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NUTRITIONAL SURVEY OF THE EVERGLADES VEGETABLE INDUSTRY[1]

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Abstract. **During the 1982-83 winter vegetable season, over 400 samples were collected from commercial growers' fields of celery (*Apium graveolens* L. var. *dulce* [Mill.] Pers.), head lettuce (*Lactuca sativa* L.) and radishes (*Raphanus sativus* L.) in the Everglades. Measurements included plant dry matter, total nutrient concentrations in leaf tissue, extractable nutrient concentrations in conductive tissue, and soil tests for pH, P, and K. Results considering environment-limited growth and the effects of soil tests on tissue nutrient contents indicate that previous diagnostic tissue and soil test levels may be unnecessarily high. The most widespread nutritional problem identified was the ubiquitous high soil pH (>6.3), which indicates continued need for research on pH management.**

Nutritional surveys in which crops in a particular area are intensively sampled for tissue analysis and corresponding soil tests have proven useful in several crops (9). These surveys are often intended to identify problem areas in crop fertility management and can indicate needs for additional research or educational efforts. Even when no problems are identified, surveys can help define the "normal" conditions for crop growth in a particular area. Such an approach is also useful in acquiring the large data sets required to define norms used in the Diagnosis and Recommendation Integrated System (DRIS) approach to crop nutritional diagnosis (6). Finally, when soil, crop, or environmental conditions in one area vary drastically from areas where diagnostic criteria have been derived, a survey can identify needed adjustments in the diagnostic norms used.

For many of the reasons above, a nutritional survey of the Everglades vegetable industry was conducted during the 1982-83 crop season. One objective was to define the "normal" nutrient concentrations in plant tissue and soils in order to derive DRIS norms, and to identify potential nutrient deficiencies or excesses. Because the nutrient supplying power of organic soils varies drastically from that of mineral soils, locally-derived tissue norms (2) are often much higher than norms or diagnostic criteria derived elsewhere (5). The form of nutrients analyzed as diagnostic (e.g., total amounts in leaf lamina versus soluble forms in conductive tissue) often varies by area or the preference of a particular worker; a comparison of these values under local conditions was desired. Finally, the growth rate of vegetables is very important (7), and should vary not only by nutritional effects, but with environmental conditions, as well. Therefore, an additional objective of this survey was to investigate the effects of environment on crop growth rates, and to evaluate growth rate as a diagnostic measure in vegetable production management.

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Materials and Methods

For this survey, celery, head lettuce, and radishes were chosen. These are 3 of the highest-valued vegetable crops in the Everglades, each worth over $24 million annually (1). Representative samples were collected from commercial growers' fields (Table 1) from October, 1982 to March, 1983. For seedling plants, whole plant tops were sampled. For yarger plants, samples consisted of the youngest mature leaves. For celery and lettuce plants, samples were divided into leaf laminae and corresponding *conductive tissue* (petiole or midrib) samples. Corresponding soil samples as well as whole plant top samples from 1 m of row, were collected at the same time. Soil samples were analyzed for pH, water-soluble P, and weak acid-extractable K by the methods used at the local soil test laboratory (4). Whole top samples were dried (after subsampling, if necessary) to determine dry matter production per m of row. Leaf blade and conductive tissue samples were dried and ground in a Wiley mill. Leaf samples were digested in H_2SO_4 and H_2O_2 (10) and analyzed for N and P colorimetrically and K by atomic absorption spectrophotometry. Petiole samples were shaken in distilled water for 10 min, and the extract analyzed NO_3-N and PO_4-P colorimetrically, and K using the atomic absorption method.

Table 1. Farms sampled in nutritional survey.

A. Duda & Sons, Inc.
Kermit Chapman and Sons, Inc.
Pioneer Farm No. 2
Roth Farms, Inc.
Shelton Land and Cattle Co., Double D. Division
South Bay Growers, Inc., Eastern Division

Results and Discussion

Tissue nutrient concentrations. Mean and CV values for tissue nutrient concentrations by crop and growth stage appear in Table 2. Tissue concentrations were generally uniform, with CV values less than 30%, except for NO_3-N in conductive tissue. In addition, there was little consistent difference for nutrient concentrations due to the stage of growth. The mean values for N, P, and K concentrations in leaf laminae were comparable to or higher than diagnostic values derived from crops grown on mineral soils (5), but were occasionally lower than similar values derived locally on crops grown on Histosols (2). Mean water-soluble N concentrations in conductive tissues were higher than those previously published (2, 5), but water soluble P concentrations were similar to those based on crops from either mineral or organic soils (2, 5). Water-soluble K in conductive tissues was higher than the values expected in crops on mineral soils, especially lettuce (5), but was lower than previously-reported values for celery grown on local Histosols (2, 4).

The high nutrient concentrations, especially water-soluble N in conductive tissues, reflect the large amounts of nutrients released annually by oxidation of the organic soil (8), as well as large fertilizer applications. Because observed lettuce leaf concentrations of N and K are lower than levels proposed by Burdine (2), deficiencies of these nutrients might be suspected. However, the very large concentrations of water-soluble N and K from lettuce midribs precludes that possibility, and suggests that previous diagnostic levels were overestimated.

Table 2. Nutrient concentrations for crops and tissues by age.

Crop	Age[z]		Leaf dry weight (%) N	Leaf dry weight (%) P	Leaf dry weight (%) K	Conductive tissue dry weight (%) NO_3-N	Conductive tissue dry weight (%) PO_4-P	Conductive tissue dry weight (%) K
Celery	0-30	x̄[y]	3.30	0.49	3.34	2.13	0.36	6.98
		CV[x]	20.3	34.7	25.4	83.1	26.2	21.6
	31-60	x̄	4.14	0.53	3.67	3.83	0.49	8.26
		CV	13.3	29.6	17.6	34.1	23.0	10.4
	>60	x̄	3.52	0.41	3.74	2.21	0.38	8.90
		CV	14.5	24.2	18.7	67.7	20.9	16.1
Lettuce	0-25	x̄	3.54	0.53	5.36	3.29	0.52	9.68
		CV	16.2	25.2	13.2	29.9	20.7	18.4
	26-50	x̄	4.06	0.52	5.68	4.14	0.48	10.3
		CV	13.8	16.8	18.5	23.9	30.9	13.8
	>50	x̄	3.69	0.46	6.04	4.31	0.47	10.5
		CV	16.2	23.4	16.4	34.8	27.0	19.6
Radish	0-15	x̄	4.63	0.56	4.29	—	—	—
		CV	28.6	15.7	22.9	—	—	—
	>15	x̄	4.62	0.49	3.97	—	—	—
		CV	15.5	17.7	23.5	—	—	—

[z]Days after transplanting (celery) or sowing (lettuce and radish).
[y]Mean values.
[x]Coefficient of variation (%).

Nutrient diagnostic criteria have traditionally been based on single-point measurements such as final dry matter production. However, vigorous and consistent growth is essential for high quality vegetable production (7). If growth is as rapid as possible under genetic or environmental constraints, then nutritional deficiencies must not exist. Therefore, the lowest nutrient concentrations corresponding to environment-limited growth can be considered sufficient. Based on this reasoning, plant top dry weights were plotted against a measure of cumulative temperature and radiation (KSTU, or Solar Thermal Units X 10^{-3}). Solar-Thermal Units are defined (3) as the cumulative value of daily mean temperature (°F) minus 31 multiplied by daily radiation (Ly). Then, the environment-limited growth was modeled (Fig. 1, 2, 3). Note that the growth curves are intended to represent the "boundary conditions" or maximum potential growth, rather than average growth. Next, a dry weight index (DWI) was calculated as observed dry weight divided by the corresponding environment-limited dry weight, and the natural logs of DWI values were plotted against the respective tissue nutrient concentrations (Fig. 4). By the above reasoning, the lowest nutrient concentration corresponding to a value of ln(DWI) greater than or equal to 0 would be considered sufficient to support the po-

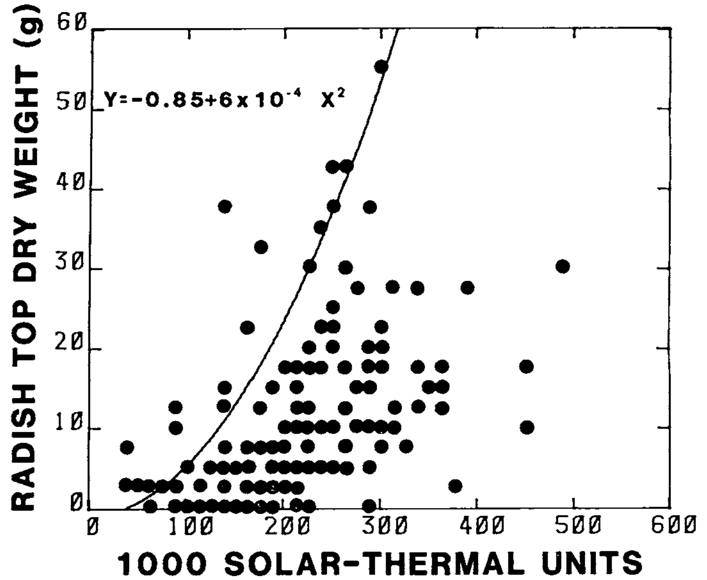

Fig. 2. Radish top dry weight in response to Solar-Thermal Units.

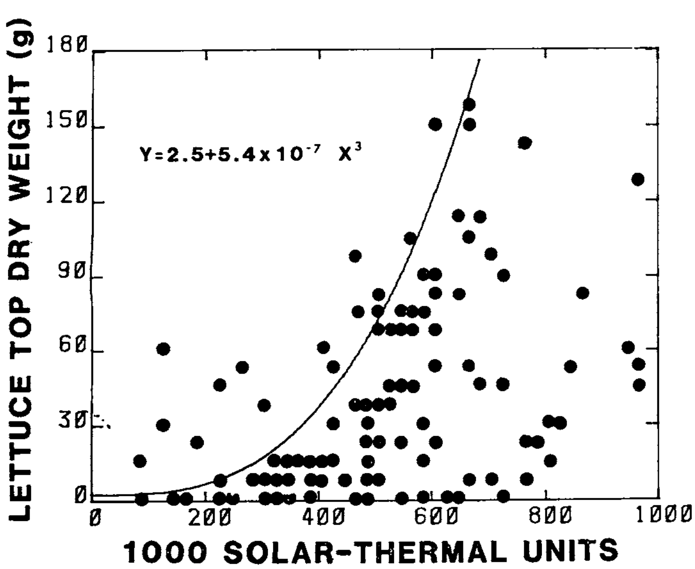

Fig. 1. Lettuce top dry weight in response to Solar-Thermal Units.

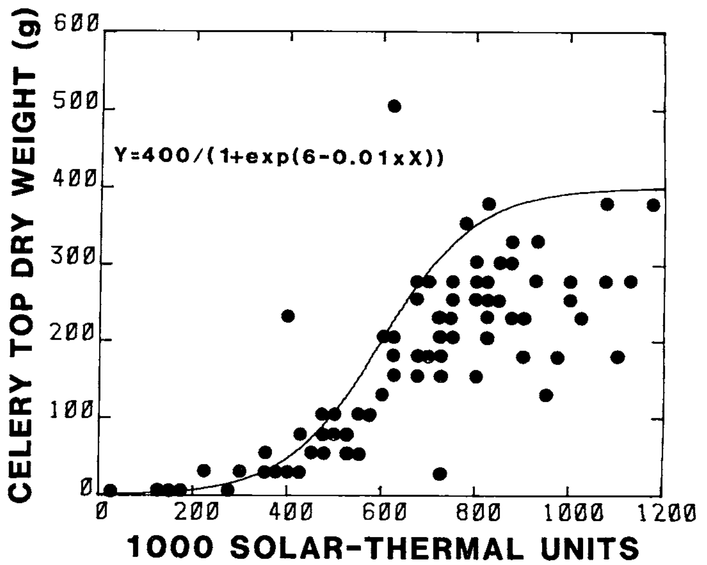

Fig. 3. Celery top dry weight in response to Solar-Thermal Units.

tential growth rate. Lower nutrient concentrations would be limiting, and would correspond to negative ln(DWI) values, or plant growth less than the environmental potential. Using this approach, critical values for nutrient concentrations based on growth rates were derived (Table 3).

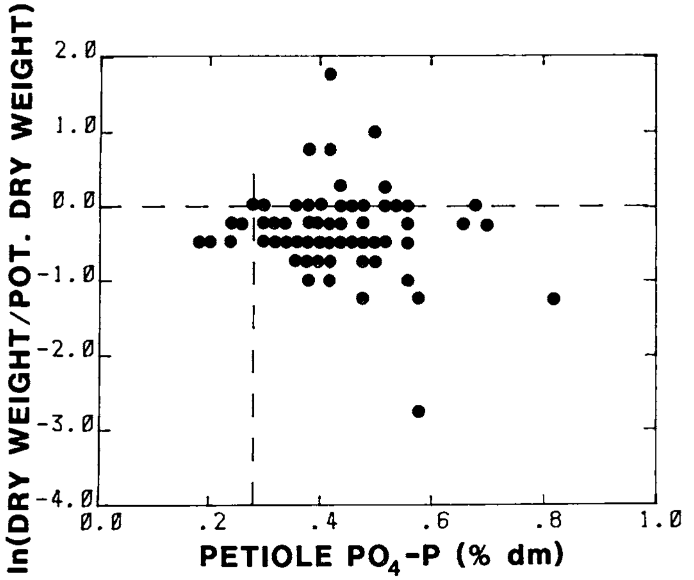

Fig. 4. Celery ln(top dry weight/potential dry weight) in response to petiole PO_4-P concentration.

Table 3. Critical nutrient concentrations based on growth rate analysis. analysis.

Crop	Leaf dry weight (%)			Conductive tissue dry weight (%)		
	N	P	K	NO_3-N	PO_4-P	K
Celery	2.6	0.26	2.2	0.2	0.28	5.4
Lettuce	2.7	0.28	4.8	1.8	0.33	7.3
Radish	3.6	0.36	2.8	—	—	—

Synthesizing the published diagnostic values and mean values for nutrient concentrations, as well as the critical nutrient concentrations required for environment-limited growth in Table 3, has led to the proposed critical tissue nutrient concentrations presented in Table 4. The previous locally-derived diagnostic tissue levels apparently reflected "luxury consumption" associated with high levels of available nutrients. I believe that the levels derived in mineral-soil studies more nearly reflect nutrient-limited growth, and the potential dry weight analysis yields comparable results. The diagnostic values presented in Table 4 should be sufficiently conservative to allow their use in routine tissue analysis interpretation. Higher tissue nutrient concentrations (based on comparable analytical methods) should represent adequate nutritional conditions.

To estimate the incidence of N, P, and K deficiencies in the Everglades vegetable industry, the number of samples for each crop exhibiting nutrient concentrations below the proposed diagnostic levels was determined (Table 4). Both measures of N nutrition identified some N deficiencies in celery, although petiole NO_3-N indicated greater incidence. Neither method showed significant N deficiency in lettuce, but N deficiency was indicated more often than P or K deficiency in radishes. Celery leaf samples were seldom deficient in P, although over 50% of celery petiole samples showed deficient levels of water-soluble P. Both measures of P nutrition showed greater than 20% incidence of P deficiency in lettuce. For both celery and lettuce, leaf K concentrations were often (>30% incidence) below the proposed levels, but water-soluble K in conductive tissue was seldom below the desired levels. Discrepancies between leaf and conductive tissue analyses in the incidence of deficiencies identified can be partly understood based on what the two tests represent. Nutrient concentrations incorporated into leaves are longer-term measures of past nutrient supply, whereas petiole or midrib analysis is a more sensitive measure of the current nutrient supply. Thus, transient reductions in nutrient availability could be reflected in conductive tissue analyses, but not leaf analyses, as with N and P on celery and P on lettuce. Conversely, recent additions of available K following long-term K deficiency could result in K deficiency in leaves, but not petioles, as with celery and lettuce. However, since K deficiency in leaves had very high incidence compared to almost none by petiole analysis, it appears that the proposed critical leaf K concentrations may be too high.

Soil test results. Soil tests provided additional information on the nutritional problems in Everglades vegetable production (Table 5). The mean soil pH in celery fields was higher than in lettuce and radish fields, and values were remarkably stable within a crop (CV values below 10%). The pH values reflect the practice of applying S to lower the soil pH for lettuce production. Although S is not generally applied in radish production, radishes are commonly planted on the most acid soil available. Soil acidification has not been widely practiced in celery production, since poor Mn availability can be overcome by foliar Mn application. However, even though soil pH is considered in lettuce and radish production, pH levels exceeded the recommended value in over 90% of the samples taken from these crops. These figures indicate the magnitude and extent of the soil pH problem in vegetable production, and establish the great need for research in this area. Judging from soil tests, P and K supplies are often low for celery production, with 67 and 94%, respectively, of samples testing below recommended levels. Lettuce is traditionally heavily fertilized, and only about 35% of samples were below recommended soil P and K tests. Radishes often follow heavily-fertilized crops and benefit from residual

Table 4. Proposed tissue nutrient concentration diagnostic norms (reference values), and percent of samples with lower nutrient concentrations.

Crop		Leaf dry weight (%)			Conductive tissue dry weight (%)		
		N	P	K	NO_3-N	PO_4-P	K
Celery	Reference	3.0	0.3	3.5	1.0	0.4	6.0
	% below	11.4	6.5	34.3	22.6	51.4	3.7
Lettuce	Reference	3.0	0.4	6.0	1.0	0.4	4.0
	% below	7.3	20.9	67.3	0.9	27.5	0.0
Radish	Reference	4.0	0.4	2.0	—	—	—
	% below	16.9	8.5	0.0	—	—	—

Table 5. Soil test values, recommended levels and percent of samples failing to meet recommended levels.

Crop	pH $\bar{x}$[z]	pH CV[y]	pH Rec[x]	pH % above	P $\bar{x}$ (kg/ha)	P CV	P Rec (kg/ha)	P % below	K $\bar{x}$ (kg/ha)	K CV	K Rec (kg/ha)	K % below
Celery	7.1	5.7	—	—	28.0	63.0	28.0	66.7	227	45.7	392	94.2
Lettuce	6.6	7.4	<6.0	91.9	54.9	68.6	33.6	33.8	330	83.9	224	35.3
Radish	6.7	7.3	<6.0	90.2	31.4	58.0	15.7	13.7	178	50.6	196	60.1

[z]Mean values.
[y]Coefficient of variation (%).
[x]Recommended soil test levels from Burdine (2).

nutrient levels. Accordingly, soil P levels were seldom below the recommendation, but K, which can be lost by leaching, tested below the recommendation in 60% of samples from radish fields.

Soil test recommended levels, like tissue analysis critical levels, are often based on single-point measures such as final yield. However, the soil test need only be as high as necessary to supply adequate nutrients to the plant, which can be determined using tissue analysis. So, for each crop, tissue analysis results were plotted against the corresponding soil tests, and the critical values of Table 4 were used to identify the minimum soil test values (Fig. 5, Table 6). Using this approach, much lower soil test values than those currently recommended were found to adequately supply plants' needs. Soil test levels higher than the minimum did increase the maximum observed tissue nutrient concentrations to a point, but the higher levels no doubt constitute "luxury consumption". Certainly, soil test levels should be maintained higher than the bare minimum in order to

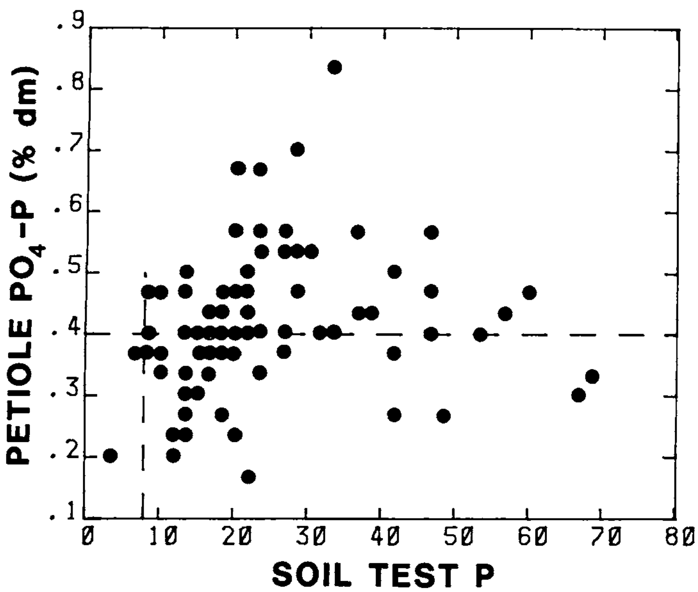

Fig. 5. Celery petiole PO_4-P concentration in response to soil test P. dm = dry matter.

overcome problems of variability in the field or short-term decreases in availability, such as due to low temperatures or leaching rains. Furthermore, fertilization to attain higher soil tests at planting may be necessary to assure adequate nutrient supplies late in crop growth. Nonetheless, it appears that recommended soil test levels could be cut by 50% and still maintain a comfortable safety margin in most cases. Even given the conservative nature of vegetable producers in the area of controllable management factors, the prospect of reducing fertilizer applications will have to be an important consideration as fertilizer and other production costs increase, and as environmental concerns continue to mount.

Conclusions

This survey was intended to describe the current status of the vegetable industry in the Everglades, and results are not amenable to recommending large changes in production practices. Further research is needed to confirm or modify many of the proposals made in this report. However, several important points can be made based on these results. First, tentative models of growth limited by time, temperature or radiation have been presented for celery, lettuce and radishes. As long as growth exceeds 90% of the predicted, or potential growth, then nutrient deficiencies can be eliminated from consideration. Second, based on published information, observed means, and growth rate analysis, tissue nutrient concentrations in leaves and conductive tissue have been presented which can confidently be used to detect nutrient deficiencies in crops. Tissue analysis is a useful and well-established management technique that should be used on a routine monitoring basis by all vegetable producers. Based on the adequacy of nutrient supplies to plants, soil test levels much lower than those currently recommended may be sufficient. Even with the current high applications of P and K, apparent deficiencies of these nutrients in celery and lettuce tissue were identified. Additional work is needed to refine both the diagnostic levels and fertility practices in these crops. The most widespread nutritional problem identified in this study was the ubiquitous high soil pH (>6.3). Research has been ongoing in the area of pH and Mn availability management, and will continue. Finally, it should be noted that this study is based on a reliable, but relatively small, sample population. In-

Table 6. Estimated minimum soil test values required to achieve reference levels of tissue nutrient concentrations.

Crop	Tissue	Reference P value (% dry weight)	Soil test P required (kg/ha)	Reference K value (% dry weight)	Soil test K required (kg/ha)
Celery	leaf	0.3	5.6	3.5	56.0
	petiole	0.4	9.0	6.0	42.6
Lettuce	leaf	0.4	9.0	6.0	89.6
	midrib	0.4	9.0	4.0	44.8
Radish	leaf	0.4	9.0	2.0	44.8

creasing the data base by continued routine sampling should enhance and refine the preliminary conclusions presented here.

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COMPATIBILITY OF FUNGICIDE-INSECTICIDE COMBINATIONS FOR DISEASE AND PICKLEWORM CONTROL ON HONEYDEW MELON[1]

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Abstract. **Three fungicide programs and 4 insecticides factorially combined were tested for efficacy and phytotoxic effects when evaluated for the control of diseases and pickleworm (*Diaphania nitidalis* (Stoll)) on honeydew-type melon (*Cucumis melo* var. *inodorus* cv. Morgan). Mancozeb (Manzate 200) and benomyl (Benlate), metalaxyl (Ridomil) and benomyl, and chlorothalonil (Bravo) were tank mixed with methomyl (Lannate), methamidophos (Monitor), acephate (Orthene), and *Bacillus thuringiensis* var. *kurstaki* (Dipel). The efficacy of all fungicides against downy mildew (*Pseudoperonospora cubensis* (Berk. & Curt.)), gummy stem blight (*Mycosphaerella citrullina* (C. O. Sm.) Gross), and scab (*Cladosporium cucumerimum* (Ell. and Arth.)) was not affected by the insecticides. Edge necrosis and slightly misshapen leaves were produced by the metalaxyl plus methomyl treatment. All 3 chemical insecticides significantly reduced the percentage of fruit damaged by pickleworm larvae. Chlorothalonil combined with *B. thuringiensis* resulted in a significantly higher percent (49%) of fruit damaged by pickleworm when compared with the bacterial insecticide alone.**

Honeydew melons are attacked by many diseases and insects including downy mildew, gummy stem blight, scab, and pickleworm. Tank mixed fungicide-insecticide combinations would be desirable for control of these pests because of reduced application costs.

The purpose of this investigation was to evaluate tank mix combinations of 3 fungicide programs with 4 insecticides for disease and insect control on honeydew melon. The experiment was conducted in the spring of 1978 at the Agricultural Research & Education Center in Immokalee.

Materials and Methods

Plots of *Cucumis melo* var. *inodorus* (cv. Morgan) were established by seeding into raised beds on 6 ft centers through holes spaced 3 ft apart in black plastic mulch. Plots, arranged in 3 randomized blocks, were 30 ft in length and contained 10 "hills" thinned to 2 plants each. Cold damaged plants were replaced with additional seed.

The soil was an Immokalee fine sand (Arenic Haplaquod) with 27-32 inch deep hardpan which allowed open ditch seep irrigation. A starter fertilizer equivalent to 25-18-33 lb./acre N, P, and K, respectively, placed in the plant beds was supplemented by 180-0-207 lb./acre of N and K banded on the bed surface 9 inches to each side of the plant row and covered with 1.25 mil black polyethylene mulch. Paraquat dichloride was applied twice at 0.6 gal/acre between the mulched beds. Nu-Iron (Cities Service Co., Atlanta, GA) was applied twice at 3.1 lb./acre as a foliar spray to correct a nutritional deficiency.

Materials evaluated and rates of application listed below were factorially combined such that all combinations of letters and numbers occurred, thereby providing one fungicide and one insecticide in each application.

Fungicides used were: A) mancozeb 80W at 3.1 lb./acre as Manzate 200 plus benomyl 50W at 0.5 lb./acre as Benlate; B) chlorothalonil 6 lb./gal F at 3 pints/acre as Bravo 6F; C) metalaxyl 2EC at 1 pint/acre as Ridomil 2E plus benomyl 50W at 0.5 lb./acre.

Insecticides used were: 1) acephate 75S at 1.3 lb./acre as Orthene 75SP; 2) methamidophos 4EC at 1 qt/acre as Monitor 4E; 3) methomyl 1.8LC at 4.5 pints/acre as Lannate 1.8 LC; 4) *Bacillus thuringiensis* var. *kurstaki* Berliner at 1.0 lb./acre as Dipel.

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