LSU AGCENTER
NEMATOLOGY RESEARCH REPORT

SEA-CROP 2008

EXECUTIVE SUMMARY

**2008 RESEARCH WITH SEA-CROP
CONDUCTED AT**

LOUISIANA STATE UNIVERSITY

In 2007-2008 a trial was conducted to evaluate the efficacy of Sea-Crop against plant pathogenic nematode species associated with major crop species in Louisiana. To date, this material has been tested on 4 economically important commodities (tomato, bell pepper, eggplant and strawberry). **Significant growth responses and yield increases have been documented on all four and significant nematode control has been demonstrated on all of the crops**. Research in 2008 with Sea-Crop involved trials with strawberry, eggplant, bell pepper, tomato and corn that were established in field environments using real-world production protocols. Microplot trials were also conducted with tomato, soybean, bell pepper and rice grown under both flooded and non-flooded conditions.

Soil treatments that significantly increased the yield of strawberry resulted from 345 pounds per acre of Methyl Bromide and from 400GPA of two percent Sea-Crop. Numerically, the greatest overall strawberry yields resulted from the combination of Methyl Bromide plus 400GPA of two percent Sea-Crop.

In the vegetable trial, Sea-Crop was evaluated against reniform nematode on eggplant, bell pepper and Tomato. With eggplant, significant yield increases were obtained with application of the product as seedling-dip, in-line-drip and as an in-transplant-hole treatments. For tomato, the product was efficacious against reniform nematodes and produced significant yield increases when employed as pre-transplant, seedling dip-treatments. Generally the application via drip irrigation produced less satisfactory nematode control and yield. Overall, the data for 2008 shows that Sea-Crop does have some activity against nematodes.

Field Trials

1. Strawberry Trial

In order to insure the presence of damaging species and levels of nematodes, soil at the Hammond, LA location, centered in the major strawberry-producing area of the state, was infested with root knot (*Meloidogyne hapla*) and ring nematodes (*Criconemella xenoplax*) prior to establishment of the test in late 2007 (see 2007 Report for planting details). A total of 4 treatments were included in the 2007 trial:

1.) Non-treated control
2.) Methyl Bromide (345 pounds/Acre) 2 weeks prior to transplanting
3.) Methyl Bromide 2 weeks prior to transplanting plus 200GPA of 2% Sea-Crop at transplanting
4.) Methyl Bromide 2 weeks prior to transplanting plus 400GPA of 2% Sea-Crop at transplanting
5.) 400GPA of 2% Sea-Crop at transplanting

2007-2008 Strawberry Data:
In all discussion of results, references to treatments with Sea-Crop imply a two percent solution.

Treatments 2, 3, 4 and 5 resulted in significant increases in plant height on 21 December 2007 (Table 1.). Plants that received treatments 3 and 4 had the greatest heights. Treatments 3 and 4 included a Methyl Bromide component prior to transplanting.

Plants that received treatments 2, 3, 4, and 5 had runner numbers that were significantly greater than the nine runners per plant mean for the nontreated control.

The numbers of *M. hapla* nematode juveniles in soil on 12/21/07 averaged 8,229 per 500cc for the non-treated control (Treatment 1).

Table 1. Strawberry Growth Data and Nematode Counts from 12/21/07.

Treatment Applied	Plant Height (cm)	Number of Leaves Per Plant	Number of Runners Per Plant	Nematodes per 500cc of Soil	
				M. hapla	*C. xenoplax*
1.	13.8c	17b	9b	8,229a	1,388a
2.	17.4b	25a	14a	2,137c	540b
3.	18.7a	27a	15a	2,465c	861b
4.	19.2a	31a	14a	2,981c	458c
5.	18.0b	29a	14a	4,096b	622b

Plant data are means of measurements from 10 plants per plot. Soil samples were collected by inserting a soil probe into the transplant hole of the plastic-covered rows (ten cores per plot) and collecting a sample to a depth of 15cm. Data were analyzed using Tukey's HSD test at the 5% level.

During 2008, strawberry fruit was harvested a total of 15 times. Harvest dates were 17, 20, 24, 27 and 31 March; 7, 10, 14, 17, 21, 24 and 28 April; and, 5, 8 and 12 May. Yield data for 2008 is summarized in Tables 2a-2c.

Strawberry fruit in all experimental plots was harvested, graded and weighed using commercial production protocols (see photos 1-5 in appendix). During hand harvesting of strawberry fruit, culls (non-marketable quality) were separated from marketable fruit. Fruit weight data was analyzed both on the basis of total yield per plot (culls and marketable fruit) and yields of marketable fruit only. Interpretation of both types of analyses was identical and therefore, only data for marketable fruit yields are included in this report.

Table 2a. Yield (pounds) of Strawberry Fruit at Intervals 1-6 During 2008.

Treatment Applied	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5	Harvest 6
1.	9.5a	4.0a	3.2a	8.0ab	4.4ab	5.9b
2.	8.1a	4.1a	5.6a	11.0ab	3.4ab	11.4a
3.	7.9a	4.4a	5.3a	11.0ab	4.4ab	10.1ab
4.	9.3a	4.4a	5.4a	9.0ab	5.4ab	8.2ab
5.	10.5a	5.1a	4.0a	8.6ab	4.3ab	9.1ab

Data are means of 4 replications and were analyzed using Tukey's HSD (Honestly Significant Difference) test at the 5% level. Means followed by common letters are not significantly different.

Table 2b. Yield (pounds) of Strawberry Fruit at Intervals 7-12 During 2008.

Treatment Applied	Harvest 7	Harvest 8	Harvest 9	Harvest 10	Harvest 11	Harvest 12
1.	2.8b	3.4f	2.6ab	2.8c	2.4c	1.4ab
2.	4.6ab	7.5abcd	4.5ab	5.1abc	4.8abc	2.3ab
3.	4.1ab	7.0abcde	4.2ab	4.7abc	4.6abc	2.0ab
4.	4.6ab	7.7abc	4.4ab	6.2abc	7.2a	2.4ab
5.	3.0ab	5.6abcdef	2.9ab	4.0abc	3.6c	1.2ab

Data are means of 4 replications and were analyzed using Tukey's HSD (Honestly Significant Difference) test at the 5% level. Means followed by common letters are not significantly different.

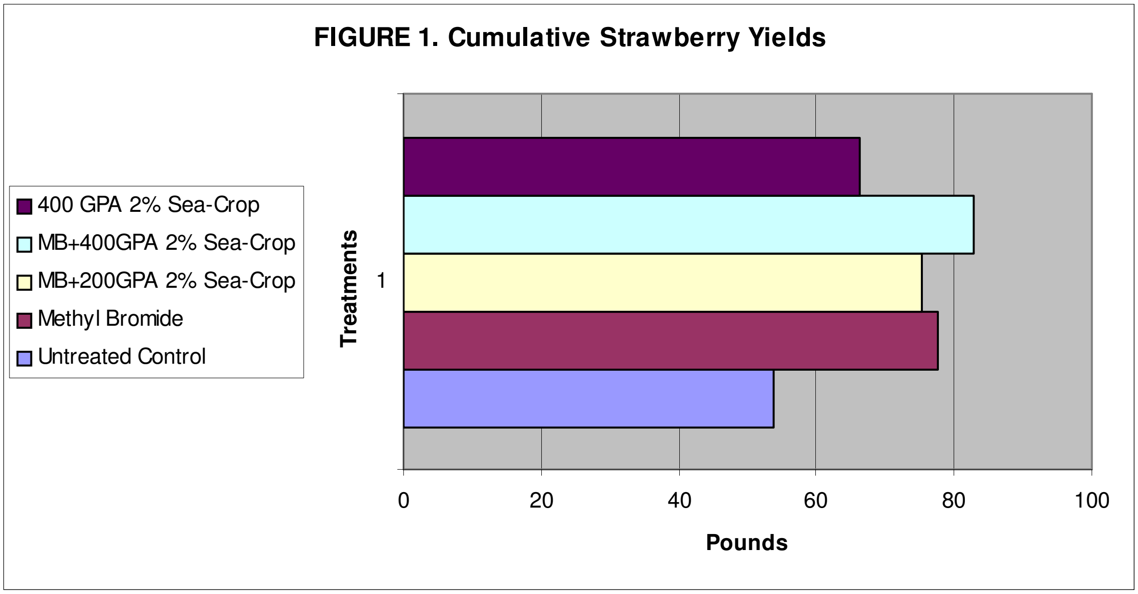
Table 2c. Yield (pounds) of Strawberry Fruit at Intervals 13-15 and Total Cumulative Yield for 2008.

Treatment Applied	Harvest 13	Harvest 14	Harvest 15	**TOTAL CUMULATIVE FRUIT HARVEST**
1.	1.0a	1.0c	2.3d	53.7g
2.	1.0a	1.2bc	4.0abcd	77.7abc
3.	1.0a	1.6abc	3.9abcd	75.2abcd
4.	1.0a	3.0ab	5.3a	82.8a
5.	.0a	1.2bc	3.2abcd	66.3abcdefg

Data are means of 4 replications and were analyzed using Tukey's HSD (Honestly Significant Difference) test at the 5% level. Means followed by common letters are not significantly different.

The cumulative fruit yields over all 15 harvests the season mirrored somewhat results seen during the individual harvests. That is, treatments that significantly increased yields were related to Methyl Bromide and to the 400GPA rate of Sea-Crop (Figure 1.). Numerically, the greatest overall yield, 82.8 pounds per plot, resulted from treatment of soil with a combination of Methyl Bromide (345 pounds/Acre, 2 weeks prior to transplanting) followed at transplanting by the application of a 400GPA rate of 2% Sea-Crop into the transplant holes.

FIGURE 1. Cumulative Strawberry Yields (in pounds) across 15 harvests for 2007-2008 Sea-Crop Trial as Influenced by 4 Treatments.



Immediately following harvest 15, soil samples were collected from all plots for analysis of nematode populations in soil (Photograph 6). Populations of the root knot nematode, *Meloidogyne incognita*, were reduced significantly by all treatments except number 5 (Figure 2.). Although root knot populations in soil were reduced significantly by all other treatments, the greatest reductions occurred with treatments 3 and 4. As was the case with root knot nematode, 400GPA of Sea-Crop into the transplant hole (treatment 5) was an ineffective treatment against the ring nematode, *Criconemella xenoplax* (Figure 3.).

Table 3. Nematode Counts from Soil Samples Collected after Harvest 15.

Treatment	Nematodes per 500cc of Soil	
Applied	*Meloidogyne hapla*	*Criconemella xenoplax*
1.	36,228a	3436a
2.	13,710de	508c
3.	11,185e	328d
4.	12,538e	877c
5.	26,461ab	4362a

Soil samples were collected by inserting a soil probe into the transplant hole of the plastic-covered rows (20 “cores” per plot) and collecting a sample to a depth of 15cm. Data was analyzed using Tukey’s HSD (Honestly Significant Difference) test at the 5% level. Means followed by common letters are not significantly different.

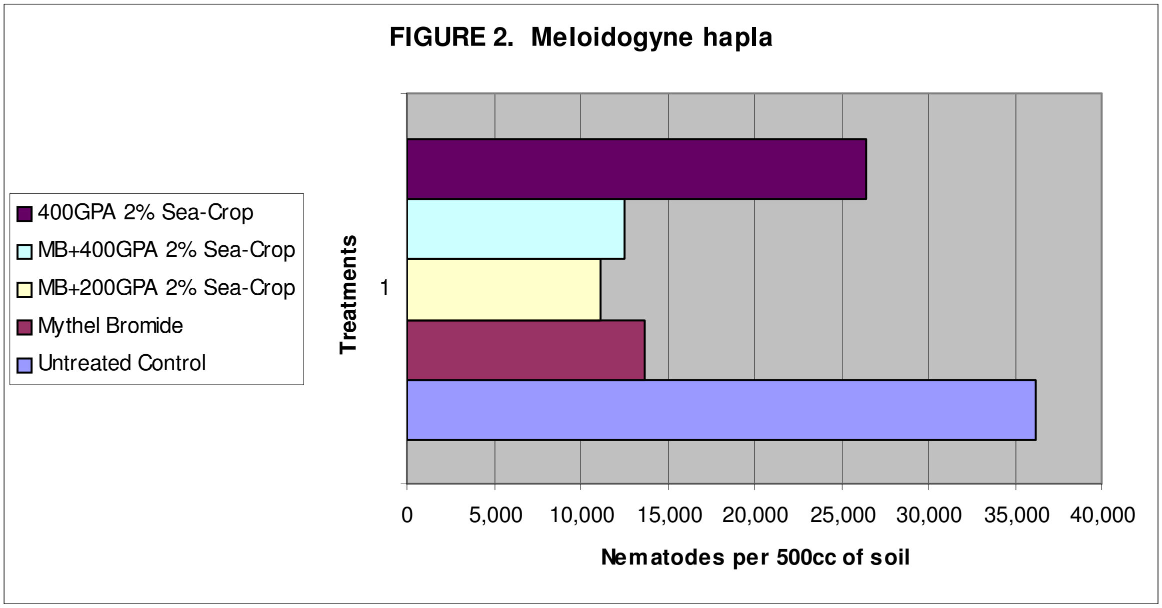


FIGURE 2. Numbers of *Meloidogyne hapla* (root-knot nematode) Juveniles per 500cc of Soil at Final Harvest of the 2007-2008 Sea-Crop Strawberry Trial as Influenced by 4 Treatments (see text for description of individual treatments). Soil for analysis of nematode populations was collected by inserting a soil probe into the transplant hole of the plastic-covered rows and collecting 20 soil "cores" per plot to a depth of 15cm.

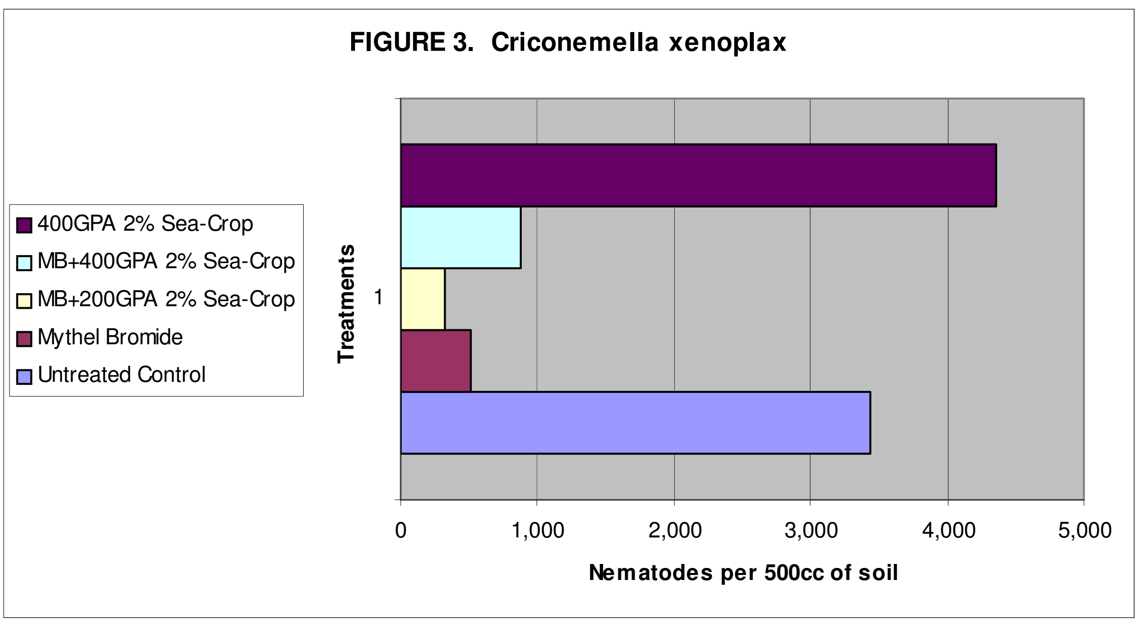


FIGURE 3. Numbers of *Criconemella xenoplax* (ring nematodes) per 500cc of Soil at Final Harvest of the 2007-2008 Cal-Agri Strawberry Trial as Influenced by 4 Treatments (see text for description of treatments).

Soil for analysis of nematode populations was collected by inserting a soil probe into the transplant hole of the plastic-covered rows and collecting 20 soil cores per plot to a depth of 15cm (Photograph 6). Intact plants were also inspected for root damage (Photograph 7).

2008-2009 activity with Strawberry:

Prior to establishment of the trial, soil samples from the site were collected and submitted for analysis to the LSU Soil Testing Laboratory. Soil fertility and pH were then adjusted as per recommendations of the soil-testing laboratory. Methyl bromide was applied as Terr-O-Gas 50 (345 pounds/Acre) concomitant with the application of 8-mm-thick black plastic film and drip lines to the rows in the field on 29 September 2008. Certified (LUC LAREAULT, Inc., 90 rue Lareault, C.P. 96, Quebec, Canada J5T 4A9) 'Festival' strawberry seedlings were transplanted as "plugs" (Photograph 8) through appropriately spaced markings on black plastic covered rows. "Seedling dip" (Photograph 9),"drip irrigation" (Photograph 10) and "in transplant hole" (Photograph 11) treatments were applied on 15 October 2008. The "in transplant hole" treatments were added to soil by apportionment, via a CO_2 pressurized backpack sprayer, of the required amount of material into the 48 strawberry seedling transplant holes in the plastic film of each plot (Photographs 12 and 13).

A randomized block design was employed for the trial. Treatments were replicated 4 times. Strawberry rows were 200' long (see Appendix, page 21).

Individual plots were 30' in length with a 3-foot gap between plots. Two parallel rows of transplant holes (24 per row/48 per plot) were punched along the length of each row for establishment of transplants and application of required chemical treatments. Drip treatments could not be completely randomized within the test; but the 4 replications did run from front to rear along the lengths of 4 individual rows. During the growing season, foliar pests and weeds are/will be managed using pesticides recommended by the Louisiana Cooperative Extension Service Plant Disease Control Guide. Plant and nematode data from the trial will be analyzed using the 'Fit Y by X' module of JMP, the Macintosh version of SAS. Treatment means are compared using Tukey's HSD (Honestly Significant Difference) test at the 5% level.

Treatments for the 2008-2009 Strawberry trial were as follows:

1.) Non-treated control
2.) Methyl Bromide
3.) Methyl Bromide plus 400GPA equivalent of 2% Sea-Crop via drip irrigation in early March of 2009
4.) Transplants soaked for 10 seconds in 2% Sea-Crop prior to transplanting
5.) Sea-Crop (80 milliliters of 2% per transplant hole) at transplanting
6.) Sea-Crop (40GPA equivalent of 2%) via drip irrigation at transplanting
7.) Sea-Crop (80 milliliters of 2% per transplant hole) at transplanting plus 400GPA equivalent of 2% Sea-Crop via drip irrigation in March 2009
8.) 400GPA equivalent of 2% Sea-Crop applied via drip at transplanting and again in March of 2009

**NOTE: Dip treatments resulted, on average, in the uptake of 8.2 grams of solution per plug. Also, a 10GPA equivalent equals 360ml for 60' plots and 180ml for 30' plots (see map on page 21). Similarly, 20, 40 and 400GPA equivalents equal respectively 720, 1,320 and 12,480ml for 60' plots and 360, 660 and 6,240ml for 30' plots.

2. Vegetable Trial

The vegetable trial was conducted at the Burden Research Plantation in Baton Rouge. Prior to establishment of this trial, soil samples from the research site were collected and submitted for analysis to the LSU Soil Testing Laboratory. Soil fertility and pH were then adjusted as per recommendations of the soil-testing laboratory for the crops to be produced. During the growing season, foliar pests and weeds were managed using pesticides recommended by the Louisiana Cooperative Extension Service Plant Disease Control Guide. Soil at this site contains high levels of the reniform nematode, *Rotylenchulus reniformis*, and only minimal levels of other nematode and fungal soil-borne pathogens. Since pepper is not a good host for reniform nematode, soil in rows to be planted with pepper was infested with the rootknot nematode, *Meloidogyne incognita,* by sprinkling soil from greenhouse cultures of the nematode into the planting area just prior to application of plastic film (Photograph 14) to the rows. In 2006, a drip-irrigation system, which we employed both for supplemental irrigation and in-line chemical application, was installed at this site in order to simulate a commercial vegetable production system. The front and rear of all plots was equipped with shut off valves that allowed for "chemigation" of desired plots in the entire, three-crop trial (Photograph 17). A randomized block design was employed for the trial. Treatments were replicated four times. Individual plots were two rows wide, 20 feet in length and spaced 36 inches on center. Transplant holes were punched along the length of each row for establishment of transplants and application of "in transplant hole" chemical treatments as described for the strawberry trial. Plant and nematode data was analyzed using the 'Fit Y by X' module of JMP, the Macintosh version of SAS. Treatment means were compared using Tukey's HSD (Honestly Significant Difference) test at the 5% level.

Tomato (variety 'BHN 640'), pepper (variety 'Stiletto') and eggplant (variety 'Santana') were established from transplants on 18 April 2008. These are the most popular varieties in the Southern U.S. for each crop, primarily because of their resistance to Tomato Spotted Wilt virus. "Seedling dip" (Photograph 15), "drip irrigation" (Photograph 16) and "in transplant hole" (same as strawberry trial) treatments were applied on 18-19 April 2008. The "in transplant hole" treatments were added to soil by apportionment, via CO_2 pressurized backpack sprayer, of the required amount of material into the seedling transplant holes in the plastic film of each plot. Fruit was hand-harvested (Photographs 18-20), weighed and pepper and tomato graded by size category on 20, 25 and 30 June and 8, 15 and 21 July.

Treatments applied were as follows:

1.) Non-Treated control
2.) 5 second dip in 0.5% Sea-Crop

The treatment produced significant increase in the yield of eggplant relative to that of the non-treated control (Table 4.).

Pepper yields were not impacted by the treatments. This due largely to the low level of nematode reproduction, either reniform or root-knot, on this crop. Even though the indigenous nematode community in soil of the pepper plots, almost exclusively reniform nematode, was augmented by the addition of root-knot, nematode levels remained low (see nematode data of Table 6.) and root knot populations were below detectable levels at the conclusion of the trial. Tomato, on the other hand, is a very good host for reniform nematode and its' pathological impact is evident from the yield data of Table 4.

Table 4. Cumulative Fruit Yields (Pounds) for the 2008 Sea-Crop Vegetable Trial (Burden Farm Research Station).

Treatment	Eggplant	Pepper	Tomato
1.	160.8b	46.7a	114.8c
2.	268.3a	61.0a	196.6a

Data are means of 4 replications and were analyzed using Tukey's HSD (Honestly Significant Difference) test at the 5% level. Means followed by common letters are not significantly different.

The "dip" treatments with Sea-Crop produced a significant yield increase with tomato results. The cumulative yield response of the three crops and data for the four tomato fruit size categories is presented graphically as Figures 4 and 5.

Table 5. Weights (Pounds) of Tomato Fruit in Four Size Categories from the 2008 Sea-Crop Vegetable Trial (Burden Farm Research Station).

Treatment	Small	Medium	Large	Extra Large	**TOTAL**
1.	1.6a	10.6a	46.3a	56.3b	114.8c
2.	2.4a	14.0a	74.0a	106.2a	196.6a

Data are means of 4 replications and were analyzed using Tukey's HSD (Honestly Significant Difference) test at the 5% level. Means followed by common letters are not significantly different. Population data for reniform nematodes present in soil at the conclusion of the vegetable trial is presented in Table 6. Eggplant and tomato are both good hosts of reniform nematode and pepper is a poor host. As mentioned earlier, however, the relatively lower reniform populations on pepper were still able to out-compete the root knot populations that were added prior to the trial. Suppression of root-knot nematode by reniform is documented on several other crops, most notably soybean and cotton (Stetina and McGawley, 1997, Journal of Nematology).

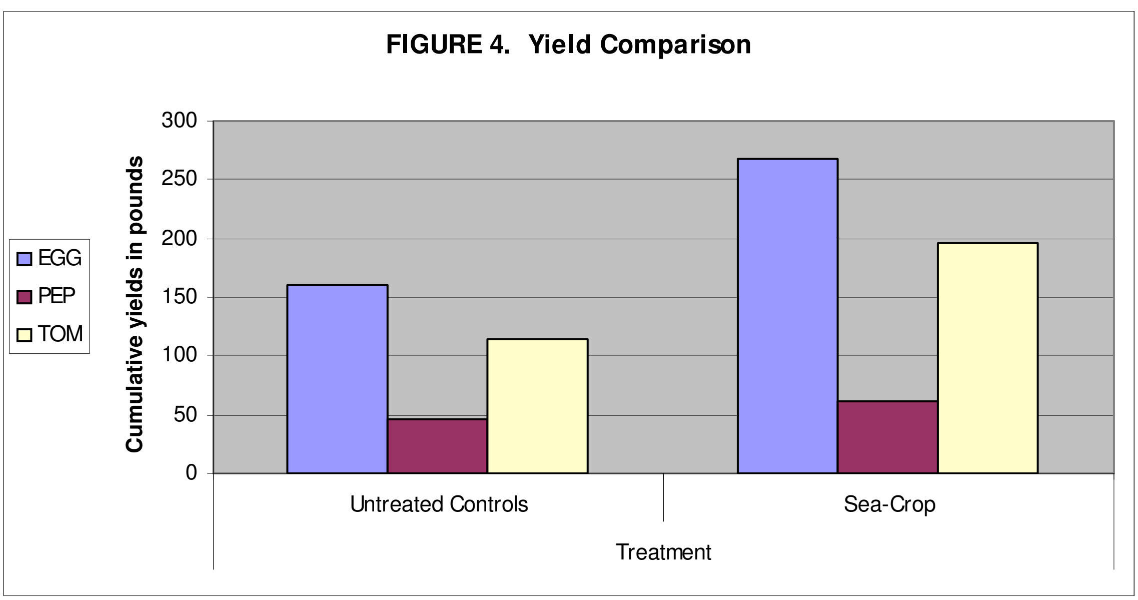


FIGURE 4. Cumulative Eggplant (EGG), Pepper (PEP) and Tomato (TOM) Yields (in pounds) Across 6 Harvests for 2008 Cal-Agri Trial as Influenced the Treatment (see text for treatment description).

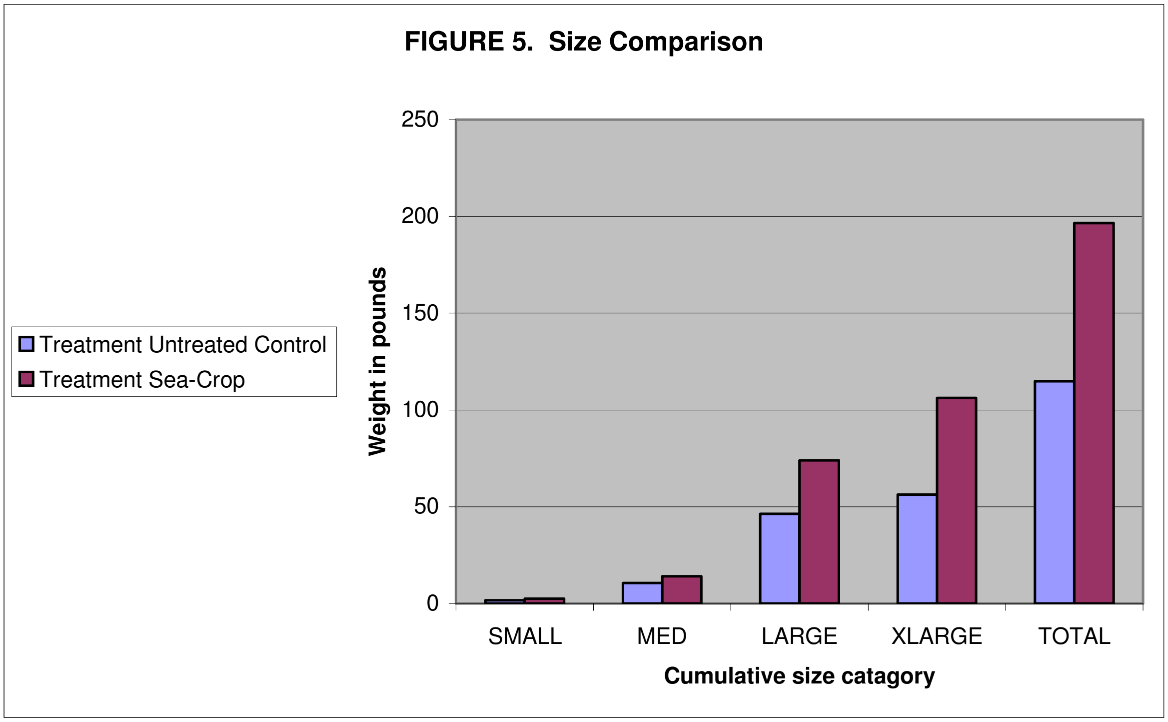


FIGURE 5. Cumulative Size Category (MED=medium, XLRGE= extra large) Weights (in pounds) of Tomato Fruit across 6 Harvests for 2008 Cal-Agri Trial as Influenced by the treatment (see text for treatment descriptions).

Table 6. Numbers of Reniform Nematode per 500cc in the 2008 Sea-Crop Vegetable Trial (Burden Farm Research Station).

Treatment	Eggplant	Pepper	Tomato
1.	82,344a	7,946a	107,002a
2.	9,274b	5,100a	74,128b

Data are means of 4 replications and were analyzed using Tukey's HSD (Honestly Significant Difference) test at the 5% level. Means followed by common letters are not significantly different.

As a dip treatment Sea-Crop produced significant reductions in populations of reniform nematode in soil at harvest. Sea-Crop was effective against reniform nematode.

3. Corn Trial

The field trial with corn (variety DeKalb 6971) was conducted at the Ben Hur Research Station in Baton Rouge. Prior to establishment, soil samples from the site were collected and submitted for analysis to the LSU Soil Testing Laboratory. Soil fertility and pH were then adjusted as per recommendations of the soil-testing laboratory. During the growing season, foliar pests and weeds were managed using pesticides recommended by the Louisiana Cooperative Extension Service Plant Disease Control Guide. Pre-trial soil samples collected from the Ben Hur site showed that indigenous nematode communities were appropriate for the corn crop as the soil had been artificially infested prior to the 2007 trial in the same location. Soil at this site was a Commerce silt loam soil [fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts] with a pH of 6.8-7.1 and an organic matter content of 1.0-1.4 percent.

Nematodes added to soil at the corn test site in 2007 were: the spiral nematode, *Helicotylenchus pseudorobustus*, the stunt nematode, *Tylenchorhynchus claytoni*, the stubby-root nematode, *Paratrichodorus minor*, the pin nematode *Paratylenchus projectus* and the ring nematode *Criconemella xenoplax.*

The corn trial was established on 26 March 2008, grew well (Photographs 21 and 22) but was not harvested due to hurricane Gustav that hit Louisiana on 1 September and devastated the entire trial and most of the research farm facility (Photograph 23).

Treatments for the Corn Trial were as follows:

1. Non-treated control
2. 50GPA of 4% Sea-Crop
3. 100GPA of 4% Sea-Crop

Nematode data presented here was from soil samples collected three weeks after hurricane Gustav. The corn crop was completely flattened by the hurricane and decomposing plant material covered the entire field, which was hand-raked in order to locate plots and collect soil samples. "Guarded" conclusions only can be gleaned from this data. There were no differences in final populations of spiral nematode associated with any of the treatments (Table 7.). With stubby root nematode, populations associated with all treatments were reduced significantly below those of the non-treated control. Values for nematode community totals, the sums of the individual population densities, were reduced significantly below that of the mean for non-treated plots. Several corn-parasitic nematode genera (pin and stunt nematodes) that were added to soil at this site in 2007 were not recoverable at the conclusion of the 2008 trial

Table 7. Post-Hurricane Totals per 500cc of Soil for Individual Nematode Populations and Community (sum of populations) from 'DeKalb 6971' Corn in Response to Application of Eight Treatments.

Treatment	Spiral[1]	Stubby-Root	Ring	**Total**
1.	935a	2,198a	1,025a	4,158a
2.	320a	1,164a	115b	1,599b
3.	205a	139b	1,730a	2,074b

[1]Spiral is *Helicotylenchus pseudorobustus*, Stubby-root is *Paratrichodorus minor*, and Ring is *Criconemella xenoplax*. Data was analyzed using Tukey's HSD (Honestly Significant Difference) test at the 5% level. Means followed by common letters are not significantly different.

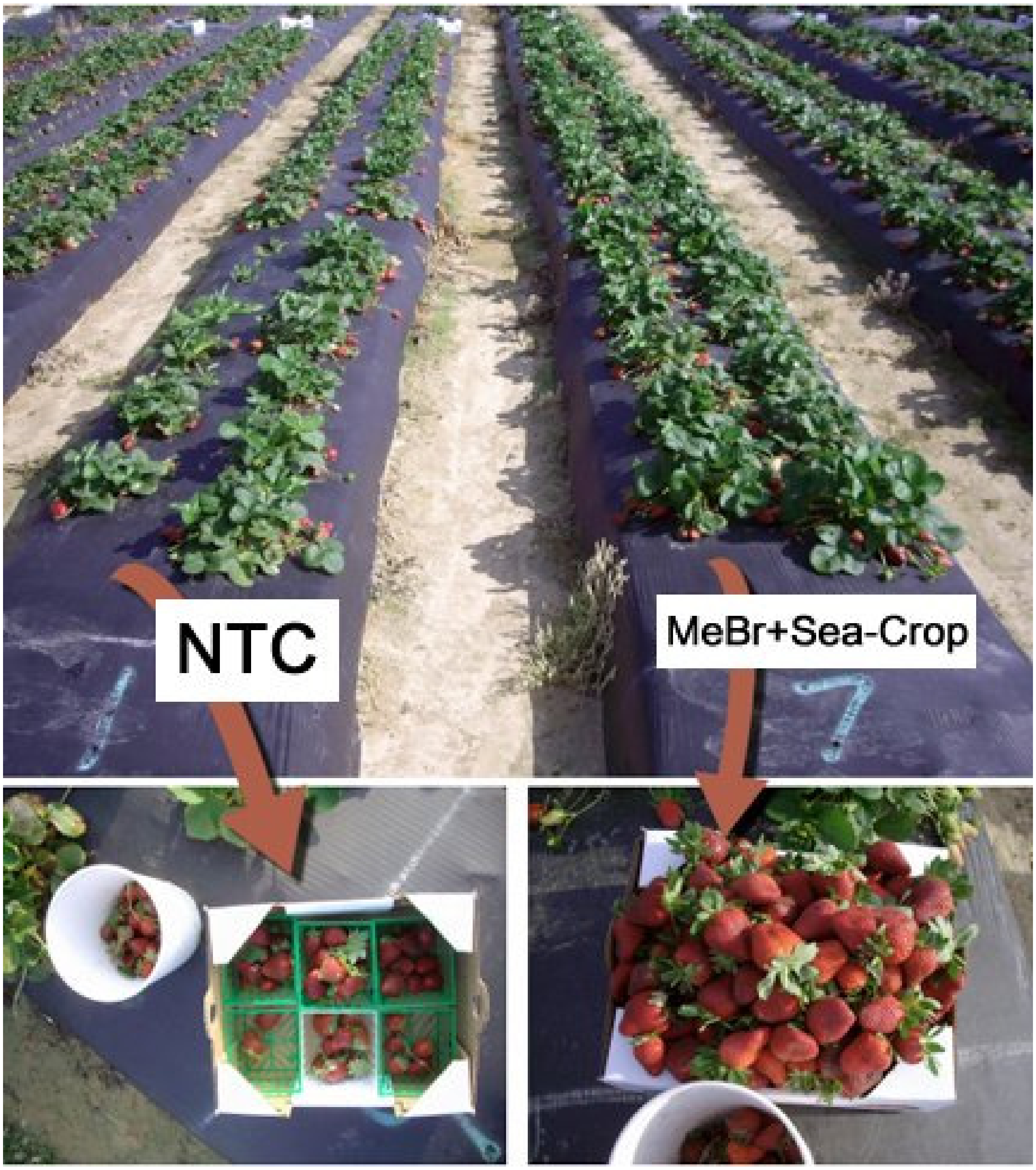
ENDNOTES:

1. All microplots were completely destroyed by hurricane Gustav. The reader is directed to the photographs on pages 38-43 of this document.
2. ABSOLUTELY all research detailed in this document resulted from cooperation with many other LSU AgCenter personnel; most notably Drs. Regina Bracy (Professor and Resident Director of the Hammond Research Station) and Jimmy Boudreaux (Professor, LSU Department of Horticulture).

APPENDIX FOR 2008 FIELD TRIALS:

Photograph 1. Overview of the Hammond, LA test site.

Photograph 2. Strawberry harvest. Note marketable fruit in flats, “culls” in bucket.



Photograph 3. Rows of strawberries representing the non-treated control (NTC) and Methyl bromide plus Agri-Verde treatments (see text for description of treatments).

Photograph 4. Weighing marketable fruit and cull yields from plots.

Photograph 5. Beautiful strawberries.

Photograph 6. Collecting soil samples for analysis of nematode populations.

Photograph 7. Bagged plants collected for examination of root systems.

Photograph 8. “Plug” strawberry seedlings used in the 2008-2009 trial.

Photograph 9. Dipping seedlings in test solutions prior to transplanting.

Photograph 10. Application of chemical treatments via drip irrigation tubing.

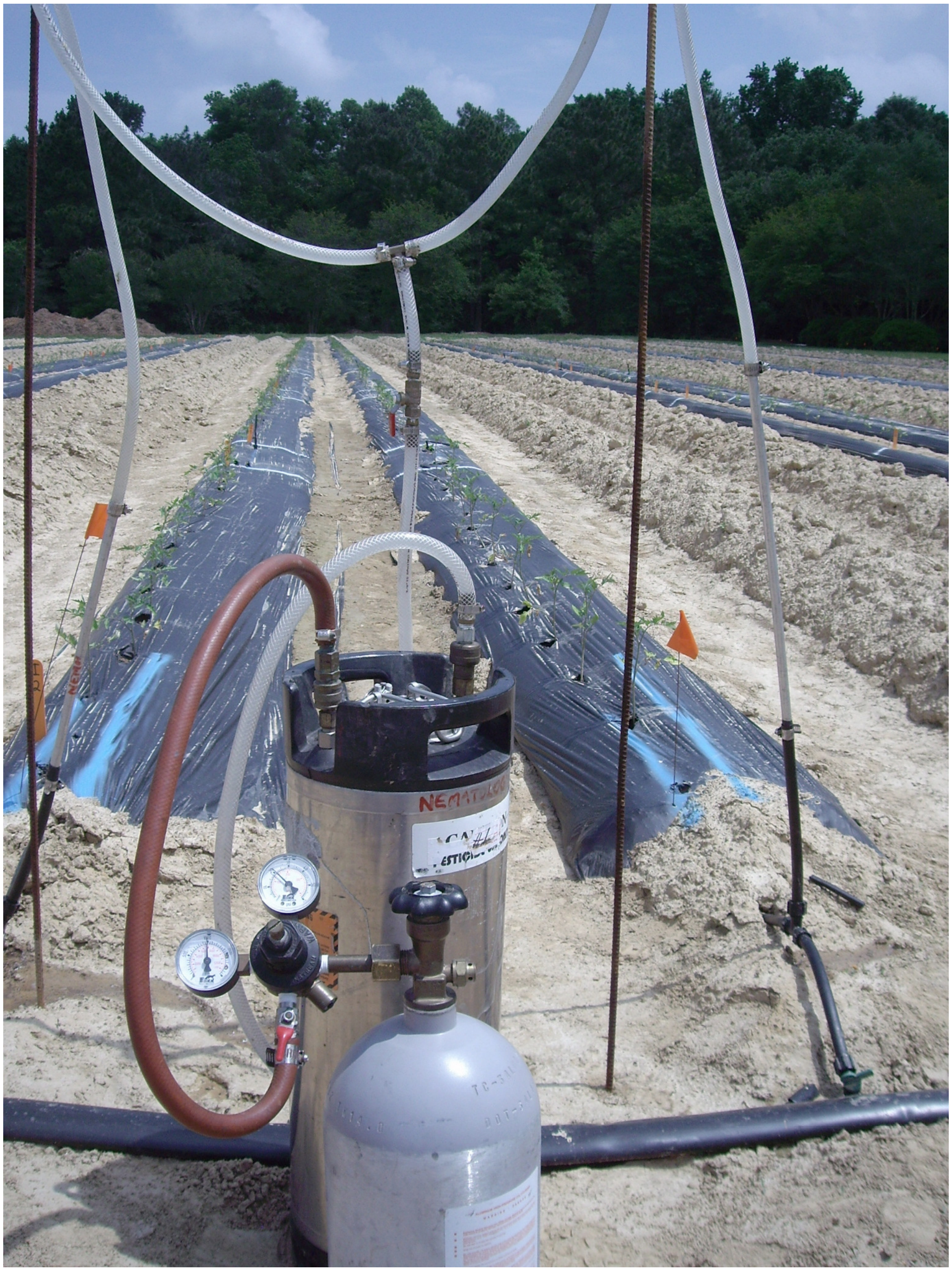
Photograph 11. Application of chemical treatments into transplant holes.

Photograph 12. Transplanting strawberry “plug” seedlings into rows.

Photograph 13. Distributing treated seedlings along row for transplanting.

Photograph 14. Application of drip tubing and plastic film to rows.

Photograph 15. Solutions used for “dip” treatments.



Photograph 16. Post-transplant application of chemicals via drip tubing.

Photograph 17. Established vegetable plots 4 weeks after transplanting

Photograph 18. Pepper fruit harvest and fruit size grading template.

Photograph 19. Tomato fruit harvest and fruit size grading template.

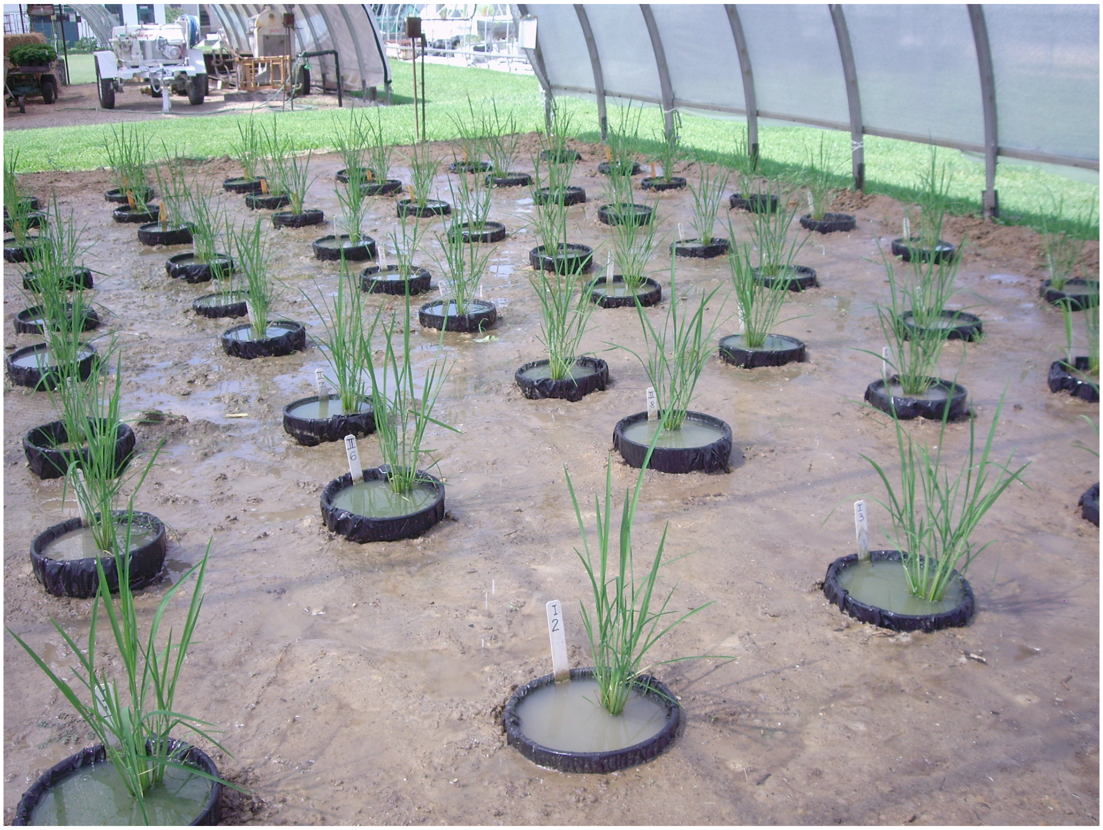
Photograph 20. Eggplant fruit harvest.

Photograph 21. Corn trial, 7 weeks after planting.

Photograph 22. Corn trial, 13 weeks after planting.

Photograph 23. Corn trial, 23 weeks after planting (1 week after hurricane Gustav).

Photograph 24. Pepper Microplot



Photograph 25. “wet” rice Microplot (5 weeks after establishment)

Photograph 26. “wet” rice Microplot (13 weeks after establishment)

Photograph 27. “dry” rice Microplot (13 weeks after establishment)

Photograph 28. Soybean Microplot

Photograph 29. Tomato Microplot (5 weeks after establishment)

Photograph 30. Tomato Microplot (13 weeks after establishment)

Photograph 31. Microplot after hurricane Gustav.

Photograph 32. Microplot after hurricane Gustav.

Photograph 33. Microplot after hurricane Gustav.

LSU
NEMATOLOGY

Edward C. McGawley