from tolerant to susceptible or very susceptible (2, 7, 15). A program of routine screening of all plant selections for ozone tolerance will insure resistant varieties of horticultural crops for the future.

LITERATURE CITED


BALANCED FERTILIZATION OF VEGETABLE CROPS THROUGH COMPUTERIZED INTENSITY AND BALANCE SOIL TESTING

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Sanford

JAMES NÉSMITH

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Gainesville

ABSTRACT

Field application of the "Intensity and Balance method" of soil testing was made by Seminole County Extension Agent to a number of vegetable crops, including cabbage, carrots, celery, corn, parsley, peppers, and watercress.

The "Intensity and Balance" program has proved to be an excellent tool for nutritional diagnostic work. Through a systematic field sampling and analytical testing program design to approach optimum or balanced fertilization, increased production, improved quality and reduced production costs were evident.

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Electronic processing of data is utilized and the computerization program is explained as to content, development and use with growers as an educational aid. A progress report on the four developmental phases is given.

INTRODUCTION

In the Sanford-Oviedo area, most vegetable fields are sub-irrigated by artesian well water through tile placed above a hardpan. This cultural system is not without its problems, foremost of which is the accumulation of soluble salts from both fertilizers and well water sources as reported by Westgate (14) as early as 1950.

Throughout the years, Florida vegetable growers have utilized various methods of soil testing on which to base fertilizer recommendations.

Westgate determined total soluble salts by electrical conductivity in a solution of one volume of soil plus two volumes of distilled water. This method of measuring total soluble salts has been a useful and popular tool by growers to determine soluble salt accumulations and as an indication of fertility levels.
As a means of determining total soluble salt levels, this method was fast and relatively accurately accurate. However, as a tool for determining fertility levels, the test could be misleading, since it was possible that the soluble salts being measured could be high in non-nutrient salts.

In 1955 Geraldson (4) proposed another method of testing which utilized a saturation extract obtained by vacuum filtration of a soil paste. This method essentially measures the nutrient level of soil solution and would more closely approximate field conditions. In subsequent papers, Geraldson (5) (6) (7) (8) refined the procedures and conducted correlation studies in association with plant growth. Geraldson called this soil test procedure, "Intensity and Balance." The "intensity" portion related to the concentration of the total soluble salts in the saturation extract measured by electrical conductivity. The "balance" referred to the proportionate amount of each nutrient and other soluble salts present.

As early as 1959, County Extension agents were encouraged by Montelaro, Marvel and Jamison (11) to use the "intensity" or total soluble salts measurements of a 2:1 soil-water mixture as a guide for fertilization and evaluation of soluble salt levels. It was suggested this be utilized on a trial or demonstration-type basis.

Montelaro, NeSmith and Geraldson (12) in 1964 revised the original program and suggested two changes: (a) Intensity should be determined through a saturation extract (ESe) rather than through a 2:1 water:soil mixture as a guide for fertilization and evaluation of soluble salt levels. It was suggested this be utilized on a trial or demonstration-type basis.

Methods and Procedure

Procedure for sampling in the field is described by Montelaro (12), Geraldson (6), and Jorgensen (9). The sample, to be useful for this test, must come from the effective root zone, taking care not to remove soil cores from freshly applied fertilized bands.

The practice followed was the taking of three cores across the row on at least five different randomized rows and proceeding diagonally across each block or field to be sampled. The accumulation of 15 composite cores gives a representative sample.

As the crop matures, the cores across the "effective root zone" area are increased to five. In each case, one core is taken from the center of the row. During one demonstration, a soil sampling tube designed to take 3 cores at a time across the row was utilized. When the crop was relatively small, the center probe of the 3-pronged soil tube made the center core in the row.

As the root zone area increased, the sampled area was likewise increased by placing one of the outside probes on the center of the row. After retrieving these three cores, the other side of the row was sampled by placing the other outside probe into the center hole previously made. Thus five cores are taken across the row area. Figure 1.

General laboratory procedures for preparation of the soil sample for I & B vacuum filtration and ultimately analysis have been described by Geraldson (6), Jorgensen (9), and Montelaro (11) (12). Other procedures have been developed in the Seminole County Extension soils laboratory.

Calcium, sodium, and potassium were determined with the use of the flame photometer; nitrate-nitrogen and magnesium by colorimetric
procedures read on the colorimeter; and chlorides were determined by a titration method. For the most part, the lab procedures used are reported in the Florida Agricultural Extension Service Soils Laboratory manual (2) and by Llewellyn (10) in the Dade County Extension soils laboratory manual.

The I & B determinations require considerable calculations, the details of which are reported by Montelaro (11) (12) and Geraldson (4) (6). The Seminole County Extension Soils Lab manual likewise gives detailed description of each calculation.

All results are reported in parts per million in soil solution. In general, each nutrient or element determined (NO₃-N, K, Ca, Mg, Na, Cl) is calculated as the relationship or ratio of these individual ions to the total concentration or intensity.

Experience in the Seminole County lab has shown that the calculations require as much as a third of the total time spent in processing a sample.

Shortage of laboratory and clerical personnel plus the time required in calculation of the I & B program led to a search for more effi-
cient means of performing these operations. It was reasoned that since so much of the program dealt primarily with mathematical manipulations, these calculations might well be done through electronic means.

Further study and analysis of the program revealed that perhaps the I & B program in its entirety might well lend itself to "computerization."

A plan for computerization of the I & B program was presented by Tucker (13). This was reviewed by NeSmith, Llewellyn and Tucker, and with the assistance of Brad Bradley, a computer programmer, implementation was initiated.

The program is being computerized in four developmental phases.

**Phase I** sets up a programming framework whereby all computations, instrument factors, and dilution factors for each of the various I & B determinations are processed by the computer. This phase, for the most part, is merely putting in the raw laboratory analytical data for basic calculations, with the end product being that type of information which previously had been hand calculated. Recommendations to the grower were based on these calculations.

**Phase II** goes deeper into the computer programming potential with optimum levels being set for each crop grown and for each of the laboratory nutrient determinations made; namely, ECe, NO₃-N, K, Mg, and Ca. The computer was programmed so that the print-out sheet showed low, optimum, and high for each of the above determinations expressed in both parts per million and as the percent of the total soluble salt concentrations. (Figure 2).

Geraldson (8) found the most desirable ratio of nutrient to total soluble salt concentration to be 3 - 10% nitrate nitrogen, 10% potassium and about 15% calcium. Since calcium to magnesium

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<td>K/MG</td>
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<td>K/MG</td>
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<td>80.0</td>
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<td>CA/MG</td>
<td>K/MG</td>
<td>CRIT</td>
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<td>4900.0</td>
<td>368.0</td>
<td>80.0</td>
<td>478.0</td>
<td>292.0</td>
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<td>HIGH</td>
<td>MED</td>
<td>MED</td>
<td>LOW</td>
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Figure 2.—A sample print-out or data sheet from the computerized intensity and balance program.
ratio was suggested to be maintained from 5:1 to 3:1, the corresponding levels percentage-wise would be 3 - 5% magnesium.

Using these levels as the median point, upper and lower levels were established for computer programming. As long as the levels remained within this suggested range, the computer printed medium or optimum. Conversely, values above or below this range were printed out as high or low respectively on the computer sheet.

In the computerized program, the optimum levels for nitrate nitrogen were set at 4.5 - 7.5%, 7.5 - 12.5% for potassium, 12.5 - 17.5% for calcium and 3.0 - 5.0% for magnesium.

Optimum levels for each crop grown also were established for intensity or total soluble salt concentration. Some of these levels are under re-evaluation and adjustment.

Excess or critical levels for ESe, Na and Cl also were set (1) (11) and the computer was likewise programmed so that these determinations were "flagged" to print out "excess" or "critical" as these levels were reached.

Ratios of calcium to magnesium and potassium to magnesium are computed and also shown on the print-out sheet.

These ratios, as well as the conditions of low, optimum, high, and excess, are bonus data that we have found to be quite useful in the Extension program with the growers. Before computerization of the I & B program, it was practical time-wise, to hand calculate only the ratio of nutrient to the total soluble salt concentration expressed as percent.

One of the most important procedural steps in the I & B program, especially on old vegetable fields, is the determination of phosphorus and copper levels. These levels, along with pH and the amount of calcium and magnesium present, are determined through an ammonium acetate analysis prior to the crop season and adjusted as necessary.

In the routine I & B program, NH₄-N in soil solution was not determined in view of Geraldson's experience (personal communication) that under most growing conditions, NH₄-N level was quite low, usually less than 1% of the ECe.

RESULTS AND DISCUSSION

The Intensity and Balance method of soil testing appears at present to have potential for application to a wide variety of crops, especially the more intensive, faster growing crops grown on sandy, or sand-organic soils under a constant and relatively high moisture level. Areas with sub-surface or seepage irrigation are readily adapted to the I & B program.

Application of the program also has been made with promising results to crops on organic soils, but to be conclusive, more experience and data are needed.

In the extensive use of the I & B program during the past two years by Seminole Extension agents, increased production has been observed as well as improved quality and reduced costs in the fertilization program. Since this work was conducted with individual growers, much of the production and cost data is privileged information.

With vegetable crops, at least two growers have reported increased production of as much as 25 - 30% with less fertilizer, and at half the fertilizer cost from previous years. The grower response in the ornamental foliage I & B program has likewise been favorable with a reported shorter production time per crop.

Records were made available from two of the demonstration farms and these data are shown in tables 1 and 2.

Weather conditions in the 1966-67 and the 1967-68 season played a major role in the fertilization program and subsequent production. Soluble salt accumulation during the extended drought in the 1967-68 season caused severe root damage. Under growers' normal practices, this damage would have been accentuated since more fertilizer would have been added to the already excessive soluble salts. During this period, total soluble salts of the solution extract (ECe) were over 7,000 PPM with sodium/ECe percent going over 18% and chlorine/ECe ratio as much as 24%.

Despite the adverse conditions in the 1967-68 year, an average of 771 crates of celery was produced as compared to the four year average of 524. Cabbage yield in the same period increased from 434 crates to 645.

It should be emphasized that this data is useful for trend analysis only. It was not a replicated experiment, but more of a demonstration-type project. No doubt some of the change noted can be attributed to good cultural practices and changes brought about by the farm managers.

While production was increased with a certainty, the factors directly attributed to the I & B program are a reduction in total poundage
Table 1. Yield, fertilizer usage and cost data from an I & B demonstration celery farm, Sanford, Florida.

<table>
<thead>
<tr>
<th>CELERY</th>
<th>1964-65</th>
<th>1966-67</th>
<th>1967-68</th>
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<tr>
<td>Yield, crates/acre</td>
<td>735*</td>
<td>804*</td>
<td>771*</td>
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<tr>
<td>Total lbs. fertilizer applied/acre</td>
<td>5224</td>
<td>4395</td>
<td>2537</td>
</tr>
<tr>
<td>Lbs. N applied/acre</td>
<td>337</td>
<td>325</td>
<td>268</td>
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<tr>
<td>Lbs. K applied/acre</td>
<td>373</td>
<td>352</td>
<td>229</td>
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<tr>
<td>Total fertilizer cost/acre</td>
<td>$129.20</td>
<td>$107.76</td>
<td>$62.04</td>
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*A 4-year (1963-66) average yield was 524 crates/acre.

of fertilizer used as well as a reduction in N and K with an accompanying reduction in cost per acre.

As the computerized program came more and more into use, needed changes in format and data became evident. The printing-out of the conditions of low, optimum, and high on the parts per million of each element was suggested after it became evident that the extremely high and extremely low total soluble salt levels (ECe) often showed confusing percentages to the grower. With a low ECe reading, the ECe/NO₃-N ratio might well show a high percentage of NO₃-N present, when, in fact, the NO₃-N level was low. The opposite of this situation, a high ECe, could show a low NO₃-N percent in the ECe/NO₃-N ratio.

In the first case nitrogen should be added. In the second case, nitrogen should be or perhaps should not be added, depending upon other conditions present.

Phase III is the area of computerization of the I & B program in which we presently are working. Phases I and II have been completed and field tested.

Phase III would take the information received in Phase I and Phase II and combine it with pre-determined alternatives to print-out the recommended fertilizer analysis, fertilizer ingredients and the amount of fertilizer needed to fit the particular situation of each sample.

In its simplest form, this phase is merely recording the data and following the mental steps taken when a lab sample sheet is viewed and a recommendation given to the grower.

To formulate such a recommendation our memory is called upon for certain background
Table 2. Yield, fertilizer usage and cost data from an I & B demonstration cabbage farm, Sanford, Florida.

<table>
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<tr>
<th>CABBAGE</th>
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<tbody>
<tr>
<td>Yield, crates/acre</td>
<td>354*</td>
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<tr>
<td>Total lbs. fertilizer applied/acre</td>
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<tr>
<td>Lbs. N applied/acre</td>
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<tr>
<td>Lbs. K applied/acre</td>
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<td>Total fertilizer cost/acre</td>
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<td>$44.53</td>
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</table>

*A 4-year (1963-66) average yield was 434 crates/acre.

In summary, the computerized I & B program has proved to be an effective educational devise for use with growers. As phases III and IV are completed, the effectiveness of the program will be greatly enhanced.

Acknowledgments

For their participation, cooperation and assistance, grateful appreciation is expressed to Dr. Will E. Waters, Head Ridge Ornamental Horticultural Laboratory, Apopka; Brad Bradley, Computer Programmer, University of Florida, Gainesville; and Chase and Company, Sanford.

REFERENCES

INFLUENCE OF LIGHT INTENSITY AND PHOTOSYNTHATE EXPORT FROM LEAVES ON PHYSIOLOGICAL LEAF ROLL OF TOMATOES

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Gulf Coast Experiment Station
Bradenton

ABSTRACT

The removal of young vegetative shoots and fruit hands from 'Floradel' tomato plants caused a rapid and severe increase in physiological leaf roll. The disorder began at the bottom of the plants and progressed upward. Shading 'Floradel' plants with saran screen (25, 50 and 75% shade) decreased the incidence and severity of leaf roll which was largely prevented by 50 and 75% shade. Sugar and starch were determined in the lower leaves and were found to be generally correlated with the degree of leaf rolling. It is hypothesized that starch accumulation in lower leaves may be the basic cause of physiological leaf roll. Potential causes of starch accumulation are listed.

INTRODUCTION

Tomato plants growing under normal culture frequently have a characteristic leaf roll varying from mild to severe. Lower leaves are first to roll, followed by a gradual development of leaf roll toward the top of the plant. Margins of leaves roll upward and inward. In mild cases, leaves become trough shaped, while in severe cases the leaf may form a tight spindle. The severity of leaf roll varies with climatic conditions, cultural practices and varieties. When leaf roll is severe, fruits are exposed to full sunlight which may result in the development of disorders such as sun scald. An excessive tendency toward the disorder may result in the discarding of a breeding line or in the lack of acceptance of a tomato variety in the areas where leaf roll is severe.

There are reports in the literature relative to the virus-caused leaf roll of potato (1,2,6,9,10) which indicate that the basic cause of the rolling which is similar in appearance to that in tomato, is basically due to a failure to export photosynthate followed by deposition of excess starch and morphological changes resulting in the characteristic leaf roll. Bremer (4) has described several types of tomato leaf roll, some of which are reversible. Nutritional relationships have been implicated (7,8) in potato and tomato leaf roll wherein the leaf roll is accentuated by conditions favoring nitrogen uptake in the form of the ammonium ion and conversely decreased when the nitrate ion constitutes a significant portion of the nitrogen supply. Preliminary studies (11) in Florida indicated that high light intensity, heavy pruning and poor fruit set or