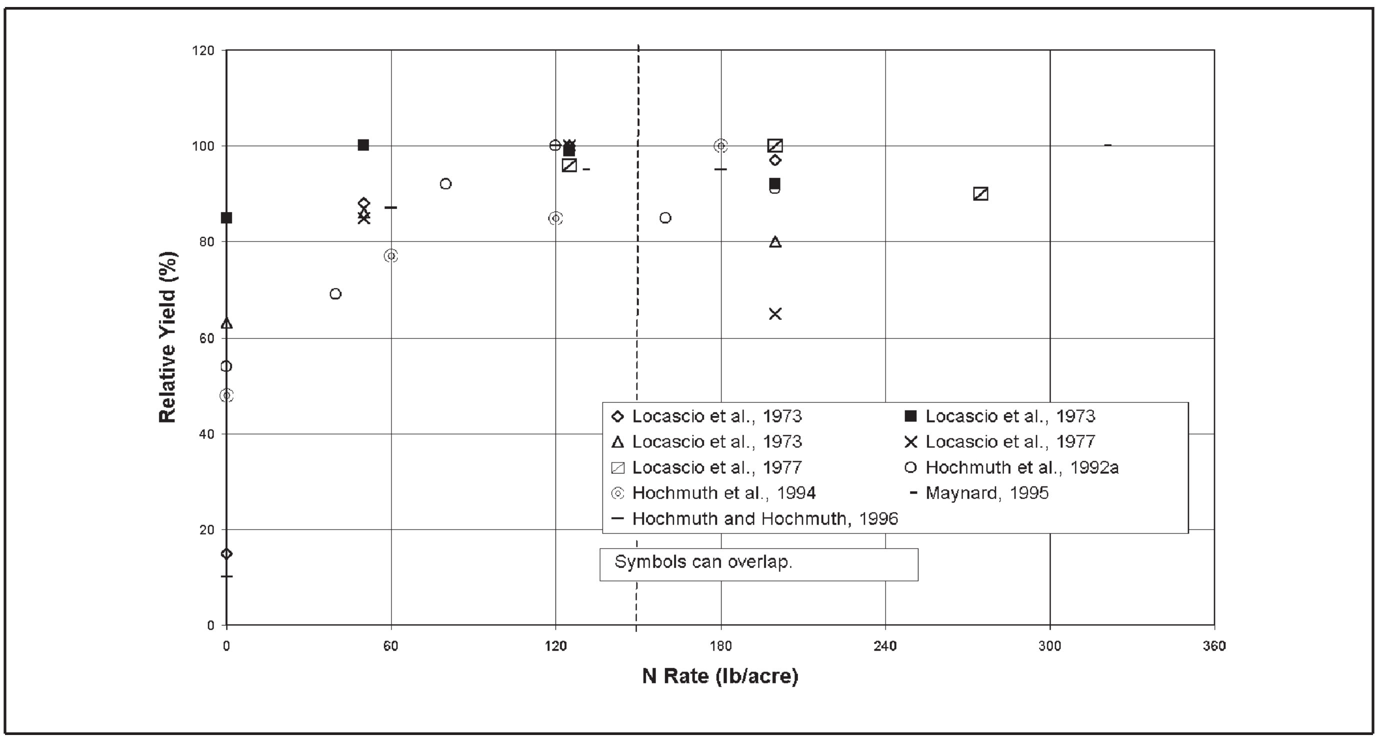

Figure 2. Relative yield of watermelon for experiments, years, and seasons as a function of added N.

Phosphorus and Potassium Soil Testing

Knowledge of soil nutrient levels, particularly P and K before planting is the starting point to predicting watermelon response to varying rates of applied nutrient. Mehlich-1 (M-1) soil extractant is used on mineral soils to determine preplant soil nutrient concentrations and provide information in order to review research for the degree of support of current fertilization recommendations.

Mehlich-1 extractant indices (expressed as ppm soil-extracted nutrient) are classified as very low, low, medium, high, and very high, and a crop specific fertilizer recommendation is made from that classification (Hochmuth et al.,1995). The M-1 solution became the accepted extractant standard in 1979 at the University of Florida. Prior to M-1, ammonium acetate and water extractants were used. Indices recorded from these methods cannot be directly equated with M-1 indices but, review of research results from studies with these extractants presents a profile of watermelon response under varying soil fertility conditions. This review also summarizes practices in water management, fertilizer sources, fertilizer application methods, and the effect of mulch in the nutrient management system.

Phosphorus

Acidic soils at Immokalee and Gainesville were limed to pHs ranging from 5.2 to 5.7 for factorial trials comparing P sources, P rates, and rates of Cu (Locascio et al., 1968). All soils were low in water extractable P. Phosphorus sources, superphosphate (SP), and concentrated superphosphate (CSP) were applied to virgin Immokalee fine sands in Immokalee. Diammonium phosphate (DAP), ammoniated superphosphate (ASP), and SP were applied to Leon fine sands in Gainesville. In Immokalee trials (1965 and 1966), watermelons were fertilized with 120 lb/acre N and 240 K_2O (5 hills, 3 x 10 feet apart). In both Gainesville trials (1966 and 1967), crops were fertilized with 130 lb/acre each N and K_2O (8 hills, 5 x 9 feet apart). Fertilizers were applied in bands, once before seeding and again at early runner stage for each trial. Supplemental N and K (15-0-14) were sidedressed as needed. The type of irrigation applied was not specified in this study, nor was use of mulch indicated. Based on the predominant form of irrigation used at each location at the time of the experiment, overhead irrigation was presumed with the Gainesville experiment and subsurface irrigation was presumed with the Immokalee location. On the Immokalee fine sand soils, highest yields of Charleston Grey watermelon were obtained with 240 lb/acre P_2O_5 from SP and CSP, in 1965 and 1966 (464 and 442 cwt/acre, 100% RY) (Locascio et al., 1968). Yields with 120 lb/acre P_2O_5 were 80 and 92% RY each year. In 1966, the highest yields in Gainesville were with 160 lb/acre P_2O_5 from ASP (264 cwt/acre). In 1967, high yields in Gainesville again occurred with 160 lb/acre P_2O_5 (284 cwt/acre) averaged over ASP and SP treatments. Application of DAP in Gainesville (1966) reduced yields and raised soil pH from 5.5 to 6.1. Leaf tissue P concentrations averaged over three copper rates (0, 2, and 4 lb/acre) were deficient at early and first flower stages (< 0.25%) and adequate (0.25 to 0.5%) at harvest stage with all P rates from 0 to 480 lb/acre P_2O_5 in Immokalee. Increasing P rates decreased tissue copper concentrations at flowering. Tissue P concentrations at early-runner stage in Gainesville trials (1966 to 1967) were adequate (0.25 to 0.5%) for both seasons. Increasing P rates decreased tissue copper concentrations in both seasons.

Preplant fertilizer rate and placement were evaluated in a three-year study (1969-1971) at Leesburg (Elmstrom et al., 1973a). Two P rates were evaluated, 120 and 245 lb/acre P_2O_5 with 120 lb/acre N and K_2O or 240 lb/acre N and K_2O. These trials predated the M-1 soil test, but a "quite low" soil P evaluation (less than 5 lb/acre) was provided by an unspecified soil analysis method. All of the P fertilizer and half of the N and K were either banded six inches below the planting row in a ten-inch band or broadcast in a 40-inch swath and incorporated. The remaining N and K were sidedressed at seedling emergence and before vines began to run. Treatments in 1971 included banding all of the P and broadcasting all of the N and K. The experimental plots were 20 x 24 feet and had two rows per plot. Mulch use or irrigation method were not specified. Band application of all applied P did not result in increased yields or higher tissue P concentrations in any year compared with broadcasting all of the P (Elmstrom et al., 1973a). Similar tissue P concentrations from band-applied treatments and from broadcast treatments indicated no variation in P availability between placement method. High yields occurred with 120 lb/acre each N-P_2O_5-K_2O applied in bands (290, 520, and 606 cwt/acre, 1969, 1970, and 1971, respectively, 100% RY). Yields were also optimized with 120 lb/acre N when the fertilizer was broadcast in 1969 and 1970 (274 and 576 cwt/acre, respectively, 100% RY), and resulted in 96% RY in the third season, 1971. Yields decreased 7 to 10% when 245 lb/acre P_2O_5 were banded with 120 lb/acre

N and K_2O. Tissue P concentrations increased 10 to 15% with banded P only when all of the N and K, instead of half, were broadcast and incorporated preplant at 240 lb/acre N and K_2O (1971) (Elmstrom et al., 1973a). The authors cited increased growth stimulated by higher available N and K for the enhanced demand for and absorption of the banded P. Yields however, were not affected by increased P absorption. IFAS recommends broadcasting and incorporating all P_2O_5 in the bed before planting, regardless of irrigation method (Hochmuth and Hanlon, 1995).

Overhead Irrigation

Watermelon trials were conducted on unmulched fields in Gainesville in 1986 and on polyethylene mulched fields in Gainesville and Dunnellon in 1988 (Hanlon and Hochmuth, 1992; Hochmuth and Hanlon, 1988; Hochmuth et al., 1993a). Crops for P rate trials in Gainesville were direct-seeded while transplants were used in N and K factorial trials in Dunnellon. Fertilizers from NH_4NO_3, CSP, K_2SO_4, and KCl sources were mixed and BC/incorporated during bed formation at all sites. Nitrogen was added uniformly at 120 lb/acre on beds spaced 8 feet apart in Gainesville experiments and 12 feet apart in Dunnellon (fertilizer was calculated based on 8-foot centers for all locations).

Excellent yields, generally double the state average of 170 cwt/acre, occurred at all sites with the recommended P rate based on preplant M-1 extractant soil tests. Gainesville soils tested high (46 ppm) and very high (120 ppm) for M-1 extracted P in 1986 and 1988 respectively, and no additional P was recommended. Watermelon yields did not respond to increased P applications from 0 to 155 lb/acre P_2O_5 in either year at Gainesville. Optimum yields occurred in 1986 on unmulched plots with zero lb/acre P_2O_5 (460 cwt/acre, 100% RY) and in 1988 on mulched plots with 50 lb/acre P_2O_5 (390 cwt/acre, 100% RY), though this yield was not different from yield with zero lb/acre P_2O_5. Researchers noted that soils in the beds were drier where overhead irrigation was applied to mulched fields, which likely resulted in lower overall yields compared to unmulched fields. Plants grown on mulched soils in Dunnellon, 1988, produced optimum yields with 80 lb/acre P_2O_5 (320 cwt/acre, 100% RY) as per the recommendation for soils with medium M-1 P concentrations. However, yields at this site were not statistically different with P rates from 0 to 155 lb/acre P_2O_5. Tissue P concentrations at early fruit set were adequate for both Gainesville trials. Data for Dunnellon were not presented.

Drip Irrigation

Phosphorus and K were broadcast and incorporated in Macclenny and Live Oak 1988 trials. Fertilizers mixed from NH_4NO_3 (120 lb/acre N), CSP, K_2SO_4, and KCl sources were applied uniformly to fields which were then mulched with black polyethylene (Hochmuth and Hanlon, 1988; Hochmuth et al., 1993a). Yields were similar with all applied P rates to 200 lb/acre P_2O_5 at both Macclenny and to 50 lb/acre P_2O_5 at Live Oak. High yield occurred with 150 lb/acre P_2O_5 (405 cwt/acre, 100% RY), the recommended rate for soils very low in M-1 soil-extracted P (6 ppm) at Macclenny (12-foot bed spacing). The Live Oak watermelon crop (7.5-foot bed spacing) resulted in high yields with zero lb/acre P_2O_5 (455 cwt/acre, 100% RY), the recommendation for soils very high in M-1 extracted P (115 ppm). Phosphorus tissue concentrations at early fruit set were adequate (0.4 to 0.49%) with all P rates at both sites.

Watermelon response to P fertilizer was evaluated at two more Macclenny sites (1989). Both ultisol soils were interpreted as very low in M-1 soil-extracted P, 5.6 and 10.2 ppm, at sites one and two, respectively (Hochmuth et al., 1993b). Site one was newly cleared pine land, with pH 5.6, and site two was previously a bahiagrass pasture, pH 5.8. Soils were fertilized with 120 lb/acre N and K_2O and experimental rates of P. A fertilizer mixture derived from NH_4NO_3, CSP, KCl, and potassium magnesium sulfate was hand spread, incorporated by rototiller, and mulched with black polyethylene. Rows were 9 feet on-center and soil water potential was measured with tensiometers and maintained at -12 centibars.

Watermelon yield response was quadratic at both locations. Maximum yield at sites one and two occurred with 200 lb/acre P_2O_5 (397 and 656 cwt/acre, 100% RY, respectively). Yield responses, however, were not different at P rates between 50 and

200 lb/acre P_2O_5. At early harvest, no fruit was harvested from plants at site one with the check treatment and very few were taken from the check treatment at site two. Total marketable yields remained low, 1.5 and 36% RY, with each zero-P treatment. Leaf-tissue P concentrations reflected deficient and near deficient levels with check treatments at both sites (Hochmuth et al., 1993b).

Two pot-cultured watermelon crops in Quincy were designed to test P availability when lime was applied one month before or after application of DAP (fall 1992) and test availability of residual P the following spring (Rhoads and Olson, 1994). Pots contained 2 kg of Norfolk loamy sand (Ap horizon) with less than 5 ppm (very low) M-1 soil-extracted P. Fertilizer was applied per kg of soil at the following rates: 128 mg N from NH_4NO_3, 300 mg K_2O from K_2SO_4, 90 or 180 mg P_2O_5 from CSP and DAP, and 1 g lime from CaO, which was applied either four weeks before or after P application (fall 1992). Nitrogen alone was applied for the spring planting. Soil water levels approached field capacity by addition of 100 ml tap water when the soil surface dried. A check treatment for each season omitted P and lime applications.

Phosphorus availability was 26% greater with CSP than DAP when lime was applied four weeks before P. Lower overall P availability occurred with both sources when lime was applied after P with 18% more available P from CSP than DAP in the first season. The highest P uptake value was taken as 100% for each season, and all other P uptake responses were calculated as a percent of that maximum. First-season P uptake was greater with CSP, 36%, than DAP, 19%, as P rate increased from 90 to 180 mg/kg, but P uptake equilibrated in the second season, (34% and 31% for CSP and DAP respectively). On acidic soils, CSP was more effective as a P source, but either source performed well in residual tests on soils limed several weeks prior to soil sampling.

Phosphorus Summary

The maximum University of Florida IFAS recommended P rate of 150 lb/acre P_2O_5 for very low P soils is indicated in Fig. 3 by the dashed line. This rate recommendation was identified by a predominance of optimum yield responses at or below this rate. Standardized IFAS recommendations for P application were adjusted downward from the 1989 recommendation of 160 lb/acre P_2O_5 for soils very low in M-1 P to the 150 lb/acre P_2O_5 rate. Recommended rates for low and medium M-1 soil P concentrations were also adjusted downward from 160 and 100 lb/acre P_2O_5 to 120 and 80 lb/acre P_2O_5, respectively. Yield response differed from the recommended rate in Gainesville and Immokalee, where acidic soils low in water extracted P increased the demand for this nutrient (Locascio et al., 1968). Yield response was similar with SP and CSP sources though DAP used on acidic soils raised pH and reduced yields. Second-season planting responded equally to DAP or CSP when lime was applied in the previous planting season. Band or broadcast placement of P had little effect on watermelon yields or tissue P concentrations when half of the N and K was broadcast preplant. Broadcasting all of the N and K preplant increased absorption of banded P in one study, but did not increase yields.

Potassium

Overhead Irrigation

Watermelon yield responses to K fertilizer at M-1 based recommendations were tested in Dunnellon, 1988 (Hanlon and Hochmuth, 1992; Hochmuth and Hanlon, 1988; Hochmuth et al., 1993a). Watermelon crops were fertilized with 120 lb/acre N (NH_4NO_3), three rates of P_2O_5 (CSP), and five rates of K_2O from a mixture of KCl and K_2SO_4. Mixed fertilizers were broadcast/incorporated in the bed area followed by mulching with black polyethylene and planting of Crimson Sweet watermelon transplants. Beds were spaced 8 feet on center. Soils in Dunnellon tested very low (10 ppm) for M-1 soil-extracted K. Total yields increased linearly from zero through the 150 lb/acre K_2O recommended rate (91% RY) and peaked with 200 lb/acre K_2O, (329 cwt/acre, 100% RY) exceeding the state average of 170 cwt/acre for 1988.

Yield benefits and reduced nutrient leaching from controlled-release (CR) fertilizer sources tested on other vegetables prompted a Live Oak watermelon trial with CR fertilizers in spring 1993 (Hochmuth and Hochmuth, 1994). Yield responses were

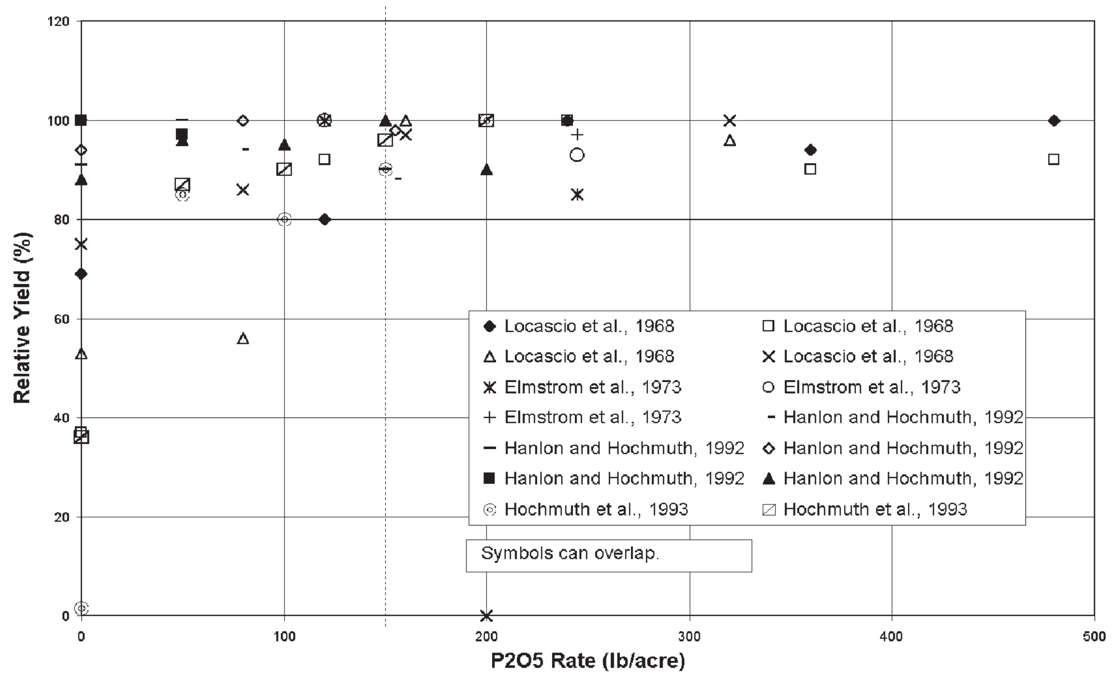

Figure 3. Relative yield of watermelon for experiments, years, and seasons as a function of added P_2O5.

compared from the following fertilizer sources; all soluble N and K, half CRN with soluble K, and half CR - N and K (50/50). Potassium was applied at 100 or 150 lb/acre K_2O as one preplant application or three split applications. Preplant fertilizers including 150 lb/acre N were broadcast/incorporated, fields were mulched with clear polyethylene only during fumigation week (then removed), and Royal Sweet watermelons were transplanted. Beds were spaced on 7.5-foot centers and fertilizer rates were calculated based on an 8-foot bed center. Overhead irrigation was used to maintain soil moisture at -10 centibars.

Soil used for these studies tested medium (52 ppm) for M-1 soil-extracted K, and 80 lb/acre K_2O were recommended (Hochmuth and Hochmuth, 1994). Yields averaged over CR treatments and two application methods responded similarly to 100 or 150 lb/acre K_2O producing 99 and 100% RYs (322 cwt/acre), respectively. Preplant applications of CR (50/50) fertilizer increased yields 18% (340 cwt/acre) over preplant soluble sources (278 cwt/acre), but three split applications of CR (50/50) decreased yields 6% (329 cwt/acre) over split applications of soluble sources (350 cwt/acre). Comparable yields (340 and 350 cwt/acre) were obtained with soluble sources applied in split applications or with CR (50/50) fertilizers applied entirely preplant. Leaf tissue K concentrations were adequate with all rates and placement schedules at early-runner-stage.

Subsurface Irrigation

Varying amounts of N and K fertilizer were evaluated for their effect on 'hollowheart' incidence using two watermelon cultivars at the Gulf Coast Research and Education Center, Bradenton, spring 1995 (Maynard, 1995). Yield responses to 180 and 360 lb/acre K_2O were similar and therefore yields were plotted in Fig. 2 as a response to added N.

The effect of varying N and K rates on the incidence of hollowheart, a condition where the rind grows faster than the inner tissue causing an internal cavity, was tested on cultivars chosen for their tendency to resist hollowheart (Maynard, 1995). Higher N and K_2O rates decreased hollowheart incidence 40 and 44% (130 - 320 lb/acre N and 180 - 360 lb/acre K_2O, respectively) in Jack of Hearts which was prone to hollowheart. The same fertilizer increases however, had no effect on hollowheart incidence in Sangria , the watermelon with hollowheart tolerance. The author reasoned that results were inconclusive and recommended additional research. Elsewhere, researchers observed that hollowheart onset occurs more frequently in fruit set on the seventh to eighth node (crown-set fruit) than fruit set on the twentieth node (lateral-set fruit), that some cultivars are more susceptible than others, and that seedless varieties are more susceptible than seeded varieties (Kano, 1993). The effects of fertilizer, water management, and environmental factors on the incidence of hollowheart are as yet unknown. Previous work with drip irrigation concluded that incidence of hollowheart was not significantly affected by increasing water levels; 4, 7, and 12 inches applied seasonally by drip irrigation to five watermelon varieties (Clark and Maynard, 1994; Maynard and Clark, 1993).

Drip Irrigation

Varying K rates were broadcast and incorporated on fields in Macclenny and Live Oak in 1988 to evaluate yield response to M-1 based K recommendations (Hanlon and Hochmuth, 1992; Hochmuth and Hanlon, 1988; Hochmuth et al., 1993a). Soils were fertilized with 120 lb/acre N (NH_4NO_3), five P_2O_5 rates (CSP), and four K_2O rates (mixture of KCl and K_2SO_4) before being mulched with black polyethylene.

Macclenny soils tested very low in M-1 soil-extracted K (6 ppm) and 150 lb/acre K_2O were recommended. Potassium rates were calculated on 8-foot bed centers for both locations with beds spaced on 12-foot centers at Macclenny and 7.5-foot centers at Live Oak. Peak yield response occurred with 70 lb/acre K_2O (411 cwt/acre, 100% RY) based on an 8-foot bed center. Early fruit set leaf K concentrations did not differ with increasing K rates. Tissue K concentrations averaged 2.0%, which was below the adequate range (2.3 to 3.5%), despite yields above the state average, 170 cwt/acre. Soils in Live Oak tested medium (38 ppm) in M-1 soil-extracted K, and 80 lb/acre K_2O were recommended. High yield occurred with 100 lb/acre K_2O (512 cwt/acre, 100% RY) and lower yields resulted with 50 lb/acre K_2O (91% RY). Leaf K concentrations increased linearly within the adequate range at Live Oak.

Soil from the upper six inches at the Suwannee Valley Agricultural Research and Education Center, Live Oak, was medium (45 ppm) for M-1 soil-extracted K, and 80 lb/acre K_2O were recommended (Hochmuth et al., 1994). Fertilizers were mixed, broadcast three feet across the row, and incorporated at experimental rates: 0, 50, 100, and 150 lb/acre K_2O (KCl) and 0, 60, 120, and 180 lb/acre N (NH_4NO_3). Beds, spaced 7.5-feet on center, were mulched with black polyethylene and drip irrigated to maintain -10 centibar tensiometer readings. 'Royal Sweet' watermelon transplants were set out on March 29, 1993.

Early harvest yields peaked with 100 lb/acre K_2O, (371 cwt/acre, 100% RY), but total season yields were not significantly affected by K rates from zero to 150 lb/acre K_2O. Although yields were not greatly different, a slight total yield increase occurred with 100 lb/acre K_2O (472 cwt/acre, 100% RY). Leaf tissue K concentrations were adequate through the first fruit stage with all K rates, but deficient with all K rates two weeks before harvest. Yields higher than the state average of 230 cwt/acre, did not appear affected by reduced leaf tissue K concentrations late in the season. Petiole K concentrations generally were 10 to 20% lower than the recommended range though levels increased uniformly with increasing K rates until preharvest sampling. As with leaf tissue K concentrations, petiole sap K levels fell late in the season, but only with the 0 and 50 lb/acre K_2O rates.

Soluble N and K sources, NH_4NO_3 and KNO_3, were supplemented with 0, 25, and 50% CR sources (polymer coated KNO_3 and urea), at Suwannee Valley Research and Education Center near Live Oak in spring 1994 (Hochmuth and Hochmuth, 1995). Beds were spaced on 7.5-foot centers and fertilizers were calculated based on 8-foot bed centers. Nitrogen at 150 lb/acre was mixed with other fertilizers, broadcast 30 inches across the bed area and rototilled. Fields were mulched with black polyethylene and tensiometers were used to guide irrigation to maintain soil moisture at -8 to -10 centibars.

Potassium fertilizer from either all soluble or soluble plus 25 or 50% CR - K sources had no effect on total marketable watermelon yield or fruit size. Current M-1 interpretations recommend 120 lb/acre K_2O for soils testing low (23 ppm) in K, but K_2O

applications of 50 lb/acre produced the same yields as those with the 150 lb/acre treatment. Yields averaged over all K sources for each rate were highest with 150 lb/acre K_2O (452 cwt/acre, 100% RY) and slightly lower with 100 and zero lb/acre K_2O (96% and 88% RY, respectively). Leaf K concentrations were deficient only with the check treatment at first flower, 2.5% (2.7 to 3.5 % is adequate), although yields with this treatment surpassed the state average of 230 cwt/acre with production of 378 cwt/acre of fruit.

Research continued in the spring of 1994 at the Suwannee Valley Research and Education Center with an evaluation of M-1 based K recommendations and calibration of petiole sap testing data (Hochmuth and Hochmuth, 1996). Potassium from KCl was applied in rates of 0, 50, 100, and 150 lb/acre K_2O with 150 lb/acre N from NH_4NO_3. Fertilizers were blended, broadcast 30 inches across the bed and rototilled. Beds were spaced on 7.5-foot centers with fertilizer rates calculated on an 8-foot bed spacing. Beds were mulched with black polyethylene and drip irrigated to maintain soil moisture tension at -8 to -10 centibars.

Based on a very low (18 ppm) M-1 soil-test result at this site, 150 lb/acre K_2O was recommended. Total season marketable yield was maximized with 100 lb/acre K_2O, (442 cwt/acre, 100% RY), in a quadratic response to applied K. With 150 lb/acre, yield was reduced to 96% RY. Petiole sap K concentrations however, were near the recommended range only with 150 lb/acre K_2O. Researchers concluded that current petiole sap sufficiency ranges were appropriate for samples taken early in the season, but were high for samples taken late in the season. Whole leaf K concentrations were adequate with all low K rates until harvest when 150 lb/acre K_2O was needed to ensure adequate K.

Watermelon yields responded positively to K rates 30 to 50% below the recommended rate or responded similarly to K rates above and below the recommended rate in the above drip-irrigated trials. Broadcast and incorporation of fertilizers preplant, as done in these studies, may have enhanced yield response. Banded-K fertilizers reduced yield response by 7 to 10% in Leesburg experiments (Elmstrom et al., 1973b). Soils analyzed for nutrient and soluble salt (SS) concentrations using saturated soil extract found soil SS concentrations increased 25% and 60% in 1969 and 1970, respectively with band versus broadcast treatments. Researchers cited early fertilizer burn and later K leaching losses, due to limited soil contact with the banded fertilizer, as factors in reduced yield response to banded fertilizers.

Blossom-End Rot

A significant inverse relationship occurred between the rate of applied K and Ca tissue concentration measured at early runner stage (Elmstrom et al., 1973b). Ca tissue concentrations decreased 10 to 25% with a K_2O rate increase from 120 to 240 lb/acre (beds were 2-row plots 20 x 24 feet). The antagonistic effect of K on Ca absorption, however, did not increase the incidence of blossom-end rot in watermelon. Conversely, when the incidence of blossom-end rot was high, 45%; tissue Ca levels were also high, 1.46%. Researchers suspect other nutrients or environmental factors increased blossom-end rot incidence.

Potassium Summary

Watermelon yields generally responded to K at or near the recommended K rate based on M-1 soil test analysis for each site. Potassium rates were adjusted upward from 1989 recommendations of 120 to 150 lb/acre K_2O (1995) for very low K soils and from 100 to 120 lb/acre K_2O (1995) for low K soils. Experiments that received drip-irrigation and broadcast applied fertilizers generally responded well below the higher 1995 rate. The dashed line in Fig. 4 indicates the maximum K rate recommended for soils testing very low in M-1 extracted K. When yields required more or less than the recommended K rate, dry soil conditions often increased demand for K, or broadcast/incorporated K fertilizer was more efficiently utilized by watermelon as with the above drip-irrigated studies. Preplant broadcast/incorporated application of 50/50, CR with soluble K sources, and overhead irrigation improved yields 18% over preplant soluble K. Soluble K sources resulted in the best yields when applied in three equal applications through the crop growth cycle. When soluble K was band-applied annually, soil soluble salt concentrations increased resulting in fertilizer burn of young watermelon plants. Variable yield responses to M-1 based K application reflects the mobility of this nutrient in sandy soils. Deeper soil sampling was suggested to assess K levels at depths easily reached by watermelon roots.

recommendation, and coated fertilizers. Effective improvements in cultural practices were also reflected in these increased yields including reduction of weed competition with polyethylene mulch, pasture grass rotations to reduce nematode

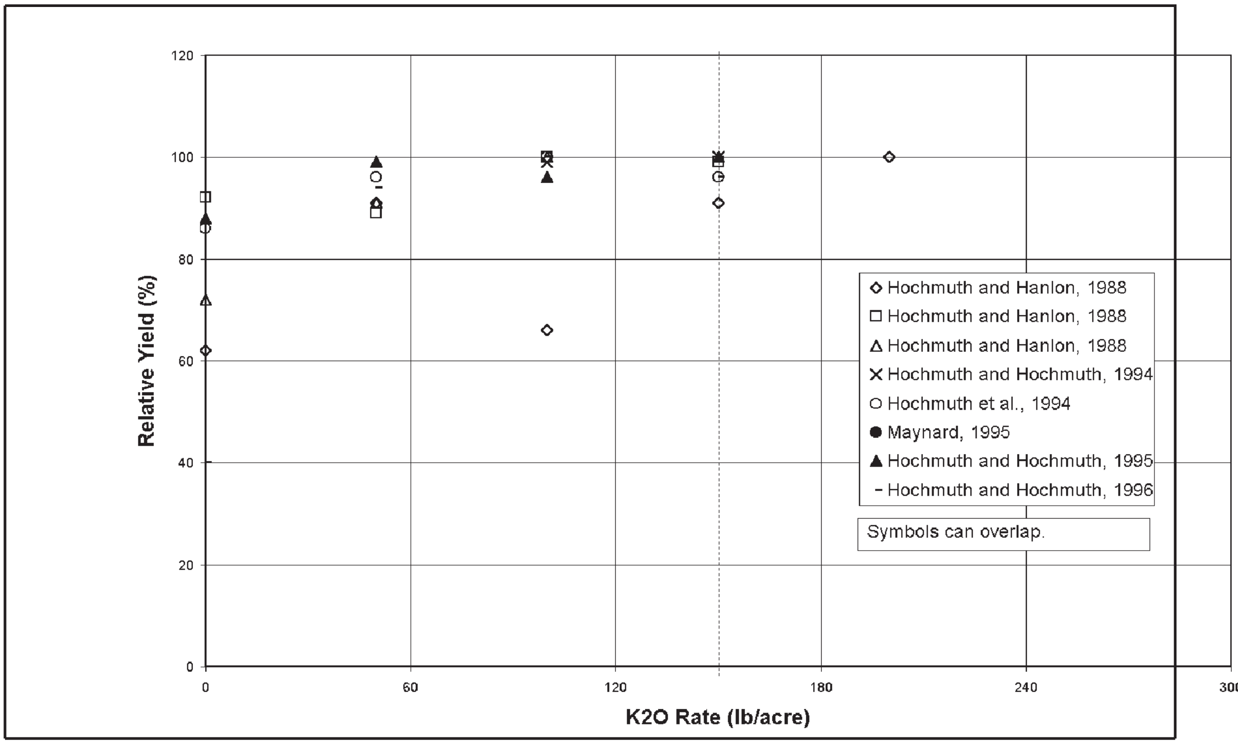

Figure 4. Relative yield of watermelon for experiments, years, and seasons as a function of added K_2O.

populations, effective herbicide use, drip irrigation, and fertigation (Maynard, 1990). Studies are needed on optimal timing of N application with drip irrigation systems and on the fate of N in the soil system as it relates to N and irrigation management. Large-scale demonstrations on commercial farms of recommended nutrient management programs are also needed. Additional research is needed with CR-N and K fertilizer sources to develop single application fertilizers effective in watermelon production. Limited research has been done with K fertilization of watermelon. Drip-irrigated trials dominate the research with yield responses to lower K rates than currently recommended.

Summary

Based on rail and truck deliveries of watermelons to major cities in the United States from October 1995 through June 1996, 30% of the marketed watermelons in the U.S. were grown in Florida (Fla. Dept. of Agr. and Cons. Serv., 1997). Efficiency of watermelon production has increased over the past thirty-five years. Watermelons grown in Florida in 1960 from 73,000 harvested acres resulted in 115 cwt/acre. In 1995, watermelon yields increased to 210 cwt/acre from 34,000 harvested acres, nearly twice the yield on half of the acreage. A similar trend was calculated from nine other watermelon producing states (Maynard, 1990). Without state fertilizer-use surveys before 1990 the importance of changes in plant nutrition cannot be quantified. Yield increases likely resulted from a combination of improvements including plant nutrition factors such as fertilizer placement, micronutrient application, lime applied according to

Research results summarized in this report document the current IFAS N, P, and K recommendations for watermelon. The N recommendation of 150 lb/acre N was most clearly supported by the research. While current P and K recommendations appear to be on target, more research is needed to more fully clarify watermelon responses to P and K fertilization.

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