FNE94-70

ORGANIC "BAG CULTURE" OF GREENHOUSE PEPPERS
FINAL REPORT

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Project Goal

My goal in this project was to develop an organically certifiable system of growing bagged peppers in the summer greenhouse. To do this, I conducted an experiment in which three fertigation solutions--my treatments--were used. One treatment was a chemical "control," while the other two were composed of materials that meet the certification standards for organic growers.

Backround

Greenhouse solanacious crops suffer from a variety of diseases, including some that are soil-borne and difficult to eradicate. In particular, northeastern greenhouse growers have been reporting increasing incidence of Corky Root (*Pyrenochaeta lycopersici*) during the last few years. This disease tends to build populations slowly for the first few years, so it's difficult to detect at first. However, since the microscopic, infective sclerotia slough off the root tissue when plants are pulled from the beds and also because it infects composites such as lettuce, it can eventually become disasterous.

The conventional solution to this problem is to grow greenhouse tomatoes and peppers in plastic "bags" filled with a soil-less mix so that the medium can be removed from the greenhouse every year. In this system, soluble nutrients are supplied through the irrigation water. But few organic growers follow this regime because they are uncertain that they can supply adequate and balanced nutrients through a fertigation solution.

I am interested in developing a bagged greenhouse pepper system for two reasons: I would like to be able to take advantage of the summer greenhouse environment by growing a cash crop in the facility and secondly, I want to avoid building populations of soil-borne diseases.

Farm Update

I am still a part-time grower and lease land from the New England Small Farm Institute in Belchertown, MA. I manage a diversified vegetable operation for Lampson Brook CSA. This CSA grew from 30 members in 1994 to 65 members in 1995 and we also began to sell to area restaurants in 1995. In addition to growing seedlings for the CSA in a rented 27' x 48' greenhouse, I also grew seedlings and cut flowers for sale to the public in 1995, and initiated a small outlet, the Overflow Stand. The CSA field totals 10 acres. In 1995, about three and half of these were in crop production and another acre and a half was in cover crops. The field where I grow strawberries, herbs, and cut flowers is 3/4 acre and the display garden by the Overflow Stand is 40' x 70'. I teach organic farming and greenhouse techniques, both at Lampson Brook CSA and on a private and consulting basis. In 1995, I had three on-site students, two of whom gave invaluable help with the bagged pepper project.

Cooperators

Ken Badgeley, formerly of Gardener's Supply Co., Burlington, VT., and now with W.H. Milikowski, Inc, Stafford Springs, CT., was a collaborator on this project. Ken and I have worked together in previous years with containerized, automatically-watered plants that we fertigated with "Roots Plus for Tomatoes." During this time, we have developed some base-line information about workable fertigation concentrations and frequencies. For the bagged pepper project, Ken designed the irrigation system and taught us how to install it. He also co-presented at our "Organic Bag-Culture Peppers" field day, giving participants information not only about the system that we used for the pepper project but also about other types of greenhouse irrigation systems.

THE PROJECT DESIGN

The experimental design was composed of four replications of each of the three treatments. My twelve "plots" were greenhouse tables, each of which held twelve plants. Consequently, there were 48 plants in each treatment and a total of 144 plants in the experiment.

Since yield data are the best indicator of the worth of a fertigation solution, we counted all harvested peppers from each plant and weighed them by tables. Additionally, I had fertigation solutions and the potting medium analyzed for nutrient content. I had planned to conduct tissue tests through the season but discovered that the small leaf size of the test plants made this impossible. Instead, I tested only twice, once before plants received fertigation and again at the end of the season. Results of the analyses are included as Attachment B.

Fertigation Solutions

Fertigation solutions must supply plants with adequate and well-balanced nutrients through a long season. Additionally, they should be relatively inexpensive and easy to use if they are to be commercially applicable.

My choice of "Roots Plus for Tomatoes" as a chemical control was based on previous work that Ken and I had conducted. Trials in 1991 and 1992 had shown that this material would carry a crop through the season. It contains humic substances, enzymes, marine algae, minerals, vitamins and chelating agents as well as the synthetically-formulated nutrients that make it ineligible for growers who adhere to organic certification standards.

A sister product, "Roots," is essentially identical to "Roots Plus for Tomatoes" but lacks the synthetically-formulated nutrients. I chose to use this product, with amendments, as a second treatment.

Compost tea, homemade from a high-quality, purchased compost, was my third choice for a treatment base. Again, I amended the material.

As originally planned, I used these three fertigation solutions. However, based on analysis from A&L Laboratory, Richmond, VA., as well as visual cues from the plants, I increased the concentration and frequency of the fertigation solutions as the season progressed. In the first weeks of the project, I fertigated with nutrient solutions twice a week; after receiving nutrient analyses, I increased this to every other day, but maintained the same concentration. After six weeks of fertigation, new leaves were slightly pale in color, so I increased the quantity of seafish in all treatments. Attachment C, "Fertigation Recipes," gives recipes for each stage of this work.

Throughout, plants received a measured half-cup of nutrient solution each time they were fertigated. They were also given plain water, sometimes twice a day during extremely hot weather, but were irrigated so that little or no nutrient leaching occurred.

The Test Crop

I chose to use Thai pepper plants, rather than tomatoes, for two reasons. Since I also use the greenhouse as a starting area for seedlings for Lampson Brook CSA, the tables are essential. I did not want to remove them for a trellised tomato crop. Additionally, many of Lampson Brook CSA members have what seems like an insatiable appetite for hot peppers, so this choice also made economic sense. However, I forgot one essential factor when designing the experiment: the utility of using a hybrid rather than an open-pollinated cultivar. The Thai pepper seed I used was open-pollinated, so there was some variation in plant habit and fruit form. Four plants were obviously dissimilar, or "off-type". Fortunately, two factors kept this problem from significantly biasing the project. The first was the number of replications and the second was an accident of timing. Since the peppers grew in four-inch pots before being transplanted into the bags and set on their treatment tables, I was able to discern differences before I began fertigating. Therefore, I could spread the off-types between different treatments. Notes on Attachment A, "Yield and Weight Data", give locations and brief descriptions of the ways in which these plants differed from the rest.

Treatment Locations

Location within a greenhouse can affect yields and plant health as a consequence of differences in temperature and light exposure. To avoid biasing the results of this experiment, treatment locations were randomized in the greenhouse. My final plan deviates from the original proposed because of changes in table layout in the facility. The "Greenhouse Treatment and Yield Map" on page 12 of this report shows the table layout and treatment locations we used in this experiment.

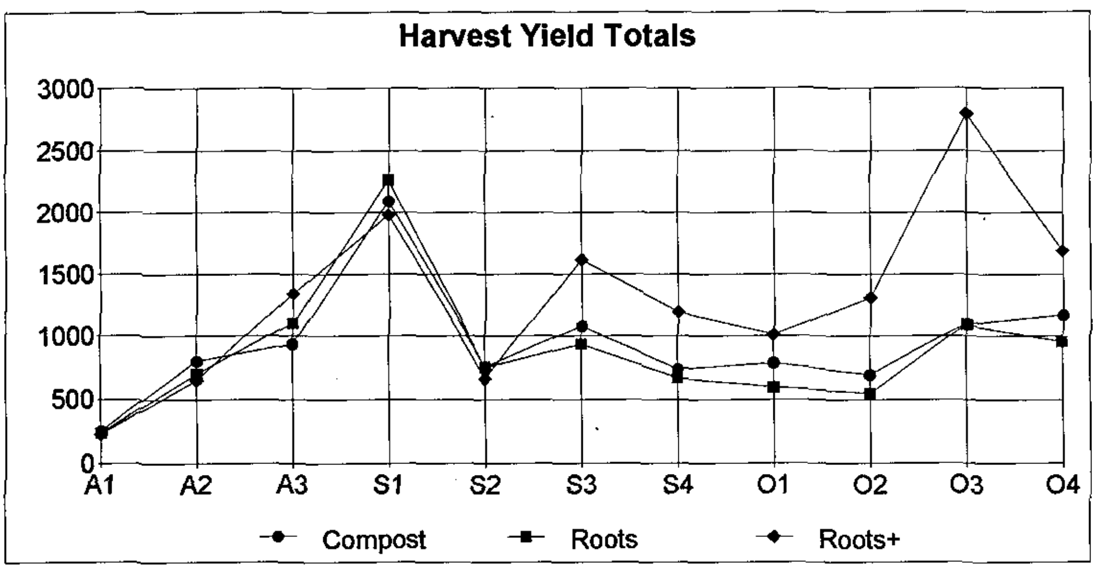
Potting Medium and Containers

While most conventional growers use a soil-less mix for bag-cultured plants, I chose to use a compost-based medium in my containers. As planned, I amended a commercially-available, compost-based soil mix with five percent Azomite and ten percent "home-made" worm cast-compost. I had assumed, when planning the project, that the drainage of the purchased potting soil would be adequate. However, this was not the case, so I added 5 percent vermiculite to the mix. I did not add worms because they were already plentiful in the worm cast-compost.

I had planned to use 3-gallon nursery cans in the experiment because they are reusable. However, Ken Badgeley strongly recommended that I use conventional poly bags. These bags have drainage (and aeration) holes up their sides as well as in the bottom and Ken has had better results with them than with nursery cans. They also appear to be resuable; the plastic is UV treated and showed no brittleness by the end of the season.

PROJECT RESULTS

Results of the project were statistically significant by a greater margin than I had expected. "Roots Plus for Tomatoes", amended with a combination of liquid seaweed and fish emulsion, yielded the largest number of peppers, a total of 14,494 peppers from the 48 plants in the treatment, with an average yield of 302 fruits per plant. The compost tea solution, also amended with a combination of liquid seaweed and fish emulsion, yielded 10,417 peppers and plants had an average of 217 fruits each, while the Roots mixture, also amended with a combination of liquid seaweed and fish emulsion, yielded 9,854 fruits with a plant average of 205 fruits. The standard deviation of the mean for these totals was 2,067 fruits while the difference between Roots Plus and the other treatments was more than 4,000 fruits. Appendix A gives yield and weight data for all pickings through the season. The summary graph below, where the vertical axis is number of peppers harvested and the horizontal axis represents the harvest date, illustrates not only the larger overall yield of these plants but also the difference as a consequence of the length of the season.



One of my primary goals was to develop a nutrient solution that could carry plants through a long season. My results indicate that I still have a great deal of work to do before I have achieved this objective. Looking at the graph on the previous page, it is not unreasonable to surmise that nutrients in the bagged medium carried the plants for the first part of the season and that they became depleted in mid- to late August, making the plants more dependent on the fertigation solution. By "S3," the September 21st picking, yield data began to be quite different; both the Compost Tea and Roots treatments fell well below the Roots Plus for Tomatoes plants.

All peppers were also weighed to determine if the treatments would affect this quality. However, while the total weight per treatment was different, weights were variable enough within each treatment to render them less useful as a means of comparison. The table below gives a summary of the total yield and weight data by greenhouse table and treatment.

SUMMARY-YIELD & WEIGHT

Compost	*Table*	Number	Weight	Avg Num	Avg Wgt
	1	2498	1327	208.17	0.53
	4	2784	1384.5	232.00	0.50
	7	2660	1127	221.67	0.42
	10	2475	1203	206.25	0.49
Totals		**10,417.00**	**5,041.50**	**217.02**	**0.48**
Roots	2	2265	1200	188.75	0.53
	6	2492	1201.5	207.67	0.48
	9	2611	1322.5	217.58	0.51
	11	2486	1259	207.17	0.51
Totals		**9,854.00**	**4,983.00**	**205.29**	**0.51**
Roots Plus	3	3476	1655	289.67	0.48
	5	3689	1915	307.42	0.52
	8	3799	1695	316.58	0.45
	12	3530	1838.5	294.17	0.52
Totals		**14,494.00**	**7,103.50**	**301.96**	**0.49**
Standard Deviations		**2067.4326**	**986.11395**	**43.071513**	**0.0091298**

Treatment location did not appear to play a part in the results. I expected that tables on the south side of the greenhouse, particularly in the middle and the rear, would give higher yields as a consequence of their warmer, brighter environment. However, as shown on the following chart, the variation within the tables in this area is far more dependent on treatment than location.

YIELD & WEIGHT BY LOCATION

Table		Num	Wght	Avg Num	Avg Wgt
(front gh, N side)	1	2498	1327	208.17	0.53
	2	2265	1200	188.75	0.53
	3	3476	1655	289.67	0.48
	4	2784	1384.5	232.00	0.50
	5	3689	1915	307.42	0.52
(rear gh, N side)	6	2492	1201.5	207.67	0.48
(rear gh, S side)	7	2660	1127	221.67	0.42
	8	3799	1695	316.58	0.45
	9	2611	1322.5	217.58	0.51
	10	2475	1203	206.25	0.49
	11	2486	1259	207.17	0.51
(front gh, S side)	12	3530	1838.5	294.17	0.52

Pest and Disease Incidence

Hot peppers grown in a greenhouse environment become more susceptible to many pests and diseases. In March and April of 1995, we had an outbreak of aphids in the greenhouse. To control them, we released imported lady beetles two to three times a week for about a month. Typically, once the brassicas are out of the house, the aphids move to the eggplants and peppers. The ladybugs keep aphid populations low but never entirely eradicate them.

The Thai pepper plants for the experiment were started in late April so that they would be an appropriate size and age for final bagging after the greenhouse had been cleared of all other seedlings. Consequently, they were at their youngest, most delectable stage just when the aphids were looking for new homes. I released lady beetles on the potted peppers twice before moving them into the bags, but expected that a lingering population would alert us to any nitrogen excesses we might have.

All through the summer, the aphids were barely noticable. It wasn't until early October that populations on a few plants got high enough to be visible. Contrary to my expectations, their incidence did not seem related to nutrient status of the plants. Instead, proximity to the central aisleway seemed influential. The most heavily infected plants were, without exception, located at the aisle-edge of the tables. Since we keep the front door of the greenhouse open to increase the amount of air that the exhaust fan pulls through the facility, it seems clear that the autumn aphids came in on the breeze and just stayed where they landed. Since they never became troublesome enough to cut yields or performance, we just let them be for the last month of the project.

Future Plans for Bagged Culture Work

In 1996, we will grow a mixed crop of bagged peppers in the greenhouse, despite the fact that I do not yet have a system that can produce as high a yield as the Roots Plus for Tomatoes treatment did. My rationale is that, even without getting top yields, plants in the Compost treatment produced enough peppers to make the investment in time and money for potting and irrigating worthwhile. I also think that we learned enough from the analyses so that we can improve both the potting medium and the fertigation solution next year.

As indicated on the analyses from A & L Laboratory, copper and nitrogen appeared to be the limiting nutrients in the system used this year. We plan to follow the suggestion given by the lab to use poultry manure compost to make up for these deficiencies.

Fortuitously, we have an on-site source of poultry manure and bedding. We have not composted this material but it is stockpiled. At the very least, year-old material will be ready to be used as an addition to the compost from which we extract the tea. Depending on its breakdown, we may even add it to the bags.

Although we will be growing many different types of peppers in the bags next year and harvesting without weighing and counting, we should develop greater understanding of the system. If it appears to work well, we may do follow-up testing in 1997, again comparing it to Roots Plus for Tomatoes. Eventually, we should be able to refine the system so that it produces top yields.

An Unexpected Bonus

The choice of an open-pollinated cultivar was unfortunate from the perspective of reducing variables. However, from a purely practical point of view, it yielded an unanticipated benefit. Because we counted every ripe pepper that came from every plant, we ended the year with excellent yield data. After we shut down the project on November 1, we retained the twelve highest yielding plants and kept them growing for an additional ten days. We saved the peppers that ripened during this time for seed, so we are assured of having started a foundation of very high yielding plants that grow well in our greenhouse environment. About ten of these plants have since been moved into homes for the winter where they are continuing to produce, even through the dark of December.

OUTREACH

On Saturday, October 14, we held an afternoon "Pepper Field Day." We advertised through the CISA newsletter and called to personally invite some greenhouse growers. Despite this, attendance was low. Since then, five growers have called to ask me how the experiment went and what I learned. Two of these people asked for a copy of this report and since I anticipate interest from others, I am making several photo-copies to have on hand.

We video-taped the workshop for future reference. However, since the experiment was not yet complete, the data presented there is incorrect. The Roots Plus for Tomatoes treatment had begun to give higher yields than the other two treatments, but the results were not as startling as they later became.

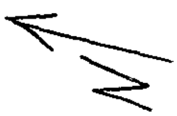
The workshop subjects included a presentation of the data we had gathered by early October, discussion of the methodology we had used for the experiment, description and demonstration of the fertigation and timed irrigation system in the greenhouse, and a brief discussion about the economic advantages of using an automated irrigation system for greenhouse culture. My goal for the workshop was to inspire other people to try to develop their own bag culture system, so I discussed the shortcomings of the Compost treatment we used quite frankly. With a good enough compost, this system should not be out of reach; I welcome all the help and/or competition I can get in developing it.

CONCLUSION

While I certainly can't claim to have met my goal of developing a bagged culture system that both met the standards set for organic certification and still produced as highly, and for as long a season, as the chemical control I used, the project was worthwhile. Thanks to the results, I now feel confident in growing the bulk of the hot peppers for the CSA in bags on the greenhouse tables. Additionally, I believe that I now have more information with which to carry the work forward. I greatly apppreciate having had the opportunity to conduct this experiment. Without the funding, I would never have been able to justify the time it took to count and weigh the nearly 35,000 peppers we grew in the experiment and without that data, I could not have been as certain about the directions we should now take in developing this cultural system.

Greenhouse Treatment & Yield Map

#1 - Compost 2498 peppers .53 gms avg. weight	#12 Roots Plus 3530 peppers .52 gms avg weight
#2 Roots 2265 Peppers .53 gms avg. weight	#11 Roots 2486 peppers .51 gms avg weight
#3 Roots Plus 3476 peppers .48 gms avg. weight	#10 Compost 2475 peppers .49 gms avg weight
#4 Compost 2784 peppers .50 gms avg weight	#9 Roots 2611 peppers .51 gms avg weight
#5 Roots Plus 3689 pepper .52 gms avg. weight	#8 Roots Plus 3799 peppers .45 gms avg. weight
#6 Roots 2492 pepper .45 gms avg weight	#7 Compost 2660 peppers .42 gms avg. weight



APPENDIX A--HARVEST DATA

TRTMNT	PLT	Aug15	Aug23	Aug30	Spt 7	Spt 13	Spt 21	Spt 28	Oct 5	Oct 15	Oct 24	Oct 30	Total
Table #1	**1**	5	26	19	39	8	41	43	81	98	91	30	**481**
Compost	**2**	3	22	26	29	24	28	9	17	16	14	18	206
	3	6	18	22	70	12	34	17	20	15	13	16	243
	4	0	5	13	30	3	7	11	14	9	20	37	149
	5	9	19	23	50	28	35	32	26	8	3	15	248
	6*	3	15	19	22	21	10	2	1	0	7	22	122
	7	4	14	19	38	20	22	7	13	14	13	12	176
	8	8	18	35	32	4	13	10	7	6	12	11	156
	9**	2	1	1	1	2	4	1	9	11	21	37	90
	10	2	14	18	33	11	28	25	47	34	26	17	255
	11	4	23	25	49	40	29	8	10	18	6	22	234
	12	0	12	14	60	13	4	1	0	5	18	11	138
Number		46	187	234	453	186	255	166	245	234	244	248	2498
Weight		13.5	90.5	154	258	110	127	74	111	112	129	148	1327
Avg. Wght.		0.29	0.48	0.66	0.57	0.59	0.50	0.45	0.45	0.48	0.53	0.60	0.53
Table #2	**1**	5	22	26	44	26	5	1	1	2	19	17	168
Roots	**2***	1	7	7	7	1	0	4	10	5	0	4	46
	3	4	18	39	58	33	77	56	32	21	10	20	368
	4	2	10	13	19	7	16	6	3	10	19	23	128
	5	7	18	20	44	14	6	8	2	5	22	6	152
	6	1	25	5	91	12	19	22	1	0	23	60	259
	7	2	7	19	24	13	14	27	17	19	27	7	176
	8	4	19	18	78	27	27	4	6	5	8	8	204
	9	3	4	22	66	17	28	20	26	35	40	20	281
	10	4	9	19	44	16	32	22	19	17	18	16	216
	11	6	21	26	26	6	5	6	3	3	5	7	114
	12	1	14	11	48	12	18	8	24	6	1	10	153
Number		40	174	225	549	184	247	184	144	128	192	198	2265
Weight		12.5	75.5	135	316	97	103	92	91	71	109	98	1200
Avg. Wght.		0.31	0.43	0.60	0.58	0.53	0.42	0.50	0.63	0.55	0.57	0.49	0.53
Table #3	**1**	11	18	25	60	7	75	64	41	40	36	15	**392**
RootsPlus	**2**	8	8	11	29	3	7	7	4	15	45	40	177
	3	6	19	34	29	6	40	15	5	21	24	7	206
	4	11	32	35	32	9	71	29	18	46	92	33	**408**
	5	5	9	30	45	8	7	22	13	12	84	51	286
	6	5	18	24	44	10	15	32	14	11	28	16	217
	7	1	13	16	36	5	25	41	23	68	69	27	324
	8	2	7	29	47	4	34	24	33	29	44	25	278
	9	3	14	36	60	28	70	42	22	18	25	17	335
	10	2	3	19	24	14	18	18	20	27	64	34	243
	11	11	16	19	17	4	13	7	8	23	64	40	222
	12	13	27	50	83	23	27	22	40	12	42	49	**388**
Number		78	184	328	506	121	402	323	241	322	617	354	3476
Weight		19.5	60	171	234	56	178	140.5	110	171	344	171	1655
Avg. Wght.		0.25	0.33	0.52	0.46	0.46	0.44	0.43	0.46	0.53	0.56	0.48	0.48

		Aug15	Aug23	Aug30	Spt 7	Spt 13	Spt 21	Spt 28	Oct 5	Oct 15	Oct 24	Oct 30	
Table #4	**1**	8	17	17	39	15	22	15	9	9	12	7	170
Compost	**2**	2	4	15	14	5	25	2	5	13	25	20	130
	3	5	28	22	54	32	65	14	9	6	22	10	267
	4	1	9	23	14	1	6	9	10	27	55	53	208
	5	12	24	31	52	45	43	30	19	11	19	18	304
	6	4	13	30	61	17	14	18	15	7	16	7	202
	7	9	32	12	82	6	11	12	11	9	12	25	221
	8	3	22	30	48	47	50	37	14	2	13	21	287
	9	4	15	10	68	6	25	10	8	15	24	36	221
	10	6	17	27	63	28	52	66	23	12	3	10	307
	11	1	6	2	16	3	9	17	7	18	38	42	159
	12	7	14	16	44	10	23	14	21	41	70	48	308
Number		62	201	235	555	215	345	244	151	170	309	297	2784
Weight		15.5	77	139	271	111	167	111	73	86	179	155	1384.5
Avg. Wght.		0.25	0.38	0.59	0.49	0.52	0.48	0.45	0.48	0.51	0.58	0.52	0.50
Table #5	**1**	8	12	28	25	5	28	8	34	49	170	13	**380**
RootsPlus	**2**	5	12	61	68	23	28	46	15	35	45	46	**384**
	3	2	11	20	6	8	36	18	23	56	79	3	262
	4	3	11	19	40	16	67	44	50	33	19	5	307
	5	10	9	36	48	5	42	36	23	40	126	72	**447**
	6	14	16	61	70	17	23	29	11	20	84	79	**424**
	7	4	18	28	43	8	13	17	18	7	37	44	237
	8#	1	9	16	67	4	21	6	7	2	9	6	148
	9	5	10	27	55	6	23	16	14	18	50	59	283
	10	1	6	9	14	1	53	11	16	57	82	37	287
	11	5	12	26	61	3	15	8	7	28	68	56	289
	12	6	5	20	13	6	20	2	20	26	85	38	241
Number		64	131	351	510	102	369	241	238	371	854	458	3689
Weight		20.5	52.5	191	293	57	174	120	128	211	462	206	1915
Avg. Wght.		0.32	0.40	0.54	0.57	0.56	0.47	0.50	0.54	0.57	0.54	0.45	0.52
Table #6	**1**	3	3	22	26	0	8	1	6	18	66	35	188
Roots	**2**	9	22	33	82	35	42	1	2	5	44	9	284
	3	10	29	30	39	0	8	5	7	7	14	18	167
	4	8	19	41	55	48	33	9	7	2	21	7	250
	5	5	5	3	28	4	4	8	25	3	10	13	108
	6	3	25	32	61	7	54	26	15	33	70	43	369
	7	7	12	13	26	9	25	14	19	43	70	15	253
	8	2	10	5	55	8	14	5	12	9	19	33	172
	9	6	10	17	68	14	20	22	15	4	12	27	215
	10**	1	1	6	6	8	18	13	10	16	7	12	98
	11	5	11	10	79	21	23	24	23	10	19	26	251
	12	3	12	18	32	7	9	1	10	4	10	31	137
Number		62	159	230	557	161	258	129	151	154	362	269	2492
Weight		20.5	55.5	142.5	269	81	106	52	71	79	201	124	1201.5
Avg. Wght.		0.33	0.35	0.62	0.48	0.50	0.41	0.40	0.47	0.51	0.56	0.46	0.48

		Aug15	Aug23	Aug30	Spt 7	Spt 13	Spt 21	Spt 28	Oct 5	Oct 15	Oct 24	Oct 30	
Table #7	1	29	79	48	94	29	24	10	9	20	30	19	391
Compost	2	3	19	14	0	3	1	3	5	9	16	21	94
	3	2	15	12	18	3	31	5	16	19	27	19	167
	4	3	12	11	51	6	15	5	12	13	25	42	195
	5	3	9	18	33	9	29	33	24	28	28	19	233
	6	7	22	38	41	28	63	34	32	23	7	11	306
	7	3	10	13	37	0	4	1	10	5	15	36	134
	8	2	11	13	26	23	34	24	30	4	25	48	240
	9	3	9	0	42	7	11	17	8	20	46	42	205
	10	3	11	28	35	23	19	9	17	10	42	73	270
	11	0	6	12	27	17	13	22	11	5	14	29	156
	12	20	43	33	59	22	9	6	10	11	14	42	269
Number		78	246	240	463	170	253	169	184	167	289	401	2660
Weight		27.5	96	124.5	192	69	102	62	73	78	141	162	1127
Avg. Wght		0.35	0.39	0.52	0.41	0.41	0.40	0.37	0.40	0.47	0.49	0.40	0.42
Table #8	1	3	8	22	40	3	22	12	10	32	50	43	245
RootsPlus	2^	8	22	43	47	18	55	51	10	14	20	7	295
	3	0	12	26	48	16	32	39	19	12	40	45	289
	4	7	23	37	28	9	39	21	16	25	77	72	354
	5	6	26	29	25	12	45	18	4	17	82	35	299
	6	2	6	16	8	14	27	19	43	55	104	34	328
	7	1	8	3	67	32	25	32	24	27	35	35	289
	8*	4	15	35	37	12	25	17	26	25	80	59	335
	9	10	15	32	38	19	20	11	12	7	79	34	277
	10	7	27	34	33	27	44	10	34	77	93	22	408
	11	7	13	50	34	5	29	13	5	26	104	63	349
	12	4	4	5	11	15	60	43	53	77	56	3	331
Number		59	179	332	416	182	423	286	256	394	820	452	3799
Weight		19.5	60.5	148	186	75	159	108	115	197	429	198	1695
Avg. Wght.		0.33	0.34	0.45	0.45	0.41	0.38	0.38	0.45	0.50	0.52	0.44	0.45
Table #9	1	1	21	32	69	47	24	5	6	5	39	23	272
Roots	2	7	19	18	53	9	6	10	5	3	20	29	179
	3	3	20	22	42	19	21	15	35	26	12	15	230
	4	1	7	3	31	7	13	15	12	16	41	30	176
	5	17	23	54	76	13	20	24	9	13	28	12	289
	6	2	6	10	47	18	6	8	15	10	22	14	158
	7	17	22	50	56	10	12	38	6	26	63	61	361
	8	2	5	22	5	4	24	9	10	27	30	23	161
	9	5	11	37	13	3	16	21	9	9	38	44	206
	10	10	14	25	90	23	17	8	6	11	26	9	239
	11	3	6	6	54	11	3	9	19	3	10	19	143
	12	4	7	16	63	8	22	15	11	12	20	19	197
Number		72	161	295	599	172	184	177	143	161	349	298	2611
Weight		22.5	73	167	292	83	76	75	65	85	190	194	1322.5
Avg. Wght.		0.31	0.45	0.57	0.49	0.48	0.41	0.42	0.45	0.53	0.54	0.65	0.51

		Aug15	Aug23	Aug30	Spt 7	Spt 13	Spt 21	Spt 28	Oct 5	Oct 15	Oct 24	Oct 30	
Table #10	**1**	3	13	8	43	22	22	6	11	13	7	40	188
Compost	**2**	3	5	9	48	10	15	24	34	12	26	10	196
	3	16	29	29	84	47	17	16	21	2	24	4	289
	4	7	15	13	19	5	13	11	14	27	24	23	171
	5	7	14	21	95	20	38	30	20	11	25	12	293
	6	2	7	20	52	13	29	16	38	15	18	15	225
	7	8	20	21	52	6	6	10	1	2	18	21	165
	8	11	21	32	67	21	8	0	1	8	38	3	210
	9	6	8	14	40	8	8	13	13	1	29	36	176
	10	4	14	15	56	9	7	5	8	12	11	16	157
	11	1	7	8	22	1	0	1	7	4	26	33	110
	12	2	16	38	44	23	63	30	42	17	12	8	295
Number		70	169	228	622	185	226	162	210	124	258	221	2475
Weight		22.5	66.5	127	304	82	104	71	100	76	144	106	1203
Avg. Wght.		0.32	0.39	0.56	0.49	0.44	0.46	0.44	0.48	0.61	0.56	0.48	0.49
Table #11	**1**	5	20	13	43	3	3	0	2	19	4	1	113
Roots	**2**	12	25	49	91	17	11	9	3	21	18	3	259
	3	0	8	13	48	31	21	17	6	0	10	15	169
	4	3	15	20	14	1	0	5	11	3	20	30	122
	5	4	6	28	34	12	29	27	5	9	28	11	193
	6	5	31	41	93	49	22	4	3	2	11	34	295
	7	2	9	21	9	11	1	5	12	4	23	27	124
	8	7	21	36	55	25	16	0	6	0	10	2	178
	9	12	26	36	55	18	22	13	11	7	15	17	232
	10	1	17	31	67	56	95	83	76	36	5	0	**467**
	11	5	9	28	11	2	7	4	19	1	10	19	115
	12	9	20	36	37	12	20	14	6	3	32	30	219
Number		65	207	352	557	237	247	181	160	105	186	189	2486
Weight		30	86	201	296	114	110	84	83	60	102	93	1259
Avg. Wght.		0.46	0.42	0.57	0.53	0.48	0.45	0.46	0.52	0.57	0.55	0.49	0.51
Table #12	**1**	2	17	31	62	35	36	38	58	28	25	22	354
RootsPlus	**2**	0	17	16	53	32	46	25	21	14	21	56	301
	3	4	10	22	37	3	30	27	10	14	81	27	265
	4	3	7	41	23	6	22	11	15	20	82	44	274
	5	5	25	36	64	34	50	53	39	13	32	42	**393**
	6	0	12	14	26	4	3	19	23	8	37	19	165
	7	2	12	30	58	49	74	36	31	16	14	40	362
	8	3	8	32	40	5	22	44	17	30	36	33	270
	9	4	13	36	47	30	58	15	12	25	22	43	305
	10	2	13	27	50	23	22	18	20	12	28	35	250
	11	1	5	18	16	3	5	11	11	27	87	29	213
	12	3	20	28	73	35	55	46	20	16	43	39	378
Number		29	159	331	549	259	423	343	277	223	508	429	3530
Weight		9.5	63	197	308	142	226	165	141	118	275	194	1838.5
Avg. Wght.		0.33	0.40	0.60	0.56	0.55	0.53	0.48	0.51	0.53	0.54	0.45	0.52
NOTES:													
* = big, fat fruit			# = long, skinny fruit				Totals in Bold indicate 12 highest yielding plants						
** = tiny plants			^ = big open plant habit										

ATTACHMENT B

REPORT NUMBER
R217-079

A & L EASTERN AGRICULTURAL LABORATORIES INC.
7621 WHITEPINE RD. RICHMOND VA. 23237 804-743-9401

SEND TO: MIRANDA SMITH
P O BOX 180
BELCHERTOWN MA 01007

CUSTOMER: MIRANDA SMITH

SAMPLES SUBMITTED BY: MIRANDA SMITH

Initial NUTRIENT SOLUTION ~~POTTING MEDIA~~ ANALYSIS REPORT

DATE OF REPORT 8/9/95

PAGE 1

SAMPLE IDENT.	Lab No.	pH	Conductivity mmhos/cm	~~Ammonia Nitrogen ppm N~~ Total N ppm	Nitrate Nitrogen ppm N	Phosphorus ppm P	Potassium ppm K	Sulfur ppm S	Calcium ppm Ca	Magnesium ppm Mg	Sodium ppm Na	Iron ppm Fe	Aluminum ppm Al	Manganese ppm Mn	Copper ppm Cu	Zinc ppm Zn	Boron ppm B
1	43518		2.75	270		170	180	50	87	24							
2	43519		0.49	40		65	65	30	130	30							
3	42520		2.44	290		150	150	54	33	12							
4	43521		3.79	480		290	510	70	50	24							

Use potting media analysis table for reference.

Paul C.H. Chu, Ph.D.

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

A & L AGRICULTURAL LABORATORIES, INC.

By C. NORMAN JONES

REPORT NUMBER
R216-41A

A&L EASTERN AGRICULTURAL LABORATORIES, INC.

7621 Whitepine Road • Richmond, Virginia 23237 • (804) 743-9401
Fax No. (804) 271-6446

ACCT # 30155

SEND TO: MIRANDA SMITH
P O BOX 180

BELCHERTOWN MA 01007

GROWER:
MIRANDA SMITH

MIRANDA SMITH

SAMPLE NO.

DATE SAMPLED

CROP SAMPLED PEPPERS
CROP STAGE – Prior to Fertigation
LAB #: 216041

DATE OF REPORT: 08/08/95 PAGE: 1

PLANT ANALYSIS

REPORT OF ANALYSIS PERCENT

	N NITROGEN	S SULFUR	P PHOSPHORUS	K POTASSIUM	Mg MAGNESIUM	Ca CALCIUM	Na SODIUM	NO3 NITRATE	
LAB ANALYSIS RESULTS	3.22 D	0.68 VH	0.29 L	4.35 S	0.49 S	1.11 S	0.06 S		
NORMAL LEVELS	4.00 5.50	0.25 0.50	0.30 0.70	4.00 5.50	0.40 0.60	1.00 2.50	0.01 0.10		

REPORT OF ANALYSIS PARTS PER MILLION

	B BORON	Zn ZINC	Mn MANGANESE	Fe IRON	Cu COPPER	Al ALUMINUM	Mo MOLYBDENUM	
LAB ANALYSIS RESULTS	76 S	60 S	69 S	130 S	4 D	71 S		
NORMAL LEVELS	35 80	25 80	60 200	60 200	10 40	10 999		

RATIOS

	N/S	N/K	P/S	P/Zn	K/Mg	K/Mn	Ca/B	Fe/Mn		
ACTUAL RATIOS	4.7	0.7	0.4	48.3	8.9	630.4	146.1	1.9		
EXPECTED RATIOS	12.6	1.0	1.3	95.2	9.5	365.3	304.3	1.0		

D=DEFICIENT L=LOW S=SUFFICIENT H=HIGH VH=VERY HIGH

REMARKS:

Plants are deficient in nitrogen & copper and are lower than desired in phosphorus.
See potting media analysis report for recommendations.

A&L EASTERN AGRICULTURAL LABORATORIES, INC.

BY C. NORMAN JONES

REPORT NUMBER
R217-96A

A & L EASTERN AGRICULTURAL LABORATORIES INC.
7621 WHITEPINE RD. RICHMOND VA. 23237 804-743-9401

SEND TO: MIRANDA SMITH
P O BOX 180
BELCHERTOWN MA 01007

CUSTOMER: MIRANDA SMITH

SAMPLES SUBMITTED BY: MIRANDA SMITH

Prior to Fertigation

DATE OF REPORT 8/9/95 PAGE 1

POTTING MEDIA ANALYSIS REPORT

SAMPLE IDENT.	Lab No.	pH	Conductivity mmhos/cm	Ammonia Nitrogen ppm N	Nitrate Nitrogen ppm N	Phosphorus ppm P	Potassium ppm K	Sulfur ppm S	Calcium ppm Ca	Magnesium ppm Mg	Sodium ppm Na	Iron ppm Fe	Aluminum ppm Al	Manganese ppm Mn	Copper ppm Cu	Zinc ppm Zn	Boron ppm B
	43545	6.8	1.49	<1	23	30	310	200	100	33	26	47	7	14	0.14	3.0	0.34

Please consult the enclosed table for optimum nutrient ratings. Nitrogen and copper levels are low. You may want to mix chicken manure in your media to increase nitrogen and copper.

Paul C.H. Chu, Ph.D.

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

A & L AGRICULTURAL LABORATORIES, INC.

By C. NORMAN JONES

A & L EASTERN AGRICULTURAL LABORATORIES, INC.
7621 Whitepine Road • Richmond, Virginia 23237-2296 • Phone: 804-743-9401

EVALUATION OF POTTING MEDIA ANALYSIS
BY MODIFIED (DTPA) SATURATED EXTRACT METHOD

Parameter	Unit	Low	Adequate	High
pH (less than 20% soil)‡	-	<5.0	5.0-6.8	>6.8
pH (more than 20% soil)‡	-	<5.5	5.5-7.0	>7.0
Conductivity (mature plant)	mmho/cm	<0.7	0.7-3.5	>3.5
Conductivity (young plant)	mmho/cm	<0.5	0.5-2.0	>2.0
Available Nitrogen (NH_4-N + NO_3-N)	ppm	<40	40-200	>200
Phosphorus (less than 20% soil)	ppm	<5	5-25	>25
Phosphorus (more than 20% soil)	ppm	<2	2-18	>18
Potassium	ppm	<50	50-150	>150
Calcium	ppm	<50	50-200	>200
Magnesium	ppm	<20	20-150	>150
Sodium	ppm		0-80	>80
Sulfur	ppm	<20	20-200	>200
Boron	ppm	<0.5	0.5-2.0	>2.0
Iron	ppm	<15	15-40	>40
Manganese	ppm	<5	5-30	>30
Zinc	ppm	<5	5-30	>30
Copper	ppm	<2	2-30	>30

‡ 1:2 media:water

< = less than   > = more than   ppm = parts per million

The above table is a general guideline. Values may change with different plant types and growth stages. For example, there is a wide range of values under "adequate." For young plants or to slow growth rate, keep nutrient levels at lower end of the adequate range. To "push" the plant growth, add nutrients to the high end of the adequate range.

To convert conductivity (mmho/cm) to soluble salts, multiply by 640 (theoretical value) or 700 (empirical value).

Saturated Extract Method was written by D. D. Warncke.
NCR Publication No. 221.

Dedicated Exclusively to Providing Quality Analytical Services

REPORT NUMBER
R308-176A

A & L EASTERN AGRICULTURAL LABORATORIES INC.
7621 WHITEPINE RD. RICHMOND VA. 23237 804-743-9401

SEND TO:
MS MIRANDA SMITH
P O BOX 180
BELCHERTOWN, MA 01007

CUSTOMER:
MIRANDA SMITH

SAMPLES SUBMITTED BY:
MIRANDA SMITH

End of Season

POTTING MEDIA ANALYSIS REPORT

DATE OF REPORT 11/13/95 PAGE 1

SAMPLE IDENT.	Lab No.	pH	Conductivity mmhos/cm	Ammonia Nitrogen ppm N	Nitrate Nitrogen ppm N	Phosphorus ppm P	Potassium ppm K	Sulfur ppm S	Calcium ppm Ca	Magnesium ppm Mg	Sodium ppm Na	Iron ppm-Fe	Aluminum ppm Al	Manganese ppm Mn	Copper ppm Cu	Zinc ppm Zn	Boron ppm B
R	45168	7.2	0.50	<1	9	4	42	32	85	16	58						
R+	45169	7.1	0.60	<1	10	27	79	19	91	16	77						
C	45170	6.9	0.41	<1	11	6	33	34	78	14	47						

Please consult the enclosed table.

Paul Chu
Paul C.H. Chu, Ph.D.

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

A & L AGRICULTURAL LABORATORIES, INC.
By C. Norman Jones
C. NORMAN JONES

REPORT NUMBER
R313-3PA

A&L EASTERN AGRICULTURAL LABORATORIES, INC.

7621 Whitepine Road • Richmond, Virginia 23237 • (804) 743-9401
Fax No. (804) 271-6446

ACCT # 30155

SEND TO: MIRANDA SMITH
P O BOX 180

BELCHERTOWN MA 01007

GROWER:
MIRANDA SMITH

MIRANDA SMITH

SAMPLE NO. ROOTS

DATE SAMPLED

CROP SAMPLED
CROP STAGE End of Season

LAB #: 313032

DATE OF REPORT: 11/10/95 PAGE: 1

PLANT ANALYSIS

	REPORT OF ANALYSIS PERCENT								
	N NITROGEN	S SULFUR	P PHOSPHORUS	K POTASSIUM	Mg MAGNESIUM	Ca CALCIUM	Na SODIUM	NO_3 NITRATE	
LAB ANALYSIS RESULTS	4.13	1.63	1.11	6.01	1.36	3.74	0.06		
NORMAL LEVELS									

	REPORT OF ANALYSIS PARTS PER MILLION							
	B BORON	Zn ZINC	Mn MANGANESE	Fe IRON	Cu COPPER	Al ALUMINUM	Mo MOLYBDENUM	
LAB ANALYSIS RESULTS	181	63	163	349	46	185		
NORMAL LEVELS								

RATIOS

	N / S	N / K	P / S	P / Zn	K / Mg	K / Mn	Ca / B	Fe / Mn		
ACTUAL RATIOS	2.5	0.7	0.7	176.2	4.4	368.7	206.6	2.1		
EXPECTED RATIOS										

REMARKS:

A&L EASTERN AGRICULTURAL LABORATORIES, INC.

BY C. Norman Jones
C. NORMAN JONES

REPORT NUMBER
R313-33A

A&L EASTERN AGRICULTURAL LABORATORIES, INC.

7621 Whitepine Road • Richmond, Virginia 23237 • (804) 743-9401
Fax No. (804) 271-6446

ACCT # 30155

GROWER:

SEND TO: MIRANDA SMITH
P O BOX 180

BELCHERTOWN MA 01007

MIRANDA SMITH

MIRANDA SMITH

SAMPLE NO. ROOTS + DATE SAMPLED

CROP SAMPLED
CROP STAGE End of Season LAB #: 313033

DATE OF REPORT: 11/10/95 PAGE: 1

PLANT ANALYSIS

	REPORT OF ANALYSIS PERCENT								
	N NITROGEN	S SULFUR	P PHOSPHORUS	K POTASSIUM	Mg MAGNESIUM	Ca CALCIUM	Na SODIUM	NO_3 NITRATE	
LAB ANALYSIS RESULTS	4.42	1.27	0.69	5.61	1.39	4.05	0.07		
NORMAL LEVELS									

	REPORT OF ANALYSIS PARTS PER MILLION							
	B BORON	Zn ZINC	Mn MANGANESE	Fe IRON	Cu COPPER	Al ALUMINUM	Mo MOLYBDENUM	
LAB ANALYSIS RESULTS	198	59	195	328	14	165		
NORMAL LEVELS								

RATIOS

	N/S	N/K	P/S	P/Zn	K/Mg	K/Mn	Ca/B	Fe/Mn		
ACTUAL RATIOS	3.5	0.8	0.5	116.9	4.0	287.7	204.5	1.7		
EXPECTED RATIOS										

REMARKS:

A&L EASTERN AGRICULTURAL LABORATORIES, INC.

BY C. Norman Jones
C. NORMAN JONES

REPORT NUMBER
R313-34A

A&L EASTERN AGRICULTURAL LABORATORIES, INC.

7621 Whitepine Road • Richmond, Virginia 23237 • (804) 743-9401
Fax No. (804) 271-6446

ACCT # 30155

SEND TO: MIRANDA SMITH
P O BOX 180

BELCHERTOWN MA 01007

GROWER: MIRANDA SMITH

MIRANDA SMITH

SAMPLE NO. COMPOST

DATE SAMPLED

CROP SAMPLED
CROP STAGE End of Season

LAB #: 313034

DATE OF REPORT: 11/10/95 PAGE: 1

PLANT ANALYSIS

	REPORT OF ANALYSIS PERCENT								
	N NITROGEN	S SULFUR	P PHOSPHORUS	K POTASSIUM	Mg MAGNESIUM	Ca CALCIUM	Na SODIUM	NO_3 NITRATE	
LAB ANALYSIS RESULTS	3.57	1.71	0.85	5.81	1.47	4.56	0.05		
NORMAL LEVELS									

	REPORT OF ANALYSIS PARTS PER MILLION							
	B BORON	Zn ZINC	Mn MANGANESE	Fe IRON	Cu COPPER	Al ALUMINUM	Mo MOLYBDENUM	
LAB ANALYSIS RESULTS	197	53	180	233	11	123		
NORMAL LEVELS								

RATIOS

	N/S	N/K	P/S	P/Zn	K/Mg	K/Mn	Ca/B	Fe/Mn		
ACTUAL RATIOS	2.1	0.6	0.5	160.4	4.0	322.8	231.5	1.3		
EXPECTED RATIOS										

REMARKS:

A&L EASTERN AGRICULTURAL LABORATORIES, INC.

BY C. NORMAN JONES

A & L EASTERN AGRICULTURAL LABORATORIES, INC.
7621 Whitepine Road • Richmond Virginia 23237 • (804) 743-9401

R308-173A
11/13/95

final fertigation solutions

MS MIRANDA SMITH
P O BOX 180
BELCHERTOWN, MA 01007

SAMPLE I.D.	LAB #	TOTAL NITROGEN mg/l (ppm)
R	45161	220
R+	45162	1450
R2	45163	280
C	45164	280

Reported on as is basis.

Paul C.H. Chu, Ph.D.

C. NORMAN JONES

ATTACHMENT C--FERTIGATION RECIPES

Initial Recipes

Roots Plus for Tomatoes

Mixed at full recommended strength
Half recommended-strength dilution of SeaFish added

Compost Tea

Used at the color of weak black tea
Half recommended-strength dilution of SeaFish added

Roots

Mixed at full recommended strength
Half recommended-strength dilution of SeaFish added

Revised Recipes

Roots Plus for Tomatoes

Mixed at full recommended strength
SeaFish mixed at full recommended strength

Compost

Used at the color of weak black tea
SeaFish mixed at full recommended strength

Roots

Mixed at full recommended strength
SeaFish mixed at full recommended strength

Each fertigation required two gallons of the treatment solution.

Compost tea was made by immersing a standard-sized pillow case, 2/3's full of finished compost, in a 55-gallon barrel of water for three weeks.