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Growth Enhancement and Systemic Acquired Resistance of Seepage-irrigated Tomato for Fall 2001/ Spring 2002

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Introduction

Florida ranks second only to California in the United States in the production of vegetables and provides the only domestically produced vegetables from December through April. Transplants are utilized on over 40% of the vegetable acreage in FL. To stay competitive and comply with regulations, FL growers must become more efficient, increase yields and reduce their dependency on pesticides in keeping with consumer desires and environmentally driven legislation. Research from our program has shown that aspects of transplant production and handling can greatly enhance yield. A transplant technology that has shown promise in satisfying several production criteria listed above is the phenomenon of systemic acquired resistance (SAR) and its associated plant growth promoting (PGP) effects. The SAR and PGP effects elicited when organisms or compounds are introduced during transplant production carry over into the field to further benefit disease/nematode/insect control and yield. Continued experimentation in this area is necessary to amplify the SAR effect, heighten production efficiency, maximize yield, and develop protocols for best management practices.

The objective of this study was to develop a research data base on plant growth enhancement and systemic acquired resistance to disease and nematode challenges elicited by the application of biologicals (fungi and bacteria), pathogenesis-related proteins, organic amendments, chemical elicitors, plant growth regulators (auxins, gibberellins, cytokinins, etc.), and/or combinations thereof on tomato transplants.

Materials and Methods

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Trials were established at the Southwest FL Research and Education Center of the University of Florida in Immokalee.

Fall 2001 Trial. Commercially grown tomato transplant variety 'Agrisett,' seeded on August 14, 2001 into 242-cell styrofoam transplant trays, were placed in the SWFREC vegetable greenhouse on September 11, 2001. Treatments were applied according to greenhouse protocol (Table 1). There were eight treatments and four replications of each treatment. Soluble fertilizer, 20-20-20 Peters Professional (Scotts-Sierra Horticultural Products Company, Marysville, OH) at 106 ppm Nitrogen was applied twice weekly.

Five plants per treatment per replication were sampled 43 days after seeding (DAS) to determine if treatment differences existed between the transplants. Roots were washed and oven dried then weighed. Shoots were measured for plant height, stem diameter, leaf area, number of true leaves, and dry shoot weight. Additional plants were pulled for nematode and disease resistance assays.

The fall trial was transplanted in the field on September 28, 2001, at 18-inch in-row spacing row, to methyl bromide chloropicrin treated 32-inch beds spaced on 6-foot centers and covered with white-on-black plastic mulch. At bedding, P was broadcast applied as 800 pounds/acre of 5-17-8 granular N-P-K fertilizer. A 19-0-19 fertilizer at 1000 pounds /acre was banded in two grooves approximately 14 inches from the plants. Irrigation was by semi-closed seepage. Thirty plants per plot were transplanted with 8 treatments and 6 replications in a randomized complete block design. Plants were staked, tied, and pruned at appropriate intervals. Treatments were applied during the growing season according to field protocol (Table 1). Plant shoots were taken for dry matter accumulation comparisons 28 and 60 days after transplant (DAT). Fresh fruit were counted and weighed at 60 DAT.

Ten plants per plot were harvested on 12/18/01, January 3, 2002, and January 16, 2002. Fruit were separated into red/breaker and mature green, then sized into medium, large, and extra-large grades.

Spring 2002-Trial 1. Commercially grown tomato transplant variety 'Florida 47" seeded on January 8, 2002 into128-cell styrofoam transplant trays were placed in the SWFREC vegetable greenhouse on February 11, 2002. Treatments were applied according to greenhouse protocol (Table 2). Samples were pulled at 50 DAS for nematode and disease resistance assays and transplant differences. This trial was transplanted to the field but was quickly lost to tomato yellow leaf curl virus which was particularly virulent in the commercial industry that season.

Spring 2002-Trial 2. Commercially grown tomato transplant variety 'Florida 47" seeded on March 2, 2002 into 200-cell styrofoam transplant trays were placed in the SWFREC vegetable greenhouse on April 8, 2002. Treatments were applied according to greenhouse protocol (Table 2). Samples were pulled at 54 DAS for nematode and disease resistance assays and transplant differences. These plants were only subjected to our greenhouse screening trials

Data collected from all trials were analyzed by ANOVA (SAS) with mean separation via Fisher's Protected LSD at $p<0.05$ and 0.1.

Pathology

Tomato plants grown and treated as described above were transplanted to 6" pots containing MetroMix® 500 (The Scotts Co., Marysville, OH), and fertilized with 5 g Sierra™ slow-release fertilizer 17-6-12 N-P-K plus minor elements (The Scotts Co., Marysville, OH). Plants were maintained in the Plant Pathology greenhouse located at SWFREC, Immokalee. Plants were inoculated 7 days after transplanting with a suspension of *Xanthomonas campestris pv. vesicatoria* (Xcv) which causes bacterial spot on tomato. The inoculum contained tomato races 1 and 3 of Xcv mixed equally at 10^4 colony forming units per ml. The bacterial suspension was sprayed onto plants until runoff with a handheld aerosol canister. The amount of disease was rated at 7 to 21 days after inoculation based upon the number of bacterial lesions and/or the percentage of symptomatic leaf area per plant and converted to a standardize scale where 0= no disease and 5= entire plant symptomatic. Plants were inoculated on 10 Oct 01 and evaluated 17 and 29 Oct 01. In the spring, plants were inoculated on 12 Mar 02 and 2 May 02 and evaluated 20 Mar 02 and 10 May 02, respectively. The numbers from four replications of each treatment were subjected to ANOVA. Mean difference separation was by Duncans Multiple Range Test.

Nematology

Pre-Plant Analysis. At the time of transplanting into pots containing field soil, five plants were destructively sampled for root analysis using the WinRhizo root scanning software package. This software calculated root length, projected area, surface area, average root diameter, root volume, number of tips, number of forks, and number of crossings for the root system.

Experimental Design. Plants from all treatments were transplanted into 4" pots containing field soil which was naturally infested with *Meloidogyne incognita* (root-knot nematode). Soil had been obtained from a research farm in Sanford, Florida, and thoroughly mixed using a cement mixer before being placed in pots. Experiments were set up in randomized complete block design with 15 replications, maintained in the greenhouse, fertilized once a week, weeded by hand, and treated with insecticide as necessary.

Post-Plant Analysis. Plants were evaluated for growth and disease after four to five weeks. Measurements included terminal shoot length (taken from the last mature leaf to base of the stem), fresh root weight, fresh shoot weight, stem diameter (taken at the base of the stem), overall root condition (scale of 1- 5; 1 = good root condition, 5 = poor root condition), and nematode gall rating (Zeck, 1971; 0 = no galling, 10 = completely galled).

Statistical Analysis. Data collected from all trials were analyzed by General Linear Models procedure (GLM) (SAS) with mean separation via LSD at $p<0.05$.

Results

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Transplant Parameters. No treatment effect was noted on tomato transplant growth ($p \leq 0.05/0.10$) for fall 2001 (Table 3). In spring 2002 (Test 1) the root:shoot ratio ($p \leq 0.05$) for ReZist Cab'Y and the Control was greater than that of all treatments except the KeyPlex + Nutri-Phite treatment (Table 4). Furthermore, ReZist Cab'Y, KeyPlex + Nutri-Phite and the Control had greater dry root matter than KeyPlex alone and Stimplex at $p \leq 0.1$ (Table 4). There were no differences among treatments during spring 2002, test 2 (Table 5).

Tomato Plant Dry Weight and Fruit Development. All treatments had significantly greater dry shoot weight 28 DAT than the Actigard treatment in the fall 2001 field trial at $p \leq 0.05$ (Table 12). KeyPlex 350DP + Nutri-Phite, KeyPlex 350DP alone, and Companion treatments had a larger fresh fruit weight 60 DAT than the Control and Actigard treatments.

Tomato Yield. Fall 2001 production yielded few red/breaker fruit at first harvest. However, red extra-large fruit production for Companion and the Control was greater than for ReZist Cab'Y and Actigard at $p \leq 0.1$ (Table 13). Green extra-large, green total, and red plus green size categories showed all treatments with greater yields than Actigard at $p \leq 0.05$. No differences among treatments were noted for second harvests. Third harvest medium red fruit production was greater for Companion, KeyPlex + Nutri-Phite and the Control compared to Actigard at $p \leq 0.1$.

Harvest yields combined showed that KeyPlex + Nutri-Phite yielded more red/breaker medium yield than all but the Control and Companion treatments. Red total yield showed the Control yielded more red/breaker weight than KeyPlex alone or Actigard. KeyPlex + Nutri-Phite and Companion yielded more total green medium fruit than the Control and ReZist Cab'Y and KeyPlex + Nutri-Phite yielded more green extra-large fruit than KeyPlex alone, Stimplex, Companion, and Actigard at $p \leq 0.1$. Overall red and green totals showed KeyPlex + Nutri-Phite treatment having greater yield capacity than Liquid Seaweed/Stimplex, KeyPlex alone, and Actigard treated plants at $p \leq 0.05$. KeyPlex + Nutri-Phite had a greater yield capacity than the Control at $p \leq 0.05$.

Table 14 represents size categories of yield in pounds per plot regardless of color. At first harvest Actigard significantly reduced extra-large fruit production compared to all other treatments at $p \leq 0.05$. Across three harvests, only Actigard produced fewer extra-large fruit than the Control and no treatment produced more extra-large fruit than the Control. Companion and KeyPlex + Nutri-Phite produced more overall medium sized fruit than the Control.

Pathology

The mean disease ratings per treatment are presented in Tables 10 and 11. In the Fall 2001 trial, the plants receiving the Actigard treatment had the highest combined disease rating at 1.67. The plants receiving the Nutri-Phite or KeyPlex treatments individually had the least amount of disease at 0.70 and 0.66 combined disease rating, respectively. Plants receiving any of the other treatments were intermediary, including the Control plants with a combined disease rating of 0.91. Two treatments, Actigard and KeyPlex + Nutri-Phite had significantly higher disease ratings compared to the Control All other treatments, although lower, were not significantly different from the Control.

In the first spring trial (March 2002), although five of the treatments had a lower disease rating compared to the untreated plants, there were no differences in ratings detected among treated plants compared to untreated plants. Among plants that were treated, plants treated with Actigard or 94815 had less disease and were significantly separated compared to three of the other treatments (ReZist, KeyPlex and Nutri-Phite, Stimplex). None of the products completely suppressed the disease.

In the second spring trial (May 2002), differences were detected among the treatments. The Control had the highest disease rating although it was not statistically significant compared to six of the nine treatments. Plants treated with KeyPlex 350 DP alone, Actigard, and Stimplex had less disease rated compared to the Control plants. Plants treated with Actigard had the least disease, very few lesions, and were significantly separated from all other treatments.

Nematology

Pre-Plant Analysis. In test 1, in plant growth and root scans performed at the time of transplanting, Rezist/Cab'Y and KeyPlex/Nutri-Phite treatments had significantly longer shoot length, surface area, number of root tips, number

of root-forks, and number of root crossings than the untreated Control treatment (Table 6). Rezist/Cab'Y and KeyPlex had smaller stem diameters than the untreated Control. Nutri-Phite, KeyPlex, Companion, Actigard and Stimplex also had significantly more root tips than the untreated Control (Table 6). Compared to all other treatments, Rezist/Cab'Y increased shoot length, reduced stem diameter, increased surface area, increased numbers of root tips, forks, and crossings (Table 6). In test 2, increases in plant growth and root structure were not as dramatic for Rezist/Cab'Y and KeyPlex + Nutri-Phite treatments (Table 8). Although Rezist/Cab'Y again increased stem diameter and root tips compared to the nontreated Control, KeyPlex + Nutri-Phite treatment reduced shoot length and root forks compared to the Control (Table 8).

Post-Plant Analysis. In test 1, there were no statistically significant differences in shoot length, root weight, root condition, or gall rate between treatments and the nontreated Control, although some treatments did significantly differ from each other with regards to these variables (Table 7). Nutri-Phite was the only treatment that significantly increased stem diameter (Table 7). In test 2, KeyPlex + Nutri-Phite was the only treatment that significantly increased shoot and root weights compared to the nontreated Control (Table 9). There were no treatments that improved root condition or reduced galling by nematodes.

Discussion

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- Few treatment differences in transplant growth enhancement were noted in these trials. However, the effect of a greater root:shoot ratio exhibited by ReZist Cab'Y and the Control over all other treatments except the KeyPlex + Nutri-Phite and the fact that ReZist Cab'Y, KeyPlex + Nutri-Phite and the Control had greater dry root matter than KeyPlex alone and Liquid Seaweed Extract/Stimplex may have implications in stand establishment relating to survivorship and reduced transplant shock.
- The fact that Actigard had a lower dry shoot weight than all other treatments in the field 28 DAT has been noted repeatedly in our SAR trials and undoubtedly contributes to regularly noted yield reductions.
- Companion, KeyPlex + Nutri-Phite, and KeyPlex alone exhibited greater early fruit development 60 DAT than the Control; a factor that may have contributed to increased yield compared to the Control for both Companion and KeyPlex + Nutri-Phite.

Further studies should be undertaken with these materials to establish patterns of affect and to unlock application questions such as timing and rate.

Pathology

These trial results are very typical to results from previous trials in two aspects: 1) suppression of disease varies from trial to trial; 2) if suppression of the disease occurs, it is usually seen as a reduction in the disease rating compared to untreated plants and it is not an absence of disease.

In the fall and one of the spring trials, the KeyPlex + Nutri-Phite treatment resulted in a significantly higher disease rating compared to either treatment alone. In the second spring trial, the combination resulted in plants with a disease rating intermediate to either product alone. Although there may be a biological basis for this, there may be other contributing factors, and this phenomenon should be examined more critically before definitive conclusions can be drawn.

Overall, the results are encouraging in demonstrating the potential of these products to suppress disease. The variability issue is most probably related to seasonal and other environmental conditions that will always, to some degree, be different from year-to-year. The complexity of factors involving both plant growth and disease interaction will probable always insure that on some level, variability at each use will exist. However, the potential exists for these compounds to be used as an enhancement of plant growth and disease suppression as a contributing tool in an integrated pest management (IMP) program.

Nematology

Differences in plant growth measurements and root disease as assessed by root condition and gall ratings were not consistent between the two tests performed in the spring 2002. Results from the first trial indicated good potential for Rezist/Cab'Y and KeyPlex + Nutri-Phite treatments in enhancing plant growth which were not observed in the second trial. None of the treatments tested reduced galling caused by root-knot nematodes. This is not unexpected as reports of inducing systemic resistance to nematode infestation in plants are extremely rare. If found however, chemicals that induce any degree of resistance towards root-knot nematode in tomato would be extremely valuable tools for incorporation into production systems.

Table 1. SAR Tomato Trial, fall 2001 – Trial Specifications

TRT	PRODUCT/*COMPANY*	GREENHOUSE APPLICATIONS	FIELD APPLICATIONS
1	ReZist and Cab'y, *Stoller*	Foliar at 5 weeks (1/2 % each of ReZist and Cab'y) Max at I qt/acre	Foliar 21 DAT (1/2 % each of ReZist and Cab'y) Max at I qt/acre
2	KeyPlex 350DP, *Morse*, and Nutri-Phite *, Biagro Western Sales, Inc.*	Foliar at 4 weeks and 6 weeks (1/2 % KeyPlex 350 DP with ¼ % Nutri-Phite)	Transplant dip (1/2 % KeyPlex 350 DP with ¼ % Nutri-Phite) Foliar weekly (1/2 % KeyPlex 350 DP with ¼ % Nutri-Phite)
3	Nutri-Phite *, Biagro Western Sales, Inc.*	Foliar at 4 weeks and 6 weeks (¼ %)	Transplant dip (¼ %) Foliar weekly (¼ %)
4	KeyPlex 350DP, *Morse*	Foliar at 4 weeks and 6 weeks (1/2 %)	Transplant dip (1/2 %) Foliar weekly (1/2 %)
5	Companion, *Growth Products*	Drench at 4 weeks and 6 weeks (16 oz/100 gallon)	Transplant dip (16 oz/100 gallon)
6	Actigard 50WG, *Novartis*	NA	Foliar (0.75 oz/100 gal) Weekly for 6 applications
7	Liquid Seaweed conc., Stimplex, *Acadian Seaplants*	Drench at 4 weeks (8ml/10 liter) with Liquid Seaweed Conc. And 6 weeks (8ml/10 liter) with Stimplex	Transplant dip (12ml/ liter Stimplex) Foliar: at 6-8 in, 1st pre-bloom, and 1st fruit set (2.6 pints/acre Stimplex)
8	Control	NA	NA

Table 2. SAR Tomato Trial, Spring 2002 – Trial Specifications

TRT	PRODUCT/*COMPANY*	GREENHOUSE APPLICATIONS	FIELD APPLICATIONS
1	ReZist and Cab'y, *Stoller*	Foliar at 5 weeks (1/2 % each of ReZist and Cab'y) Max at I qt/acre	Foliar 21 DAT (1/2 % each of ReZist and Cab'y) Max at I qt/acre
2	KeyPlex 350DP, *Morse*, and Nutri-Phite *, Biagro Western Sales, Inc.*	Foliar at 4 weeks and 6 weeks (1/2 % KeyPlex 350 DP with ¼ % Nutri-Phite)	Transplant dip (1/2 % KeyPlex 350 DP with ¼ % Nutri-Phite) Foliar weekly (1/2 % KeyPlex 350 DP with ¼ % Nutri-Phite)
3	Nutri-Phite *, Biagro Western Sales, Inc.*	Foliar at 4 weeks and 6 weeks (¼ %)	Transplant dip (¼ %) Foliar weekly (¼ %)
4	KeyPlex 350DP, *Morse*	Foliar at 4 weeks and 6 weeks (1/2 %)	Transplant dip (1/2 %) Foliar weekly (1/2 %)
5	Companion, *Growth Products*	Drench at 4 weeks and 6 weeks (16 oz/100 gallon)	Transplant dip (16 oz/100 gallon)
6	Actigard 50WG, *Novartis*	NA	Foliar (0.75 oz/100 gal) Weekly for 6 applications
7	Stimplex, *Acadian Seaplants*	Drench at 4 weeks and 6 weeks (12ml/ liter)	Transplant dip (12ml/ liter) Foliar: at 6-8 in, 1st pre-bloom, and 1st fruit set (2.6 pints/acre Stimplex)
8	Control	Water	Water
9	94815, *Enquce Biochemicals*	NA	Transplant dip (1 gram/liter) Use distilled water

Table 3. Systemic acquired resistance trial, tomato transplant data, fall 2001.

Treatment	Stem Length (cm)	Stem Dia (mm)	Leaf Area (cm^2)	Dry Shoot (g)	Dry Root (g)	True Leaf (no)	Root Shoot Ratio
ReZist and Cab'Y	6.8	2.81	16.80	0.1390	0.0354	3.0	0.255
KeyPlex 350DP + Nutri-Phite	7.1	2.81	17.32	0.1311	0.0336	3.0	0.259
Nutri-Phite	7.2	2.86	17.37	0.1468	0.0362	3.0	0.248
KeyPlex 350DP	7.6	2.86	18.18	0.1515	0.0365	3.0	0.243
Companion	7.4	2.81	16.76	0.1448	0.0355	3.0	0.247
Liquid Seaweed Conc./Stimplex	7.3	2.79	17.30	0.1399	0.0363	3.1	0.260
Control	7.3	2.78	16.11	0.1384	0.0343	2.9	0.250
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS
$LSD_{0.10}$	NS	NS	NS	NS	NS	NS	NS

Table 4. Systemic acquired resistance trial, tomato transplant data, test 1, spring 2002

Treatment	Stem Length (cm)	Stem Dia (mm)	Leaf Area (cm^2)	Dry Shoot (g)	Dry Root (g)	True Leaf (no)	Root Shoot Ratio
ReZist and Cab'Y	12.4	2.38	25.75	0.2447	0.0645	4.2	0.265
KeyPlex 350DP + Nutri-Phite	12.8	2.43	26.24	0.2545	0.0630	4.2	0.247
Nutri-Phite	12.6	2.37	24.96	0.2488	0.0584	4.0	0.237
KeyPlex 350DP	12.3	2.38	24.70	0.2441	0.0555	4.0	0.228
Companion	12.8	2.37	25.35	0.2500	0.0590	4.0	0.237
Stimplex	13.0	2.38	26.17	0.2520	0.0558	4.0	0.222
Control	12.4	2.41	25.71	0.2443	0.0638	4.1	0.262
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	0.020
$LSD_{0.10}$	NS	NS	NS	NS	0.0061	NS	0.017

Table 5. Systemic acquired resistance trial, tomato transplant data, test 2, spring 2002

Treatment	Stem Length (cm)	Stem Dia (mm)	Leaf Area (cm^2)	Dry Shoot (g)	Dry Root (g)	True Leaf (no)	Root Shoot Ratio
ReZist and Cab'Y	10.4	2.98	24.92	0.3273	0.0842	5.0	0.259
KeyPlex 350DP + Nutri-Phite	10.4	2.97	23.93	0.3226	0.0846	5.0	0.262
Nutri-Phite	10.2	2.99	24.25	0.3255	0.0887	4.9	0.274
KeyPlex 350DP	10.7	3.03	24.79	0.3466	0.0917	4.9	0.266
Companion	10.4	2.99	24.08	0.3249	0.0901	4.9	0.279
Stimplex	10.7	3.08	24.98	0.3490	0.0904	5.0	0.260
Control	10.5	2.97	24.77	0.3319	0.0886	4.8	0.268
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS
$LSD_{0.10}$	NS	NS	NS	NS	NS	NS	NS

Table 6. Systemic acquired resistance trial, tomato transplant root scan data Spring 2002, test 1

Treatment	Shoot Length (cm)	Stem Diameter (mm)	Surface Area (cm^3)	Tips (no.)	Forks (no.)	Crossings (no.)
Rezist and Cab'y	315 a[1]	0.60 d	57.98 a	1277 a	2534 a	434 a
KeyPlex 350DP + Nutri-Phite	173 b	1.02 abc	51.21 a	701 b	1773 b	226 b
Nutri-Phite	127 bcd	1.05 abc	41.48 b	671 b	1431 bc	156 bcd
KeyPlex	133 bc	0.95 c	38.15 bc	676 b	1455 cd	143 cd
Companion	131 bc	0.99 abc	38.62 b	678 b	1416 bc	172 bc
Actigard 50WG	129 bc	0.98 bc	38.47 b	767 b	1373 c	157 bcd
Stimplex	128 bcd	1.03 abc	39.92 b	837 b	1401 bc	159 bcd
Control	102 cd	1.26 ab	36.81 bc	340 c	1177 cd	121 cd
94815	79 d	1.28 a	31.11 c	259 c	954 d	92 d
$LSD_{0.05}$	50.56	0.30	7.31	309.5	393.7	75.85

[1] Letters indicate significant differences between treatments at LSD = 0.05

Table 7. Systemic acquired resistance trial, tomato growth and disease after four weeks in root-knot nematode infested field soil, Spring 2002, trial 1.

Treatment	Shoot Length (cm)	Stem Diameter (mm)	Shoot Weight (g)	Root Weight (g)	Root Condition[1]	Gall Rate[2]
Rezist and Cab'y	52.51 ab[3]	6.01 b	39.37 ab	13.63 ab	2.00 a	4.05 a
KeyPlex 350DP + Nutri-Phite	52.87 ab	6.04 b	42.64 ab	14.01 ab	1.26 b	4.51 a
Nutri-Phite	52.76 ab	6.87 a	44.30 a	15.85 ab	1.24 b	4.54 a
KeyPlex	50.48 b	5.78 b	38.23 b	13.93 ab	2.11 a	4.37 a
Companion	49.52 b	5.90 b	37.51 b	13.11 b	1.89 ab	4.15 a
Actigard 50WG	55.08 a	6.01 b	38.08 b	11.13 b	2.11 a	3.71 a
Stimplex	50.13 b	6.06 b	37.63 b	21.28 a	2.29 a	3.99 a
Control	53.15 ab	6.09 b	42.79 ab	14.32 ab	1.86 ab	4.06 a
94815	53.04 ab	6.25 b	40.87 ab	13.29 b	1.77 ab	3.73 a
$LSD_{0.05}$	3.80	0.57	5.71	7.79	0.70	1.07

[1] Root Condition Rating: 1 = healthy, white roots, 5 = discolored, decomposed roots
[2] Gall Rate: 1 = no galling, 10 = complete galling (Zeck 1971)
[3] Letters indicate significant differences between treatments at LSD = 0.05

Table 8. Systemic acquired resistance trial, tomato transplant root scan data, Spring 2002, test 2

Treatment	Shoot Length (cm)	Stem Diameter (mm)	Surface Area (cm^3)	Tips (no.)	Forks (no.)	Crossings (no.)
Rezist and Cab'y	223.18 abc[1]	0.87 a	60.52 a	436 d	2045 abc	271 ab
KeyPlex 350DP + Nutri-Phite	199.30 c	0.83 ab	52.05 bc	503 cd	1843 c	242 b
Nutri-Phite	221.47 abc	0.75 b	51.70 c	600 bc	1929 bc	289 ab
KeyPlex	254.15 a	0.78 ab	62.20 a	640 b	2324 a	339 a
Companion	228.40 abc	0.87 a	61.09 a	788 a	2268 ab	317 a
Actigard 50WG	224.59 abc	0.78 ab	54.90 abc	885 a	1967 abc	281 ab
Stimplex	253.48 a	0.75 b	59.74 ab	782 a	2201 abc	317 a
Control	242.46 ab	0.76 b	57.52 abc	898 a	2267 ab	300 ab
94815	215.25 bc	0.81 ab	54.48 abc	869 a	2067 abc	286 ab
$LSD_{0.05}$	37.88	0.11	7.82	133.3	376.5	71.6

[1] Letters indicate significant differences between treatments at LSD = 0.05

Table 9. Systemic acquired resistance trial, tomato growth and disease after four weeks in root-knot nematode infested field soil, Spring 2002, test 2

Treatment	Shoot Length (cm)	Stem Diameter (mm)	Shoot Weight (g)	Root Weight (g)	Root Condition[1]	Gall Rate[2]
Rezist and Cab'y	34.69 ab[3]	5.52 abc	17.03 ab	8.79 ab	1.95 c	3.38 b
KeyPlex 350DP + Nutri-Phite	37.40 a	5.91 a	19.67 a	9.75 a	2.01 c	3.33 b
Nutri-Phite	34.10 ab	4.75 c	14.37 bc	6.37 abc	2.21 bc	2.77 b
KeyPlex	29.71 bc	4.75 c	10.61 cd	5.55 bc	3.51 a	6.18 a
Companion	31.64 bc	5.73 ab	12.44 bcd	5.43 bc	2.64 bc	3.57 b
Actigard 50WG	31.93 b	5.07 abc	11.16 cd	4.87 c	3.01 ab	2.29 b
Stimplex	33.61 ab	5.45 abc	14.25 bc	6.64 abc	2.50 bc	3.46 b
Control	33.00 ab	5.59 abc	12.65 bcd	5.81 bc	2.67 bc	3.71 b
94815	26.53 c	4.90 bc	8.47 d	6.23 abc	3.52 a	3.31 b
$LSD_{0.05}$	5.13	0.85	4.86	3.66	0.83	1.86

[1] Root Condition Rating: 1 = healthy, white roots, 5 = discolored, decomposed roots
[2] Gall Rate: 1 = no galling, 10 = complete galling (Zeck 1971)
[3] Letters indicate significant differences between treatments at LSD = 0.05

Table 10. Bacterial spot on tomato leaves treated with various compounds, Fall 2001.

Treatment	10/17/2001	10/29/2001	Combined
Control	0.98[1] bcd[2]	0.84 ab	0.91 cde
KeyPlex + Nutri-Phite	1.33 b	1.1 a	1.22 b
Nurti-Phite	0.83 cd	0.58 b	0.7 e
KeyPlex	0.7 d	0.63 b	0.66 e
Companion	0.85 cd	0.8 ab	0.83 de
Actigard	2.28 a	1.06 a	1.67 a
Liquid Seaweed	1.13 bc	1.2 a	1.16 bc
Rezist + Cab'y	1.08 bcd	0.93 ab	1.0 bcd

[1] Disease rating scale was 0 to 5 with 0= no disease and 5= 100% of plant leaf area affected.
[2] Numbers followed by same letters are not significantly different P=0.5.

Table 11. Bacterial spot on tomato leaves treated with various compounds, Spring 2002.

Treatment	3/12/2001	5/10/2002
ReZist+ Cab'y	3.8[1] a[2]	2.5 a
KeyPlex + Nutri-phite	3.55 ab	2.45 ab
Nutri-Phite	2.8 cd	2.6 a
KeyPlex	2.95 bc	2.1 bc
Companion	2.95 bc	2.65 a
Actigard	2.65 d	0.85 d
Liquid Seaweed	3.75 a	1.85 c
Control	3.3 abc	2.7 a
94815	2.7 cd	2.45 ab

[1] Disease rating scale was 0 to 5 with 0= no disease and 5= 100% of plant leaf area affected.
[2] Numbers followed by same letters are not significantly different P=0.5.

Table 12. Field sample data for SAR tomato trial, Fall 2001

Treatment	28 DAT Dry Shoot (g)	60 DAT		
		Dry Shoot (g)	Fresh Fruit (no)	Fruit Weight (g)
ReZist and Cab'Y	28.6	220.9	29	861.6
KeyPlex 350DP + Nutri-Phite	26.8	208.8	33	954.7
Nutri-Phite	28.4	226.6	28	824.2
KeyPlex 350DP	27.9	209.8	27	941.5
Companion	28.8	217.0	27	932.7
Actigard 50WG	20.1	204.6	22	394.1
Liquid Seaweed/Stimplex	26.4	228.0	26	743.2
Control	27.6	227.4	23	635.1
$LSD_{0.05}$	4.7	NS	NS	256.6
$LSD_{0.10}$	3.9	NS	NS	213.6

Table 13. SAR tomato trial yield in pounds per plot, fall 2001.

Harvest Treatment	Red Medium	Red Large	Red Extra-Large	Red Total	Green Medium	Green Large	Green Extra-Large	Green Total	Red and Green Total
First									
ReZist and Cab'Y	0	0.1	1.0	1.1	0.7	2.7	32.2	35.6	36.7
KeyPlex 350DP + Nutri-Phite	0	0.0	2.4	2.4	0.9	3.2	32.4	36.6	38.9
Nutri-Phite	0	0.0	1.2	1.2	0.7	3.0	32.0	35.7	36.9
KeyPlex 350DP	0	0.0	1.3	1.3	0.8	3.0	28.2	32.0	33.3
Companion	0	0.0	3.0	3.0	0.6	3.5	28.6	32.6	35.6
Actigard 50WG	0	0.1	0.4	0.4	0.6	2.3	20.9	23.7	24.2
Liquid Seaweed/Stimplex	0	0.0	1.2	1.2	0.5	2.6	32.7	35.9	37.1
Control	0	0.0	2.6	2.6	0.6	2.2	28.7	31.5	34.0
$LSD_{0.05}$	----	NS	NS	NS	NS	NS	5.1	5.6	5.7
$LSD_{0.10}$	----	NS	1.5	1.5	NS	NS	4.2	4.6	4.8
Second									
ReZist and Cab'Y	0.0	0.0	2.5	2.5	2.3	5.3	27.0	34.6	37.2
KeyPlex 350DP + Nutri-Phite	0.5	0.4	2.0	2.9	1.8	5.3	29.7	36.9	39.8
Nutri-Phite	0.0	0.3	2.9	3.2	1.9	5.7	29.8	37.4	40.6
KeyPlex 350DP	0.1	0.2	1.7	2.0	1.8	5.3	28.4	35.4	37.4
Companion	0.2	0.2	2.4	2.7	2.5	4.9	26.3	33.7	36.4
Actigard 50WG	0.0	0.2	1.4	1.6	1.7	4.4	26.4	32.4	34.0
Liquid Seaweed/Stimplex	0.1	0.0	2.0	2.2	2.0	4.0	22.6	28.6	30.9
Control	0.2	0.2	2.4	2.8	1.4	4.3	27.4	33.0	35.9
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS	NS
$LSD_{0.10}$	NS	NS	NS	NS	NS	NS	NS	NS	NS
Third									
ReZist and Cab'Y	0.9	0.6	1.4	2.9	8.6	6.7	18.6	34.0	36.8
KeyPlex 350DP + Nutri-Phite	1.6	0.6	1.9	4.2	10.3	6.9	15.6	32.8	37.0
Nutri-Phite	0.8	1.0	1.3	3.0	8.1	6.7	14.8	29.5	32.6
KeyPlex 350DP	0.5	1.0	1.6	3.1	7.6	7.8	12.6	27.9	31.0
Companion	1.4	0.7	1.8	3.8	10.8	9.6	13.8	34.1	38.0
Actigard 50WG	0.2	0.0	1.4	1.6	10.0	9.1	17.1	36.2	37.7
Liquid Seaweed/Stimplex	0.8	0.3	2.6	3.7	8.7	8.4	13.0	30.2	33.9
Control	1.4	1.2	2.0	4.7	8.4	7.2	14.6	30.2	34.8
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS	NS
$LSD_{0.10}$	0.8	NS	NS	NS	NS	NS	NS	NS	NS

Total									
ReZist and Cab'Y	1.0	0.6	5.0	6.5	11.6	14.7	77.9	104.2	110.7
KeyPlex 350DP + Nutri-Phite	2.1	1.0	6.3	9.4	13.1	15.4	77.8	106.2	115.6
Nutri-Phite	0.8	1.3	5.3	7.4	10.7	15.3	76.7	102.7	110.1
KeyPlex 350DP	0.6	1.2	4.5	6.3	10.1	16.2	69.1	95.4	101.7
Companion	1.5	0.9	7.1	9.5	13.8	18.0	68.7	100.5	110.0
Actigard 50WG	0.2	0.2	3.2	3.6	12.2	15.8	64.4	92.3	95.9
Liquid Seaweed/Stimplex	0.9	0.3	6.0	7.2	11.2	15.0	68.4	94.7	101.9
Control	1.6	1.4	7.0	10.1	10.4	13.6	70.6	94.7	104.8
$LSD_{0.05}$	1.1	NS	NS	3.7	NS	NS	NS	NS	11.4
$LSD_{0.10}$	0.9	NS	NS	3.1	2.2	NS	8.5	NS	9.5

Table 14. SAR tomato trial yield size grades (pounds per plot), and average fruit weight, fall 2001.

Harvest Treatment	Medium	Large	Extra-Large	Average Fruit Wt. (lb)
First				
ReZist and Cab'Y	0.7	2.8	33.3	0.489
KeyPlex 350DP + Nutri-Phite	0.9	3.2	34.8	0.516
Nutri-Phite	0.7	3.0	33.2	0.511
KeyPlex 350DP	0.8	3.0	29.5	0.518
Companion	0.6	3.5	31.6	0.510
Actigard 50WG	0.6	2.4	21.3	0.482
Liquid Seaweed/Stimplex	0.5	2.6	34.0	0.499
Control	0.6	2.2	31.2	0.508
$LSD_{0.05}$	NS	NS	5.2	NS
$LSD_{0.10}$	NS	NS	4.3	NS
Second				
ReZist and Cab'Y	2.4	5.3	29.5	0.454
KeyPlex 350DP + Nutri-Phite	2.3	5.7	31.8	0.451
Nutri-Phite	1.9	6.0	32.7	0.457
KeyPlex 350DP	1.8	5.6	30.0	0.451
Companion	2.6	5.1	28.7	0.456
Actigard 50WG	1.7	4.6	27.8	0.453
Liquid Seaweed/Stimplex	2.1	4.0	24.7	0.463
Control	1.6	4.5	29.8	0.467
$LSD_{0.05}$	NS	NS	NS	NS
$LSD_{0.10}$	NS	NS	NS	NS
Third				
ReZist and Cab'Y	9.5	7.3	20.0	0.375
KeyPlex 350DP + Nutri-Phite	12.0	7.5	17.6	0.375
Nutri-Phite	8.9	7.6	16.1	0.370
KeyPlex 350DP	8.1	8.7	14.2	0.373
Companion	12.1	10.3	15.5	0.362
Actigard 50WG	10.2	9.1	18.5	0.368
Liquid Seaweed/Stimplex	9.5	8.7	15.7	0.369
Control	9.8	8.4	16.6	0.367
$LSD_{0.05}$	NS	NS	NS	NS
$LSD_{0.10}$	2.4	NS	NS	NS
Total				
ReZist and Cab'Y	12.6	15.4	82.8	0.435
KeyPlex 350DP + Nutri-Phite	15.2	16.4	84.1	0.438
Nutri-Phite	11.5	16.6	82.0	0.442
KeyPlex 350DP	10.7	17.3	73.6	0.442
Companion	15.4	18.9	75.8	0.431
Actigard 50WG	12.4	16.0	67.5	0.420
Liquid Seaweed/Stimplex	12.2	15.4	74.4	0.438
Control	12.0	15.1	77.7	0.441
$LSD_{0.05}$	2.8	NS	10.0	NS
$LSD_{0.10}$	2.3	NS	8.3	NS