Project Title: Pest Management Grants Final Report

Grant Agreement Number: 09-PML-G003

Contract Title: Demonstration and Implementation of Integrated Pest Management in the Production of Bedding and Container Color Plants

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Table of Contents

Project Summary……...…….…….…… page 3

Results

Results: Bedding Plant Propagation……...…...…….….……..page 5

Results: Bedding Plant Finish……page 6

Results: Container Color……page 7

Cooperator Meetings and Project Deliverables……page 7

Summary and Conclusions…….……..…….……...page 6

Project Summary

The bedding and container color plant industry provides plant material for the urban environment in the form of bedding plants, which are planted into the ground, and container color, which are used for indoor and outdoor decoration in containers. This is a large industry, with 820 producers and a wholesale value in 2008 of over 1 billion dollars. Plants (about 100 species and several hundred varieties) are produced and sold year round. Not every grower produces the same plant mix, although there are some plant species common to every grower. The common arthropod, disease, and weed pests occur on all plant species grown. In California, production of these plants is rapid; an eight to ten week crop cycle is typical. Most growers make their profits from rapid turnover of large numbers of plants, which results in low tolerance for pest injury and limited options for the generally slower biological control options that are available.

Current pest management practice in this industry is best described as "spray and pray." Because of the short crop cycle, large number of key pests, and limited tolerance for plant injury, most growers feel they must use regular, prophylactic pesticide applications. Sprays are made every seven to fourteen days throughout the crop for the most damaging pathogen (fungal root rots, fungal leaf spots, bacterial leaf spots) and arthropod pests (thrips, spider mites, fungus gnats, whiteflies, aphids), resulting in one to three weekly applications. This is expensive, wasteful, and hazardous to workers and the environment.

Given the crop diversity among bedding and container color growers, it is not possible to focus on pest management for individual plant/pest combinations. Our project is looking instead at changes that can be made in the cropping system to affect many pests. Our goal for the three-year project is to reduce the number of pesticide applications in the production of bedding and container color plants by 30%, and to reduce organophosphate, carbamate, and pyrethroid applications to 15% or less of total insecticide applications.

Our specific objectives are:

Objective 1. Form a collaborative, interdisciplinary team that will use a systems approach to develop more effective pest management solutions for bedding and color plant production.
Objective 2. Enhance pest identification and monitoring skills as well as understanding of pest thresholds and tolerances among collaborating growers.
Objective 3. Promote wider use of arthropod biological control through the release of natural enemies and the use of entomopathenogenic fungi.
Objective 4. Introduce novel pest control tactics to the bedding and color plant industry.

Results

Objective 1. *Form a collaborative, interdisciplinary team that will use a systems approach to develop more effective pest management solutions for bedding and color plant production.*

The IPM team met by conference call twice in 2010. In 2011, one on-site meeting with the full team was held at the Center for Applied Horticultural Research in Vista, with two additional partial team meetings at Ball Tagawa in Arroyo Grande. There was one team conference call in 2011 and one in 2012.

The IPM team was:

Dr. Michael Parrella, UC Davis Entomology	Dr. Christine Casey, UC Davis Entomology	Mr. James Bethke, UC Farm Advisor
Ms. Chrissie Davis, Koppert Biological Systems	Dr. Dave Fujino, UC Davis Center for Urban Horticulture	Dr. Deborah Mathews, UC Riverside Plant Pathology
Ms. Julie Newman, UC Farm Advisor	Dr. Lucia Villavicencio, Center for Applied Horticultural Research	Dr. Loren Oki, UC Davis Plant Sciences
Dr. Cheryl Wilen, UC IPM Weed Science	Dr. Kimberley Steinmann, CA DPR	Ms. Rebecca Sisco, IR-4 Program Western Region
Dr. Ann Chase, Chase Horticultural Research	Mr. Mark Robertson, CA DPR	

Objective 2. *Enhance pest identification and monitoring skills as well as understanding of pest thresholds and tolerances among collaborating growers.*

Informal training through site visits was conducted with all collaborators. Specific meetings were held as follows:

2010:

July	Nurserymen's Exchange, Ball Tagawa (2 meetings), Cal Color (2 meetings), Altman Plants (3 meetings)

2011:

January	Altman Plants
March	Cal Color Growers
April	Altman Plants
May	Nurserymen's Exchange
June	Cal Color, Nurserymen's Exchange
July	Cal Color Growers (2 meetings), Altman Plants, Ball Tagawa
September	Ball Tagawa, Cal Color

2012

February	Cal Color

Objective 3. *Promote wider use of arthropod biological control through the release of natural enemies and the use of entomopathenogenic fungi.*

The fungus gnat predator, *Hypoaspis miles* (sold as Entomite-M), was incorporated into the demonstrations conducted in container color plants. The details of this work are presented in Objective 4. In short, no difference in fungus gnat populations (monitored by counting larvae on potato disks) was seen in Entomite-treated vs. non Entomite-treated plants.

Growers were also given samples of Entomite-M to use at their own discrection.

Objective 4. *Introduce novel pest control tactics to the bedding and color plant industry.*

IPM in Bedding Plant Propagation

Demonstration 1: Salvia and Vinca at Cal Color Growers

This IPM demonstration was conducted at Cal Color Growers in Morgan Hill, CA in May and June 2011 during seed propagation of two crops. Pythium root rot had been on-going problem in these very sensitive young plants and the grower was purchasing an effective but expensive media with biofungicide incorporated to address the problem in his most sensitive crops. Two IPM treatments were employed to determine if crop quality comparable to that of the PGX media could be obtained. The grower determined the IPM treatments and all assessments were made by IPM team members four weeks after seeds were sown.

IPM treatment 1: Plant growth promoter Activated Effective Microorganims (AEM) applied once at 1:500

IPM treatment 2: Plant growth promoter Activated Effective Microorganims (AEM) applied once at 1:500 plus Subtilex biofungicide (*Bacillus subtilis* MB1600) that is incorporated into ProMix PGX

Grower standard: Subtilex biofungicide (*Bacillus subtilis* MB1600) that is incorporated into ProMix PGX

Media: Grower's in-house peat-based Cal Color mix or ProMix PGX with biofungicide

Crops: Salvia (*Salvia farinacea* 'Blue Rhea') and vinca (*Catharanthus roseus* 'Cooler Mix')

Percent loss per flat: visual estimate of the percentage of dead or missing plants in the 288 cell flat

Flat quality: 1 to 5, with 1= all dead to 5 = all healthy

Both crop species had significantly more plant loss in the Cal Color media (Figure 1). In vinca, we saw a trend for reduced loss in the PGX media when AEM was added (mean % loss PGX = 12.71%; PGX+AEM = 10.71%). Although the difference is not statistically significant, from a practical standpoint over a large number of plants, this could affect profitability. This difference was not seen in salvia, suggesting that AEM might be more useful for species that are slower to germinate.

Both crop species were of significantly poorer quality in the Cal Color media than in the PGX media (Figure 2, Figures 3a and 3b left photos). In vinca, the addition of AEM to the PGX media significantly improved crop quality (Figure 2, Figure 3a right photo). In salvia, there was no statistical effect of adding AEM to the PGX media (Figure 2), but AEM-treated plants in PGX media had slightly larger leaves and were taller than plants in PGX-only media (Figure 3b, right photo).

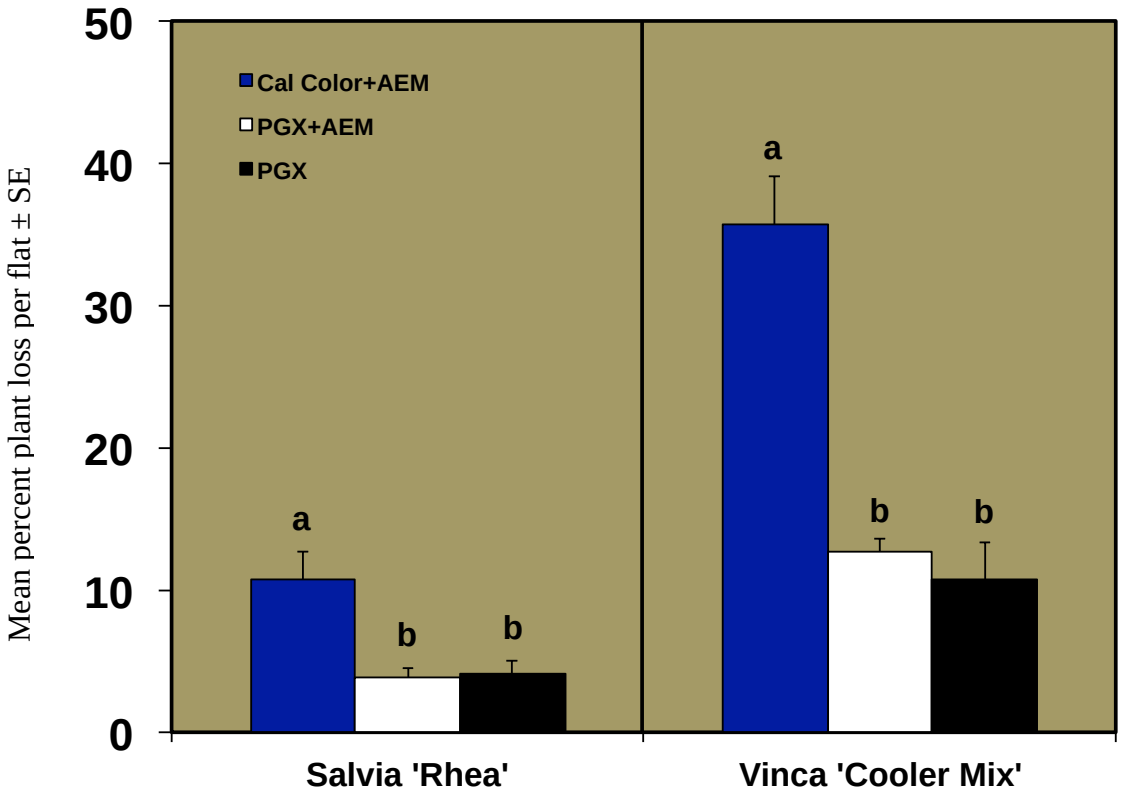


Figure 1. Mean percent loss per flat by treatment. Columns within a plant with different letters are significantly different. Treatment effect was tested using ANOVA and means separation was done with Tukey's test. The salvia data was $\log_{10}$ transformed to meet the assumptions of ANOVA. Salvia: df=2,20; F=6.7711; p=0.0064. Vinca: df=2,20; F=31.0858; p=0.0001.

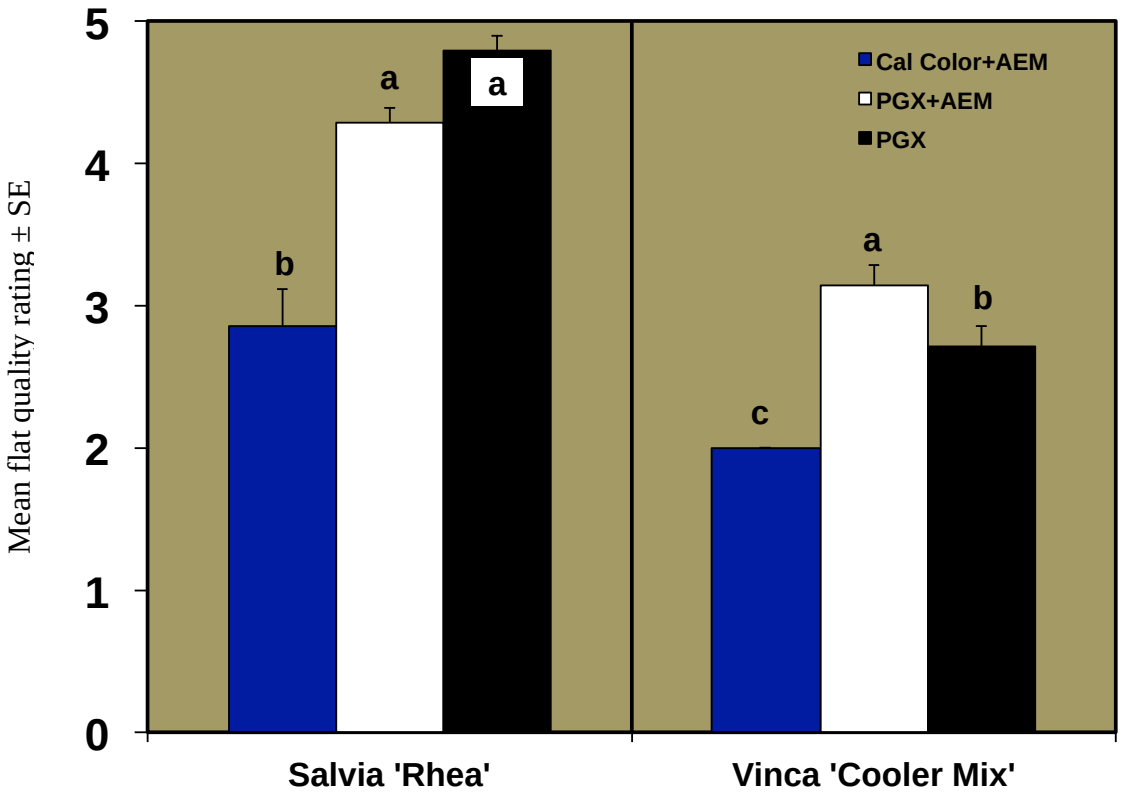
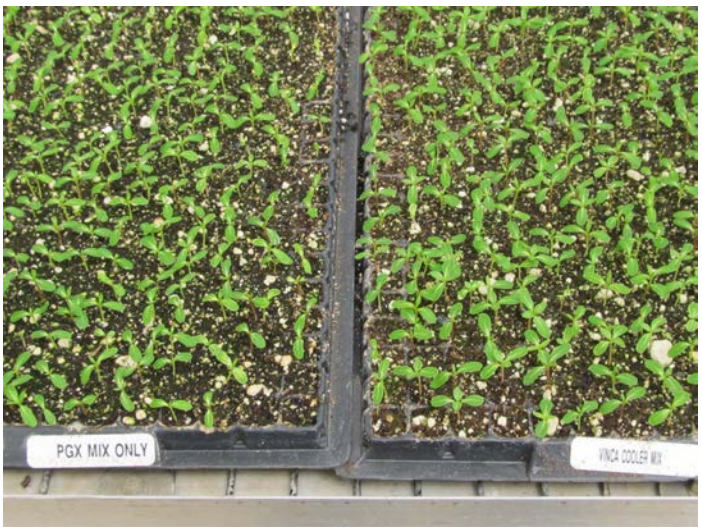


Figure 2. Mean flat quality by treatment. Columns within a plant with different letters are significantly different. Salvia treatment effect was tested using Welch ANOVA as data could not be transformed to meet the assumptions of ANOVA. Vinca was tested using ANOVA. Means separation was done with Tukey's test. Salvia: df=2,11.13; F=23.9547; p=0.0001. Vinca: df=2,20; F=32.6667; p=0.0001.

Vinca – Cal Color+AEM (right) vs. PGX+AEM (left)



Vinca – PGX only (left) vs. PGX+AEM (right)

Figure 3a. Effect of AEM addition to crop quality in vinca.

Salvia – Cal Color+AEM (left) vs. PGX+AEM (right)

Salvia – PGX only (left) vs. PGX+AEM (right)

Figure 3b. Effect of AEM addition to media on crop quality in salvia.

Demonstration 2: Salvia, pansy, and vinca at Ball Tagawa Growers

This IPM demonstration was conducted at Ball Tagaws Growers in Arroyo Grande, CA in August and September 2011 during seed propagation of three crops. As a propagator whose only business is providing young plants to other growers to finish, disease control is of upmost importance. This grower was already following good sanitation practices to help manage root rot disease. They are VeriFlora certified and were interested in expanding their use of biological pest management products.

IPM treatment 1: Plant growth promoter Activated Effective Microorganims (AEM) at 1:500 applied weekly

IPM treatment 2: RootShield biofungicide (*Trichoderma harzianum*) at 4 oz per 100 gallons applied weekly

Grower standard: Pageant (pyraclostrobin and boscalid) at 12 oz per 100 gallons applied as per label directions

Control: untreated

Media: Peat-based Sunshine mix

Crops: Salvia (*Salvia farinacea* 'Blue Rhea'); pansy (*Viola* x *wittrockiana* 'Morpheus') and vinca (*Catharanthus roseus* 'Coconut Cooler')

Percent loss per flat: visual estimate of the percentage of dead or missing plants in the 288 cell flat

Flat quality: 1 to 5, with 1= all dead to 5 = all healthy

Plants were assessed two and five weeks after seeds were sown. There were differences in crop quality at two weeks, but by five weeks after sowing all crops and treatments were at quality levels of 4 or 5, both of which are acceptable for sale. The poorest quality at two weeks was seen in the grower standard treatment in salvia, suggesting that this crop might be sensitive to the fungicide.

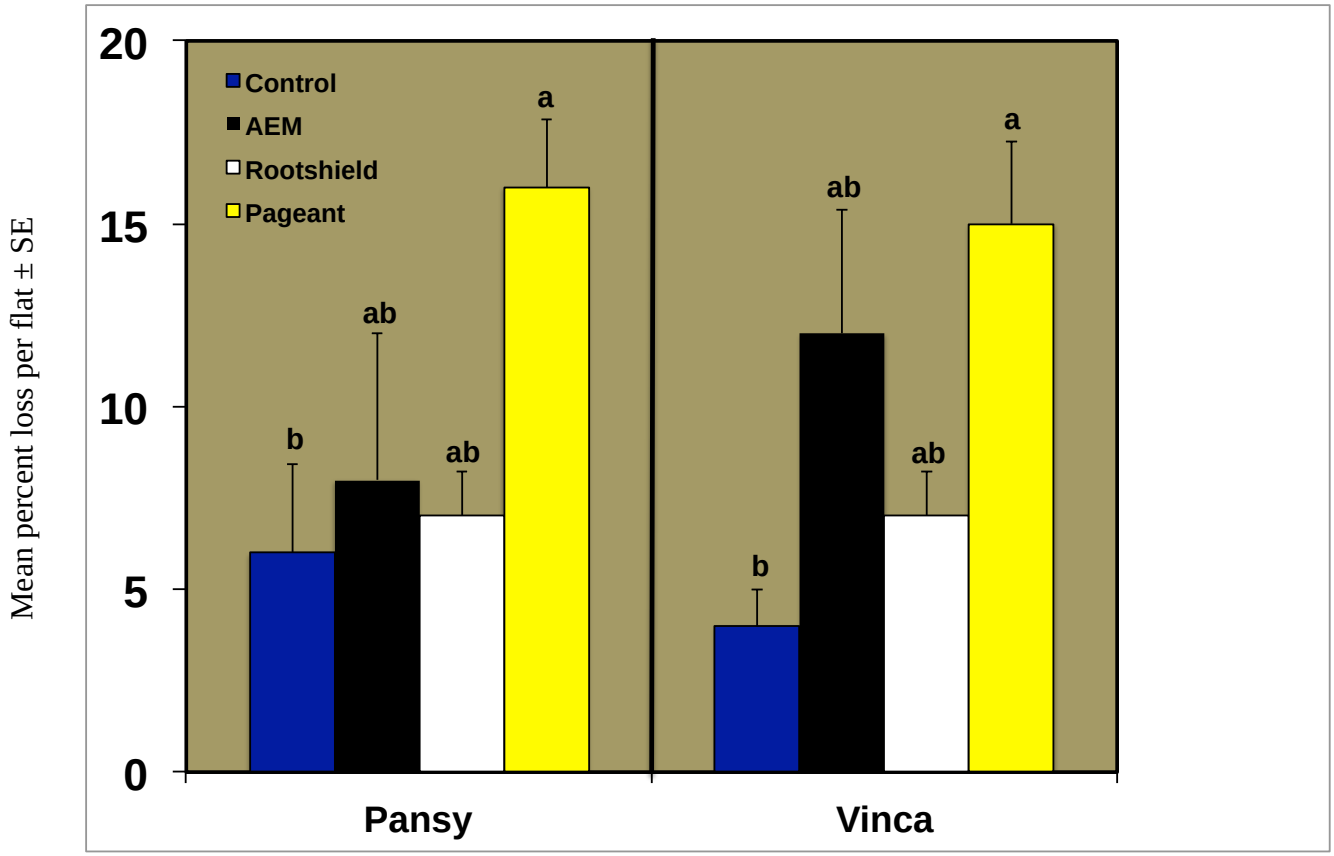


Figure 4. Mean percent loss per flat by treatment two weeks after sowing. Columns within a plant species with different letters are significantly different. Treatment effect was tested using ANOVA and means separation was done with Tukey's test. The vinca data was $\log_{10}$ transformed to meet the assumptions of ANOVA; untransformed data is presented. Pansy: df=3,19; F=4.1833; p=0.0230. Vinca: df=3,19; F=4.9861; p=0.0125. There was no loss in any of the salvia treatments.

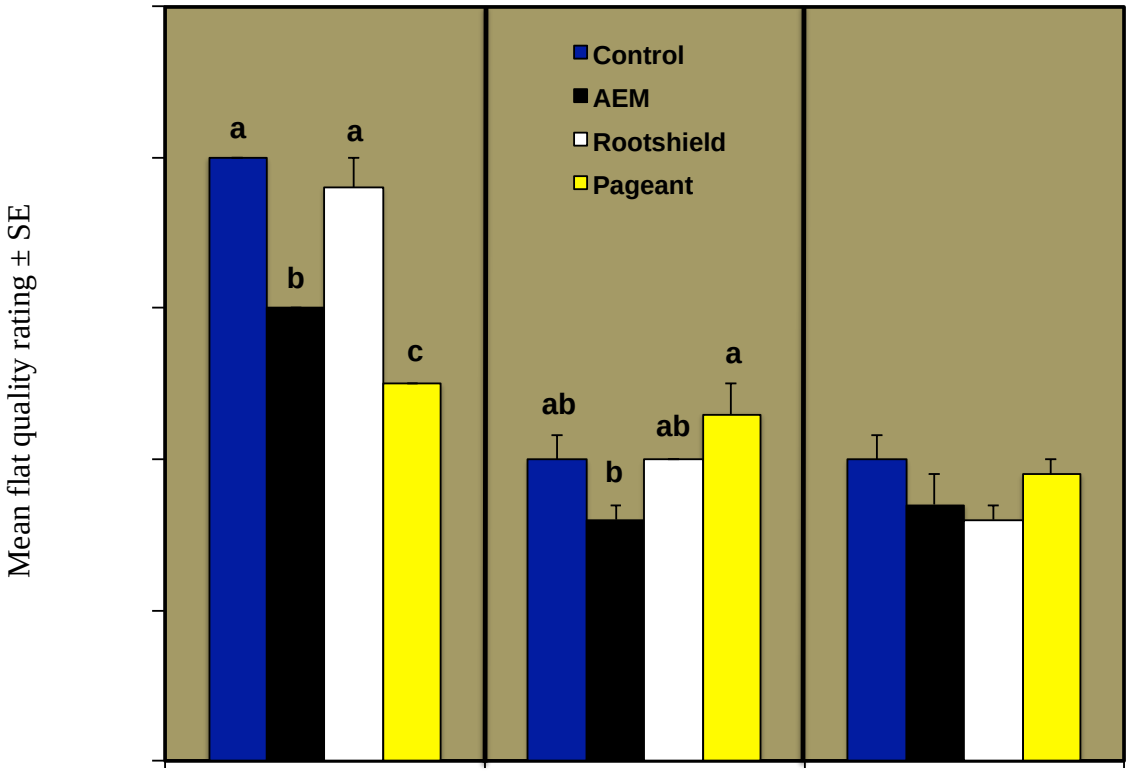


Figure 5. Mean flat quality by treatment two weeks after sowing. Columns within a plant species with different letters are significantly different. Treatment effect was tested using ANOVA and means separation was done with Tukey's test. Salvia: df=3,19; F=48.9167; p=0.0001. Pansy: df=3,19; F=4.4; p=0.0194. Vinca: df=3,19; F=1.5686; p=0.2359.

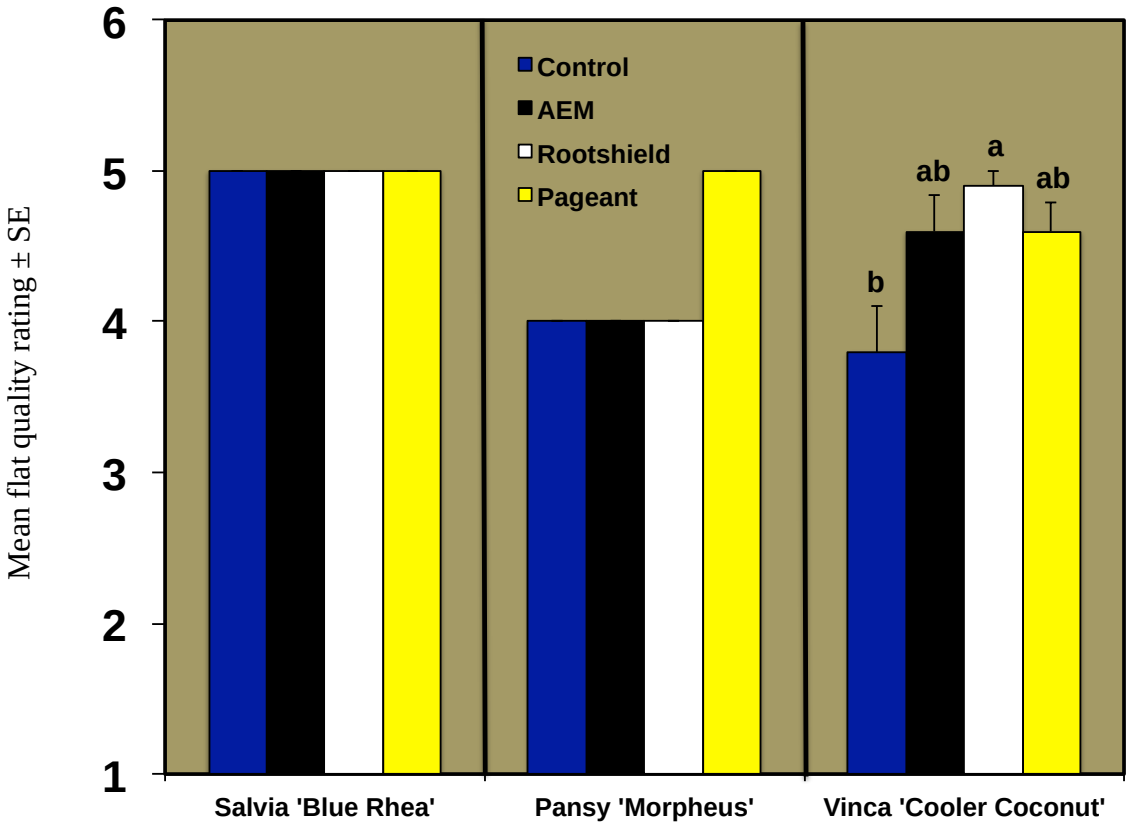


Figure 6. Mean flat quality by treatment five weeks after sowing. Columns within a plant species with different letters are significantly different. Treatment effect was tested using ANOVA and means separation was done with Tukey's test. Vinca: df=3,19; F=4.5641; p=0.0171.

IPM in Bedding Plant Finish

Demonstration 1: Vinca, impatiens, pansy, and salvia at Cal Color Growers

This bedding plant IPM demonstration was conducted in June and July 2011 at Cal Color Growers in Morgan Hill. The grower makes his own media and has experienced problems with *Pythium* spp. contamination. Our goal was to evaluate the effect of various biofungicides and plant growth promoters on plant loss and crop quality in some of his key bedding plant crops to determine if these products could produce an acceptable crop under pressure from this pathogen. All treatments were applied once when the plants were transplanted three weeks after seeds had been sown. No other insecticides or fungicides were applied. The IPM treatments were determined by the grower and all assessments were made by the IPM team six and nine weeks after seeds were sown.

IPM treatment 1: Plant growth promoter Ag1000 (formerly AEM) that contains known species and concentrations of yeast and lactic acid bacteria. Applied once at 1:500

IPM treatment 2: Plant growth promoter Ag1000 (formerly AEM) that contains known species and concentrations of yeast and lactic acid bacteria. Applied once at 1:500 plus Subtilex biofungicide (*Bacillus subtilis* MB1600) that is incorporated into ProMix PGX

IPM treatment 3: RootShield biofungicide (*Trichoderma harzianum*) at 4 oz per 100 gallons applied weekly

Grower standard: Subtilex biofungicide (*Bacillus subtilis* MB1600) that is incorporated into ProMix PGX

Media: Grower's in-house peat-based Cal Color mix or ProMix PGX with biofungicide

Crops: Salvia (*Salvia farinacea* 'Blue Rhea'); pansy (*Viola tricolor* 'Crystal Bowl Mix); and vinca (*Catharanthus roseus* 'Cooler Mix')

Percent loss per flat: visual estimate of the percentage of dead or missing plants in the flat, where one flat contains six 6-packs; each value represents an average of five flats

Flat quality: visual estimate of the overall quality of the flat that considers the number of dead plants, plant height and leaf size, and overall plant appearance as shown below. One flat contains six 6-packs; each value represents an average of five flats

Plug treatment: media/treatment in which the plugs were produced (weeks 1 to 3; 288 cell trays)

Finish treatment: media/treatment in which the plugs were produced (weeks 4 to 9; 6-packs)

Figure 7. Flat quality examples in Vinca ‘Cooler Mix’

The effect of the various treatments varied by crop age and species (Tables 1, 2, 3, and 4).

Plug treatment	Finish treatment	Production week	% loss per flat±SE	Flat quality±SE (1 to 5 scale)
Grower media+Ag1000	Grower media	Six	0	1.6±0.19
Grower media+Ag1000	Grower media	Nine	0	4±0.22
PGX media	Grower media	Nine	0	4.3±0.12
Grower media+Ag1000	Grower media+ Ag1000	Six	0	1.6±0.29
Grower media+Ag1000	Grower media+ Ag1000	Nine	0	4.6±0.19
PGX media	Grower media+ Ag1000	Nine	0	4±0.16
Grower media+Ag1000	Grower media+RS	Six	0	2.2±0.12
Grower media+Ag1000	Grower media+RS	Nine	0	4.6±0.29
PGX media	Grower media+RS	Nine	0	4.2±0.25

Table 1. Results in Impatiens 'Xtreme Mix'.

Figure 8. Impatiens finish quality was the same regardless of treatment.

Plug treatment	Finish treatment	Production week	% loss per flat±SE	Flat quality±SE (1 to 5 scale)
Grower media+Ag1000	Grower media	Six	0	1.6±0.24
Grower media+Ag1000	Grower media	Nine	0	3.7±0.41
PGX media	Grower media	Six	0	1.4±0.24
PGX media	Grower media	Nine	0	2.7±0.12
Grower media+Ag1000	Grower media+RS	Six	0	2.3±0.25
Grower media+Ag1000	Grower media+RS	Nine	0	3.4±0.29
PGX media	Grower media+RS	Six	0	1.3±0.12
PGX media	Grower media+RS	Nine	0	2.5±0.27
Grower media+Ag1000	PGX+RS	Six	1±1.00	1.5±0.16
Grower media+Ag1000	PGX+RS	Nine	0	3.3±0.25

Table 2. Results in Pansy 'Crystal Bowl Mix'.

Figure 9. Pansy quality was variable.

Plug treatment	Finish treatment	Production week	% loss per flat±SE	Flat quality±SE (1 to 5 scale)
Grower media+Ag1000	Grower media	Seven	6±1.87	2.60±0.24
Grower media+Ag1000	Grower media	Ten	0	3.50±0.16
PGX media	Grower media	Seven	1±1.00	2.80±0.12
PGX media	Grower media	Ten	0	5
Grower media+Ag1000	Grower media+ Ag1000	Seven	23±10.68	1.60±0.24
Grower media+Ag1000	Grower media+ Ag1000	Ten	10±6.12	1.50±0.16
Grower media+Ag1000	Grower media+RS	Seven	42±6.44	1.50±0.16
Grower media+Ag1000	Grower media+RS	Ten	0	2.80±0.20
Grower media+Ag1000	PGX	Seven	2±2.00	2.8±0.12
Grower media+Ag1000	PGX	Ten	0	5
Grower media+RS	PGX	Seven	1±1.00	3.5±0.27

Table 3. Results in Salvia 'Blue Rhea'.

Figure 10. Salvia appears to do better in PGX media (plants on right) compared to grower media with Ag1000 (plants on left).

Plug treatment	Finish treatment	Production week	% loss per flat±SE	Flat quality±SE (1 to 5 scale)
Grower media+Ag1000	Grower media	Six	2±1.22	2.7±0.20
Grower media+Ag1000	Grower media	Nine	0	2.7±0.25
PGX media	Grower media	Six	3±2.00	2.8±0.34
PGX media	Grower media	Nine	0	3.2±0.64
PGX media+Ag1000	Grower media	Six	2±1.22	3.4±0.24
PGX media+Ag1000	Grower media	Nine	0	3.2±0.80
Grower media+Ag1000	Grower media+AEM	Six	2±2.00	3.6±0.24
Grower media+Ag1000	Grower media+AEM	Nine	0	3.2±0.37
PGX media	Grower media+AEM	Six	7±3.74	3.1±0.29
PGX media	Grower media+AEM	Nine	0	2.6±0.58
PGX media+Ag1000	Grower media+AEM	Six	1±1.00	2.7±0.20
PGX media+Ag1000	Grower media+AEM	Nine	0	2.7±0.51
Grower media+Ag1000	Grower media+RS	Six	10±8.80	2.4±0.29
Grower media+Ag1000	Grower media+RS	Nine	0	2.5±0.55
PGX media	Grower media+RS	Six	0	3.5±0.16
PGX media	Grower media+RS	Nine	0	3.6±0.43
PGX media+Ag1000	Grower media+RS	Six	0	4±0.27

Table 4. Results in Vinca 'Cooler Mix'.

Figure 11. Vinca quality was variable.

IPM in Container Color

Demonstration 1: Root Disease in Lavender

This bedding plant IPM demonstration was conducted in September and October 2010 at the Center for Applied Horticulture Research in Vista, CA. The grower standard fungicide treatment was compared with two IPM approaches for managing root disease (primarily Phytophthora root rot) in lavender (*Lavandula stoechas* Ooh la Lavender™ Pink). All irrigation was done with recycled water as it was suspected that this was a source of plant pathogens. Untreated liners were planted into one quart containers using a peat-based media. Treatments were develop and assessed by the collaborating grower.

IPM treatment 1: Xeroton-3, a disinfectant, applied to the media at every irrigation or weekly at 1:500 and 1:2500 dilutions.

IPM treatment 2: Effective Microorganisms (EM), a plant growth promoter, applied to the media at every irrigation or weekly at 1:500 and 1:1000 dilutions.

Grower standard: Aliette® WDG (aluminum phosphonate) at 12.8 fl oz per 100 gallons every 28 days; and Heritage® (azoxystrobin) at 4oz per 100 gallons every 14 days. Two drench applications of Aliette WDG and three of Heritage were made during this demonstration.

Crop: Lavender (*Lavandula stoechas* Ooh la Lavender™ Pink)

Media: Peat-based Sunshine Mix

Root disease was assessed visually as follows:
1 = More than 75% of the root system diseased or decayed.
2 = between 51 and 75% of the root system diseased or decayed.
3 = between 26 and 50% of the root system diseased or decayed.
4 = between 1 and 25% of the root system diseased or decayed.
5 = Roots white and healthy; no disease present.

Root distribution was measured on a scale from 5 (roots uniformly distributed throughout the volume of the pot) to 1 (poor root distribution).

The lack of disease in the control suggests that the irrigation water is not a source of pathogens for this crop. Most of the IPM treatments were comparable to the grower standard in terms of root disease and quality.

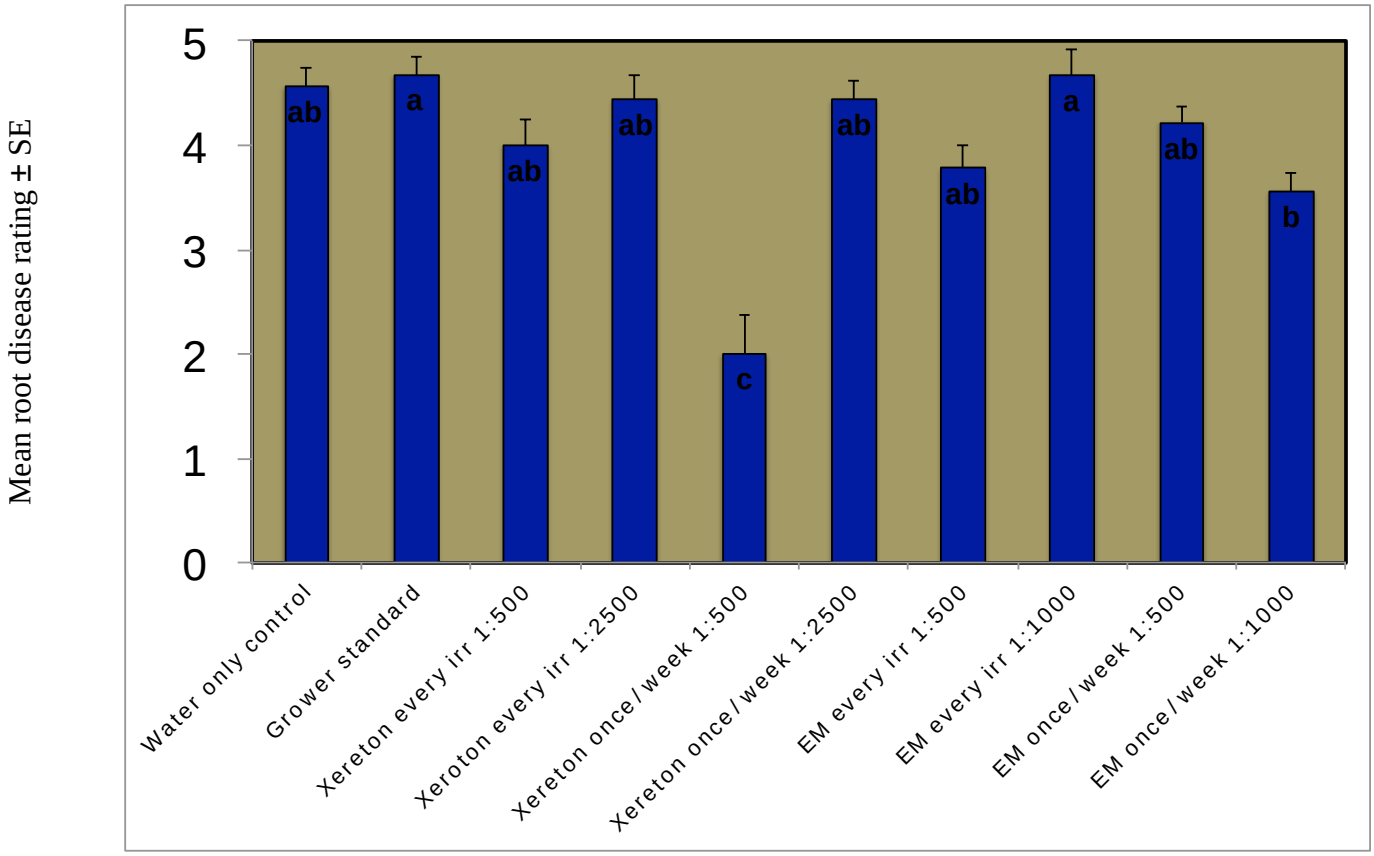


Figure 12. Root disease rating in lavender at finish. ANOVA: df=9,89; F=13.0617; p=0.0001. Means separation was done with Tukey's test. Columns with different letters are significantly different.

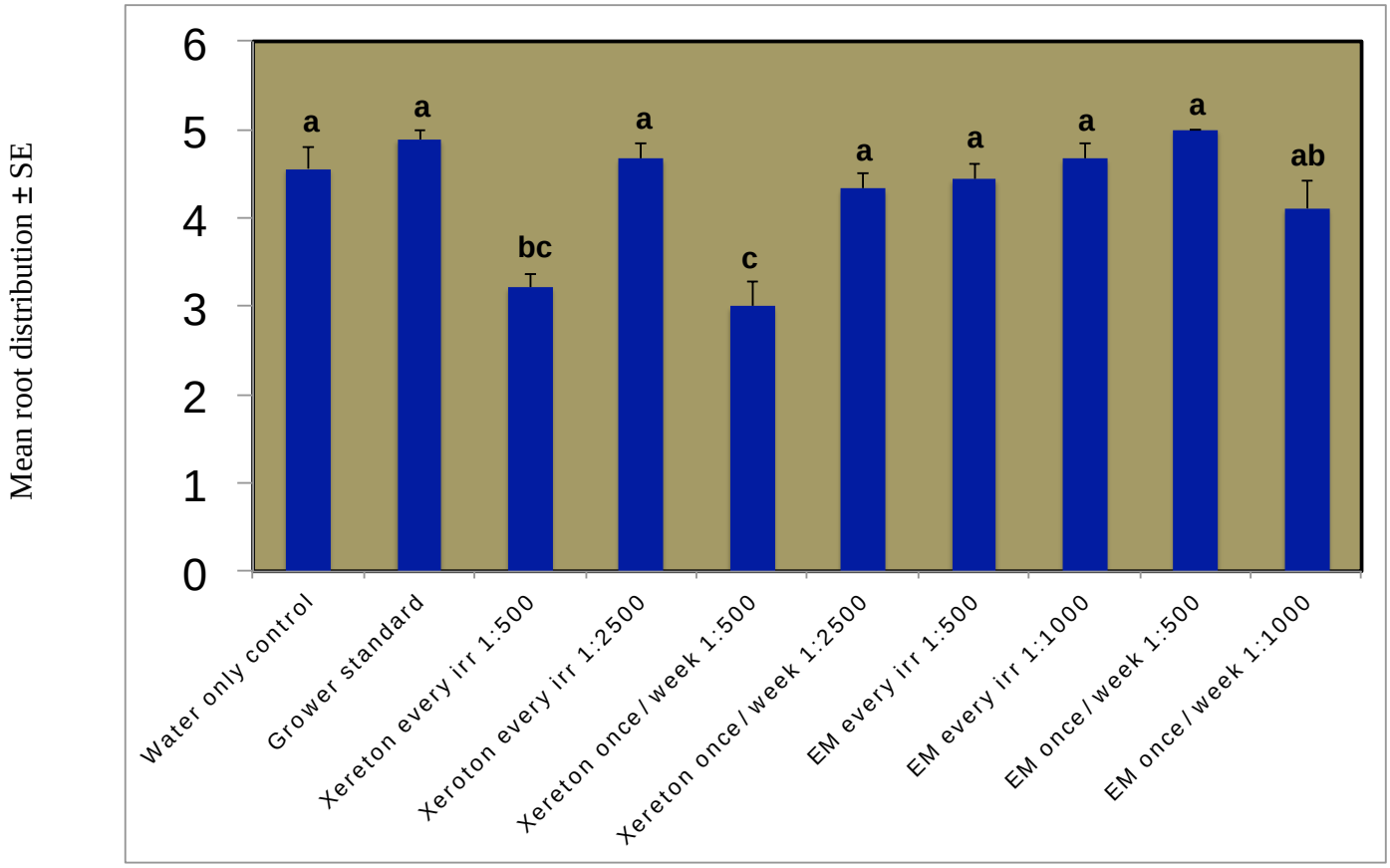


Figure 13. Root distribution in the soil ball of lavender at crop finish. ANOVA: df=9,89; F=11.7476; p=0.0001. Means separation was done with Tukey's test. Columns with different letters are significantly different.

Demonstration 2: Powdery mildew on gerbera

This demonstration was conducted in April 2011 at the Center for Applied Horticulture Research in Vista, CA to evaluate options for control of the foliar disease powdery mildew on Gerbera daisy 'Festival Orange.' Plants were grown in 4-inch pots using a peat-based media. Plants were exposed to powdery mildew-infested plants one day after the first treatment was applied and evaluation of disease severity continued for one month. Treatments were developed by the IPM team and assessments were made by the collaborating grower.

IPM treatment 1: Effective Microorganisms (EM), a plant growth promoter, applied weekly as a foliar spray at 1:250 and 1:500 dilutions.

IPM treatment 2: Regalia SC (*Reynoutria sachalinensis*) biofungicide applied weekly as a 1% foliar spray.

Grower standard: Compass® O (trifloxystrobin) applied weekly at 4 oz per 100 gallons

Crop: Gerbera daisy (*Gerbera jamesonii* 'Festival Orange)

Media: Peat-based Sunshine Mix

Treatment	**Mean % leaf coverage with powdery mildew**			
	7 DAT	14 DAT	21 DAT	28 DAT
Control	0	1.25a	48.13a	84.38a
Compass® O	0	0.25a	6.375c	70.63ab
EM 1:500	0	0.25a	15.5b	51.25b
EM 1:250	0	0.88ab	23b	61.25b
Regalia SC 1%	0	0b	0.88d	6.25c
P value		0.0388	0.0001	0.001

Table 5. Mean percent disease severity of powdery mildew on Gerbera daisy. Values followed by different letters within a column are significantly different.

All treatments reduced disease relative to the control, although this powdery mildew appears to be resistant to Compass® O. The IPM treatment Regalia SC was highly effective at controlling the disease.

Demonstration 3: Root rot in gardenia

This demonstration took place at Altman Plants in Vista, CA. Herbaceous cuttings of gardenia (*Gardenia veitchii*) were planted on Nov. 4, 2011. Twenty 50-cell trays of each plant species were available per treatment, 10 trays per treatment were sampled at each sampling time. one group received a 1-time release of *Hypoaspis miles* (Entomite-M) on Dec. 9, 2011. Potato disks (2.5 mm diameter, 1mm thick) were placed vertically in one random cell per tray per treatment and collected 48 hours after placement and the number of fungus gnat larvae were counted once a week.

Once plugs reached market size, twenty plugs per treatment on the non-*Hypoaspis* treated group were randomly selected and planted in 6.5" (Gardenia) and 4.5" (Genista) containers filled with Sunshine Mix #1 amended with 5lbs Osmocote 13-13-13 per cubic yard. Plants were placed on benches in a climate controlled greenhouse set at 75/65º day/night temperatures and natural light. Ten plants per treatment received EM at 1:500 once a week while a second group of 10 plants per treatment received water only.

IPM treatment 1: Plant growth promoter Ag1000 (formerly AEM) that contains known species and concentrations of yeast and lactic acid bacteria. Applied weekly at 1:500 starting one week after planting

IPM treatment 2: RootShield (*Trichoderma harzianum*) biofungide at 4 oz per 100 gallons applied weekly starting one week after planting

IPM treatment 3: *Hypoaspis miles* for control of fungus gnats released once at the start of the crop

Grower standard: Subdue MAXX® (mefenoxam) at 2 oz per 100 gallons applied once one week after planting

Control: water only

Crop: Gardenia (*Gardenia veitchii*)

Media: Peat-based Sunshine Mix

There were small differences in plant quality under the various treatments (Fig. 14). The Ag1000 treatment had a positive effect on both root and shoot dry weight relative to the other treatments (Fig. 15). *Hypoaspis miles* did not have an effect on the fungus gnat larvae population.

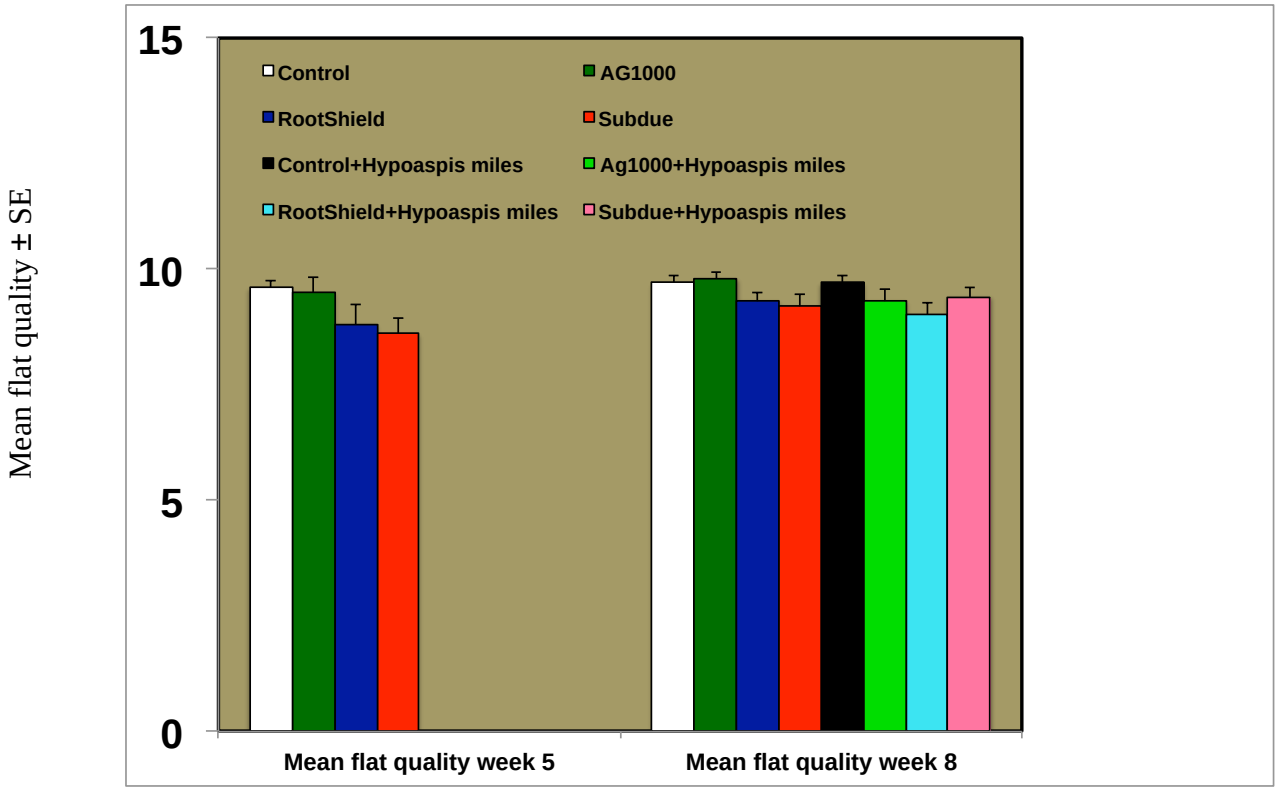


Figure 14. Effect of IPM and grower standard treatments on mean flat quality in Gardenia. ANOVA: week 5: df=3,39; F=2.1932; p=0.1057. ANOVA week 8: df=7,79; F=1.7839; p=0.1037

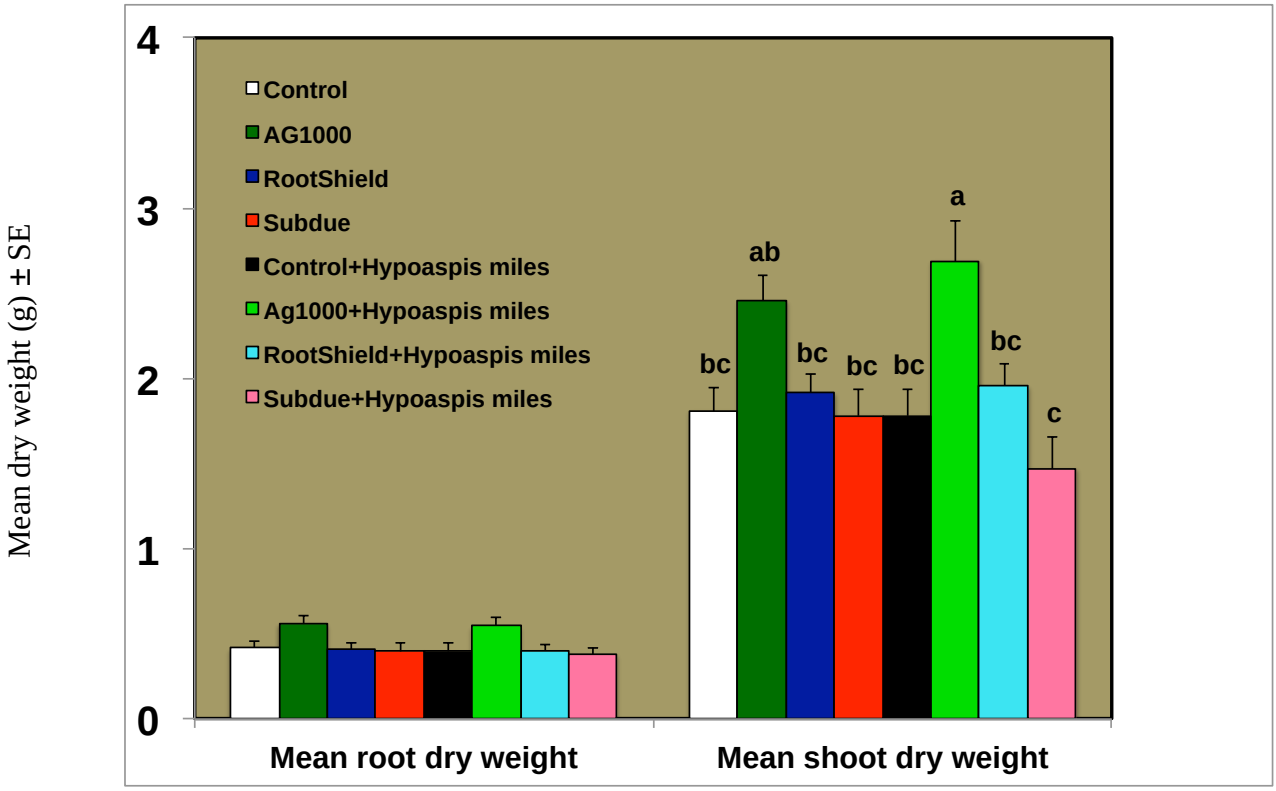


Figure 15. Effect of IPM and grower standard treatments on root and shoot dry weight in gardenia eight weeks after transplant. ANOVA: root dry wt: df=7,79; F=2.5516; p=0.0210. ANOVA shoot dry wt: df=7,79; F=5.8188; p=0.0001. Means separation was done using Tukey's test. Columns with different letters are significantly different.

Number of weeks after cuttings were planted	P value for effect of *Hypoaspis miles* on mean number of fungus gnat larvae
3	0.0833
4	0.3041
5	0.2906
6	0.311
7	0.1076
8	0.6317
9	0.0504

Table 6. Mean number of fungus gnat larvae per potato disk.

Demonstration 4: Root rot in Genista

This demonstration took place at Altman Plants in Vista, CA. Herbaceous cuttings of genista (*Genista racemosa*) were planted on Nov. 4, 2011. Twenty 50-cell trays of each plant species were available per treatment, 10 trays per treatment were sampled at each sampling time. one group received a 1-time release of *Hypoaspis miles* (Entomite-M) on Dec. 9, 2011. Potato disks (2.5 mm diameter, 1mm thick) were placed vertically in one random cell per tray per treatment and collected 48 hours after placement, the number of fungus gnat larvae were counted once a week. Once plugs reached market size, twenty plugs per treatment on the non-*Hypoaspis* treated group were randomly selected and planted in 6.5" (Gardenia) and 4.5" (Genista) containers filled with Sunshine Mix #1 amended with 5lbs Osmocote 13-13-13 per cubic yard. Plants were placed on benches in a climate controlled greenhouse set at 75/65º day/night temperatures and natural light. Ten plants per treatment received EM at 1:500 once a week while a second group of 10 plants per treatment received water only.

IPM treatment 1: Plant growth promoter Ag1000 (formerly AEM) that contains known species and concentrations of yeast and lactic acid bacteria. Applied weekly at 1:500 starting one week after planting

IPM treatment 2: RootShield (*Trichoderma harzianum*) biofungide at 4 oz per 100 gallons applied weekly starting one week after planting

IPM treatment 3: *Hypoaspis miles* for control of fungus gnats released once at the start of the crop

Grower standard: Subdue MAXX® (mefenoxam) at 2 oz per 100 gallons applied once one week after planting

Control: water only

Crop: Gardenia (*Gardenia veitchii*)

Media: Peat-based Sunshine Mix

There was a strong positive effect of Ag1000 on genista plant quality (Fig. 16), growth (Fig. 18) and mortality (Fig. 19) relative to the other treatments. In this study, *Hypoaspis miles* did not have an effect on the fungus gnat larvae population.

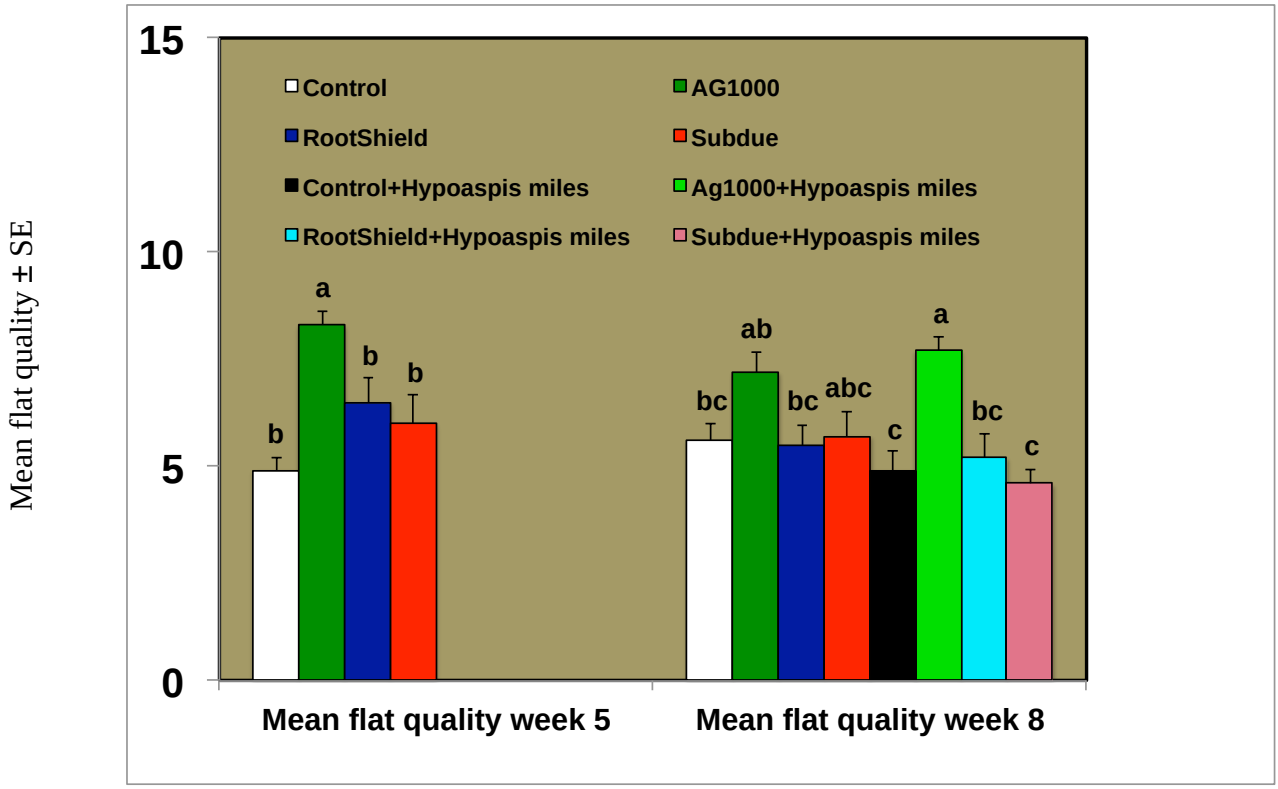


Figure 16. Effect of IPM and grower standard treatments on mean flat quality in genista five and eight weeks after transplant. ANOVA: week 5: df=3,39; F=8.0816; p=0.0003. ANOVA week 8: df=7,79; F=5.4300; p=0.0001. Means separation was done using Tukey's test. Columns within each time interval with different letters are significantly different.

Figure 17. Example of plant quality ratings in genista, with 2 (left) to 5 (right).

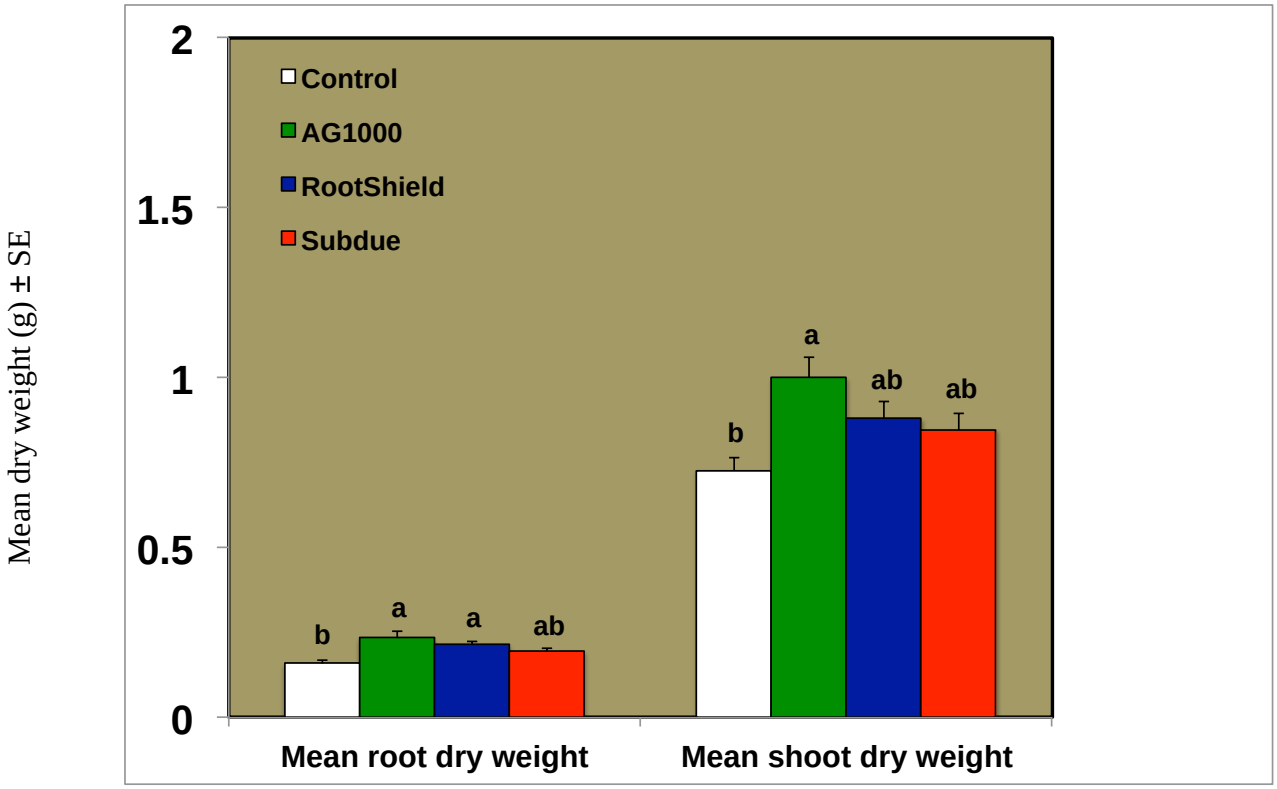


Figure 18. Effect of IPM and grower standard treatments on root and shoot dry weight in genista 11 weeks after transplant. ANOVA: root dry wt: df=3,79; F=4.5891; p=0.0052. ANOVA shoot dry wt: df=3,79; F=4.3780; p=0.0068. Means separation was done using Tukey's test. Columns within each parameter with different letters are significantly different.

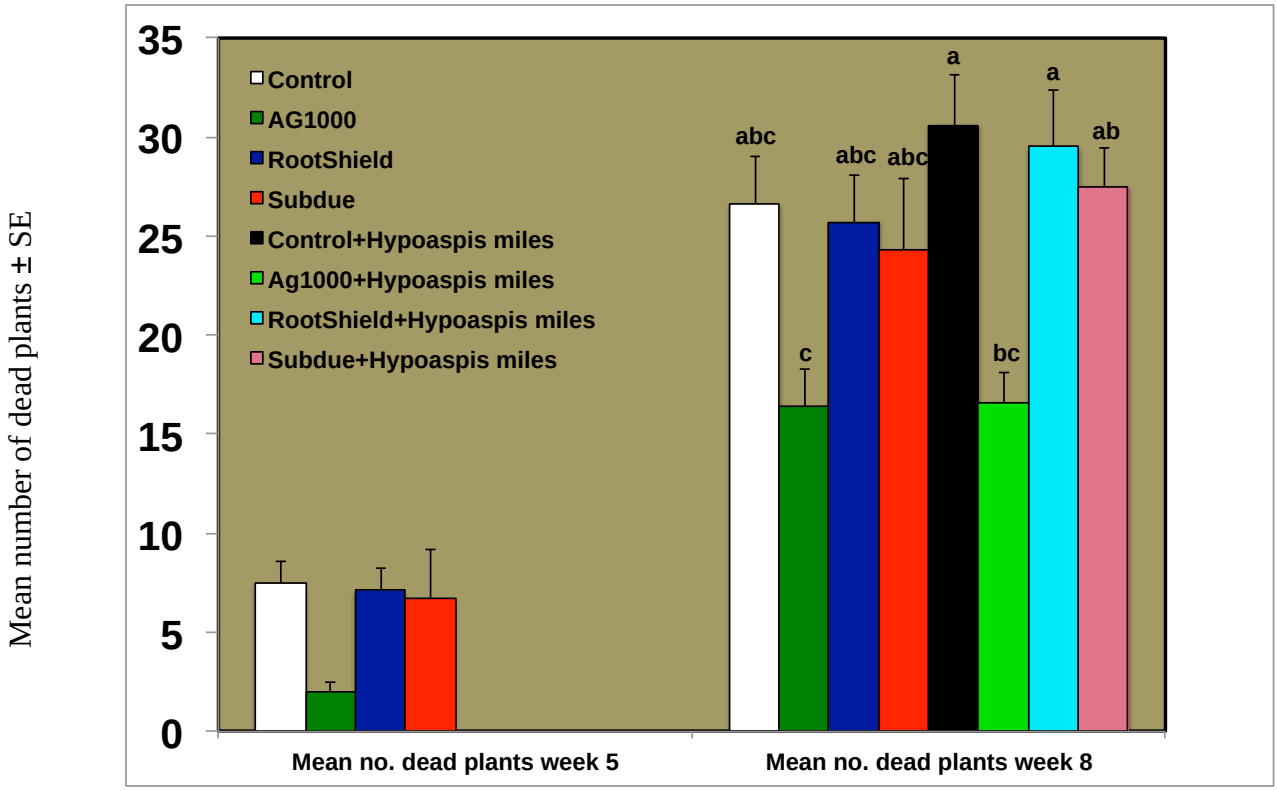


Figure 19. Effect of IPM and grower standard treatments on the number of dead plants in genista five and eight weeks after transplant. ANOVA: week 5: df=3,39; F=2.9686; p=0.0447. ANOVA week 8: df=7,79; F=4.7747; p=0.0002. Means separation was done using Tukey's test. Columns with different letters are significantly different.

Number of weeks after cuttings were planted	P value for effect of *Hypoaspis miles* on mean number of fungus gnat larvae
6	0.0342
7	0.2206
8	0.059
9	0.1213
10	0.0026
11	0.1774
12	0.4756

Table 7. Mean number of fungus gnat larve per potato disk.

Bedding and Container Color IPM Alliance Cooperator Meetings and Deliverables

2010

July	Nurserymen's Exchange
	Ball Tagawa (2)
	Cal Color Growers (2)
	Altman Plants (3)

2011

January	Altman Plants
March	Cal Color Growers
April	Altman Plants
May	Nurserymen's Exchange
June	Cal Color Growers
	Nurserymen's Exchange
July	Cal Color Growers
	Cal Color Growers
	Altman Plants
	Ball Tagawa Growers
September	Ball Tagawa Growers
	Cal Color Growers

2012

February	Cal Color Growers

Deliverables

Published articles

- Sting (Newsletter of the International Organization of Biological Control Working Group on Integrated Control in Protected Crops), January 2010
- CORF (now UCNFA, University of California Nursery and Floriculture Alliance) newsletter, Winter 2010
- Project poster; used at several meetings

Grower presentations

- Nurserymen's Exchange (3)
- Cal Color (9)
- Ball Tagawa (4)
- Altman Plants (6)

Stakeholder presentations

- California Association of Nurseries and Garden Centers 2010
- University of California Nursery and Floriculture Alliance 2010
- Northern California Entomology Society 2010
- International Plant Propagator's Society 2011
- California Department of Pesticide Regulation Pest Management Advisory Committee project summary 2011

Scientific presentations

- Entomological Society of America Annual Meeting 2010
- Entomological Society of America Annual Meeting 2011

Team meetings

- 2010 (conference call)
- 2010 (conference call)
- January 2011 (full, on-site)
- 2011 (partial, on-site)
- 2011 (partial, on-site)
- 2011 (conference call)
- 2012 (conference call)

Project Manual

- Best Management Practices for Bedding and Container Color Plant Production in California, March 2012, 73pp.

Project Webpage

ucanr.org/sites/entomology/BPIPM

Summary and Conclusions

Challenging economic conditions make IPM difficult

The project did not start as quickly as we anticipated, nor were we able to complete the number of demonstrations we would have like to at all sites. Much of this was due to the difficult economic climate that left our collaborators hesitant to implement changes to their production programs, even on a small scale. As conditions improved in 2011 we were able to complete several demonstration projects.

Biofungicides and sanitation are effective

In many of our demonstrations the untreated plants had ratings comparable to both the grower standard and the IPM treatments, highlighting the importance of sanitation and other non-chemical management practices. In some of the demonstrations (the most notable examples are Regalia SC on powdery mildew in gerbera and Ag1000 on root rot in genista), the biological products gave substantially better results than the grower standard chemical treatment.

Product efficacy can vary by crop species and production stage

At both Cal Color and Ball Tagawa we saw different responses to the same treatment in the same crop early in the crop (week 2 or 3) compared to finish (week 5 or 9). Different plant species also responded differently to both the grower standard and the IPM treatments. This could be due to phytotoxicity or different pathogen species occuring on different crop species.

Insect monitoring is not a priority in short-term crops

All growers were asked to use sticky cards for insect monitoring, but actually doing this or in counting cards that did get placed was not a priority. Disease management was seen as the priority, even though the link between fungus gnats, shore flies, and root rots was understood. Thus we were able to do very little evaluation of insect monitoring tools.

Quick, easy-to-use educational tools are important

Growers are busy, and much of the on-site training was done while walking through growing areas. Referrals to web sites seemed to be more desireable than printed material, which is becoming less relevant in the age of smart phones and tablets. This led to the decision to publish the project manual in an electronic format.

Did we accomplish our goals?

The major goals for this project were to reduce the number of pesticide applications in the production of bedding and container color plants by 30% and to reduce organophosphate, carbamate, and pyrethroid applications to 15% or less of total insecticide applications. In a sense we accomplished these in that many of our demonstrations included an untreated control that often was of comparable quality to the grower standard and the IPM treatments. In other

instances we did not reduce the number of applications because the number of IPM applications was equal to or greater than the grower standard. However in all cases this is balanced against the fact that the IPM protocol incorporated products of reduced toxicity and reduced resistance risk.

When presented with this information, however, the bottom line for the growers was that the risk of crop loss was too great to not use prophylactic pesticide applications.