The Cost of Adopting IPM Treatments for Pest and Disease Control by The California Bedding and Color Container Plant Industry

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Introduction

The bedding and container color plant industry provides plant material for the urban environment. They produce both bedding plants, for outdoor use, and container color plants, which are used for either indoor or outdoor decoration. This is a large industry in California and accounts for a significant portion of the $3.7 billion in value generated by the California greenhouse and nursery industry in 2012.

Unlike conventional crop production where a few varieties may be grown, producers in this industry can have upwards of 100 species and several hundred varieties of product growing in their facilities year round. Not every producer grows 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." The short crop cycle, large number of key pests, and limited tolerance for plant injury lead most growers to believe 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. The Alliance Project focused on changes that could be made in the cropping system to affect many pests.

Although there can be advantages to using IPM practices with respect to reduced environmental damage and employee health risks, growers must make pest management decisions which are economically feasible. This report will use the results from the IPM Bedding and Container Color Plant Alliance demonstrations to estimate costs of each demonstration trial conducted. I will estimate the costs of implementing each treatment within the specific trials. My estimates will be extrapolated to one acre of commercial plant production within a greenhouse.

Estimation of Costs

In each of the demonstration trials conducted by the IPM Bedding and Container Color Plant Alliance there were a set of different treatment options. The cost estimations for this project are based on the specific protocols for each treatment within the specific trial. In order to provide more reliable cost estimates, the inputs required for each treatment were extrapolated to one acre of commercial production.

Specific operating cost data from participating greenhouse operations were not made available for this project. Data used in estimating treatment costs comes from multiple sources. For chemical costs, prices were obtained from internet marketing sites. It is assumed that a commercial greenhouse will pay wholesale or bulk rates for each chemical. Therefore, for each chemical used in the demonstration trials the lowest price per unit quoted from internet marketers was used. Labor costs associated with treatments were estimated using the average hourly wage rate for farm workers in the Western U.S from The U.S. Bureau of Labor Statistics . Final cost estimates are given on a single acre or flat basis. These cost estimates reflect the labor and inputs required to plant and treat one acre of production for the same duration of time as specified in each trial.

The results from the IPM Bedding and Container Color Plant Alliance trials with respect to crop loss were used to estimate the final cost per unit of marketable product. Crop quality assessments, although not applicable to cost do provide a possible measure of shelf life and probability of sale of the final product.

IPM in Bedding Plant Propagation

Demonstration 1: Propagation of Salvia and Vinca at Site #1

This IPM demonstration was conducted at a grower location in Morgan Hill, CA in May and June 2011 during seed propagation of Salvia and Vinca. Pythium root rot had been on-going problem in these very sensitive young plants. To combat this, the grower was purchasing a media, ProMix PGX, with biofungicide incorporated to address the problem in the most sensitive crops.

For this demonstration two IPM treatments were employed to determine if crop quality comparable to that of the PGX media could be obtained but at a lower cost. The grower determined the IPM treatments and assessments were made by IPM team members four weeks after seeds were sown.

The first IPM treatment was one application of Activated Effective Microorganisms (AEM) at initial planting (Table 1). The AEM was applied at a concentration of 1:500 and the plant medium was the standard homemade mix produced on site by the grower. The second IPM treatment was one application of AEM at a concentration of 1:500 in combination with use of the ProMix PGX growing medium with incorporated biofungicide. In addition, flats were also propagated using the grower's standard ProMix PGX with no other treatment applications.

Table 1: Trial Treatments for Demonstration 1

	IPM Treatment #1	IPM Treatment #2	Standard
Activated Effective Microorganims (AEM)	A[1]	A[1]	
ProMix PGX with Subtilex Biofungicide		B[2]	B[2]
Grower Produced Medium	B[2]		

[1] Treatment was applied once to plants during demonstration trial.
[2] Treatment was mixed into planting medium at beginning of demonstration trial.

Loss:
Both crop species had significantly more plant loss in the grower produced media. In vinca, there was a trend for reduced loss in the PGX media when AEM was added (mean percent loss PGX = 12.71 percent; PGX+AEM = 10.71 percent). This difference was not statistically significant.

Quality:
Both crop species were of significantly poorer quality in the grower-produced media than in the PGX media. In Vinca, the addition of AEM to the PGX media significantly improved crop quality. In Salvia, there was no statistical effect of adding AEM to the PGX media, but AEM-treated plants in PGX media had slightly larger leaves and were taller than plants in PGX-only media.

The initial costs of planting an acre of Vinca and Salvia using the grower's own medium mix along with a one time application of AEM was estimated to cost $3.14 per flat, or about 10 percent less than treatment #2 or the grower standard (Table 2). This initial cost advantage was offset for Vinca by the high percentage of crop loss reported over the three-week growing period. The result of the significantly higher crop loss was a higher cost per flat of marketable product at the end of the growing period. Although Salvia also had a significantly higher mean crop loss under treatment #1 compared to the other two treatments, the cost per sellable flat was still the lowest of the three. Furthermore, the flats grown under treatment #1 had a significantly lower mean quality score, which could decrease the probability of being sold.

Table 2: Estimated Costs per Flat of Implementing Bedding Plant Propagation Demonstration Trial #1 Treatments Over One Acre of Production.

		IPM Treatment #1[1]	IPM Treatment #2[2]	Standard[3]
Total cost per flat planted[4]		$1.73	$2.05	$2.04
Mean Percent Loss Recorded[5]				
	Salvia 'Rhea'	10.71a	3.86b	4.14b
	Vinca 'Cooler Mix'	35.71a	12.71b	10.71b
Cost per Sellable Flat[6]				
	Salvia 'Rhea'	$1.94	$2.13	$2.13
	Vinca 'Cooler Mix'	$2.69	$2.35	$2.29
Mean Flat Quality Measure[7]				
	Salvia 'Rhea'	2.86a	4.29b	4.79b
	Vinca 'Cooler Mix'	2.00a	3.14b	2.71c

[1] Treatment #1 is a one-time application of Activated Effective Microorganisms (AEM) at a concentration of 1:500 to the plant medium mix produced by the grower.
[2] Treatment #2 is a one-time application of AEM at a concentration of 1:500 and the use of Subtilex biofungicide that is incorporated into ProMix PGX plant medium.
[3] standard is the use of Subtilex biofungicide that is incorporated into ProMix PGZ plant medium.
[4] Total cost per flat is an average of material and labor costs to plant and treat one acre of flats for three weeks.
[5] Mean percent loss per flat is the average of a visual estimate of the percentage of dead or missing plants in the 288 cell flat. This data comes from the results of demonstration trial conducted by the IMP Bedding and Container Color Plant Alliance. Different letters represent statistically significant difference at the p=.0001.
[6] Cost per sellable flat is the sum of materials and labor costs to plant and treat one acre of flats divided by the number of marketable flats remaining at the end of the trial period.
[7] Mean flat quality is an average of flat quality measured on a scale of 1 to 5, with 1= all dead plugs to 5 = all healthy plugs the flat. This data comes from the results of demonstration trial conducted by the IMP Bedding and Container Color Plant Alliance. Different letters represent statistically significant difference at the p=.0001.

Demonstration Trial #2: Salvia, Pansy, and Vinca At Site #2

This IPM demonstration was conducted at a grower in Arroyo Grande, CA over a 5-week period from August to September 2011. Comparison of four treatments was conducted during seed propagation of Salvia, Pansy and Vinca. This grower is a propagator whose business provides young plants to other growers to finish. Disease control for this grower is of upmost importance.

This grower was already following good sanitation practices to help manage root rot disease. They are VeraFlora certified, which is a voluntary certification program that promotes sustainable practices in the floriculture and horticulture industries. Under this certification program the grower is required to apply least toxic pest and disease management and control systems, and are encouraged to integrate organic practices when possible. Where organic practices are not fully implementable on a practical basis, the certification requirements establish a minimum requirement related to the use of registered pesticides and fertilizers, integrating practices that minimize the overall use of synthetic pesticides and fertilizers. Therefore, this grower is motivated to find effective IPM treatments that are not cost prohibitive.

This trial compared the effectiveness of two IPM treatments to the grower's standard management practice and an untreated control (Table 3). All crops were propagated in the same peat based medium.

Table 3: Trial Treatments for Demonstration 2

	IPM Treatment #1	IPM Treatment #2	Grower Standard	Control
Activated Effective Microorganims (AEM)	A[1]			
RootShield biofungicide (*Trichoderma Harzianum*)		A[1]		
Pageant (*Pyraclostrobin and Boscalid*)			A[1]	
Untreated				X

[1] Treatment was applied weekly for the duration of the demonstration trial.

Estimates of costs for each treatment include the cost to begin propagation plus the labor costs for each application. For the AEM, RootShield and Pageant it is estimated that it would take two people 1.5 hours to apply each product over an acre of production.

Loss:
The mean percent flat loss numbers indicate that the grower standard of a weekly application of Pageant produced the highest loss among Pansy and Vinca. The lowest percentage of loss was in the control. Not surprisingly, the low percent loss of flats associated with the untreated control resulted in the lowest cost per sellable flat.

Quality:
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.

Table 4: Estimated Costs per Flat of Implementing Bedding Plant Propagation Demonstration Trial #2 Treatments Over One Acre of Production.

		IPM Treatment #1[1]	IPM Treatment #2[2]	Grower Standard[3]	Control[4]
Total cost per flat planted[5]		$1.81	$1.91	$1.82	$1.80
Mean percent loss recorded[6]					
	Pansy	8.0ab	7.0ab	16.0a	6.0b
	Vinca	12.0ab	7.0ab	15.0a	4.0b
	Salvia	0.0a	0.0a	0.0a	0.0a
Cost per sellable flat[7]					
	Pansy	$1.97	$2.05	$2.17	$1.92
	Vinca	$2.06	$2.05	$2.14	$1.88
	Salvia	$1.81	$1.91	$1.82	$1.80
Mean flat quality measure[8]					
	Pansy	4.0a	4.0a	5.0a	4.0a
	Vinca	4.5ab	5.0a	4.5ab	3.5b
	Salvia	5.0a	5.0a	5.0a	5.0a

[1] Treatment #1 is a weekly application of Activated Effective Microorganisms (AEM) at a concentration of 1:500.
[2] Treatment #2 is a weekly application of RootShield biofungicide at a concentration of 4 ounces per 100 gallons of water.
[3] Grower standard is a weekly application of Pageant biofungicide (pyraclostrobin and boscalid) at a concentration of 12 ounces per 100 gallons of water.
[4] The control received no treatment.
[5] Total cost per flat is an average of materials and labor costs to plant and treat one acre of flats for five weeks.
[6] Mean percent loss recorded comes from the results of demonstration trial conducted by the IMP Bedding and Container Color Plant Alliance. Different letters represent statistically significant difference at the p=.0001.
[7] Cost per sellable flat is the sum of materials and labor costs to plant and treat one acre of flats divided by the number of marketable flats remaining at the end of the trial period.
[8] Mean flat quality is an average of flat quality measured on a scale of 1 to 5, with 1= all dead plugs to 5 = all healthy plugs in the flat. This data comes from the results of demonstration trial conducted by the IMP Bedding and Container Color Plant Alliance. Different letters represent statistically significant difference at the p=.0001.

IPM in Bedding Plant Finish:

Demonstration 3: Finish of Vinca, Pansy, and Salvia at Site #1

This bedding plant IPM demonstration was conducted over an 8-week period from June to July 2011 at a commercial grower located in Morgan Hill, California.

The grower makes his own planting media and has experienced problems with Pythium spp. contamination. This demonstration trial was conducted to evaluate the effect of various biofungicides and plant growth promoters on plant loss and crop quality in some of the key bedding plant crops produced by the grower. Also, this trial was conducted to determine which of the different treatments could produce an acceptable crop under pressure from this pathogen.

The first three weeks of the trial followed the growth from seed to transplant plugs. Seed propagation portion of this trial was conducted using four different treatments (Table 5).

Table 5: Treatments for Seed Propagation in Demonstration Trial 3, Week 1 to Week 3

	Treatment #1	Treatment #2	Treatment #3	Treatment #4
AEM (1:500)	A[1]	A[1]		
Grower Media	B[2]			
ProMix PGX with Subtilex		B[2]	B[2]	B[2]
RootShield		C[3]	C[3]	

[1]Treatment was applied once to plants during demonstration trial.
[2] Treatment was mixed into planting medium at beginning of demonstration trial.
[3] Treatment was applied weekly to plants during demonstration trial.

For the propagation phase percent loss per flat was recorded (Table 6). No production loss data was recorded for Vinca, Pansy or Salvia grown in the ProMix media and not receiving treatments. No production loss data was recorded for Pansy grown in ProMix media and receiving a weekly application of RootShield.

Table 6: Mean Percent Flat Loss During Plug Propagation by Treatment

	Grower Media+ AEM	ProMix + RootShield+ AEM	ProMix+ RootShield	ProMix
Vinca	60	40	26	NA[1]
Pansy	43	37	NA[1]	NA[1]
Salvia	30	7	2.7	NA[1]

[1] No production loss data from propagation phase was recorded.

Mean percent loss per flat data indicates that those products propagated in the grower's own media suffered higher losses. Vinca lost an average of 60 percent of production across flats when grown in the grower's media mix. Salvia faired the best but still experienced an average loss of 30 percent of production.

Table 7: Cost per Transplantable Flat Following Initial Propagation

	Grower Media+ AEM	ProMix + RootShield+ AEM	ProMix+ RootShield	ProMix
Total Cost per Flat	$2.74	$3.36	$3.36	$3.05
Cost per Transplantable Flat				
Vinca Plugs	$6.85	$5.61	$4.54	NA
Pansy Plugs	$4.81	$5.34	NA	NA
Salvia Plugs	$3.91	$3.62	$3.45	NA

Comparing total cost per flat of plug propagation without factoring in production losses the grower's media with a one-time application of AEM was the least costly treatment per flat at $2.74. This was followed by propagation in ProMix media, which was 11 percent higher per flat. The weekly application of RootShield increased the cost per flat by 23 percent over the grower media + AEM treatment and by 10 percent over using the ProMix media alone.

When factoring in the high portion of lost production over the propagation period, the costs per marketable flat was highest for Vinca and Salvia using the grower media + AEM treatment (Table 7). Weekly application of RootShield showed a reduction in production loss, and therefore, resulted in a less costly production of plugs for Vinca and Salvia. Ultimate cost per plug flat using just the ProMix treatment was unknown, as data was not recorded.

Following the propagation phase, plugs were transplanted from 288-cell plug flats to 36-cell finish packs. Finish production was an additional six weeks. During this time each of the three varieties were treated using one of six specific treatments (Table 8).

Table 8: Bedding Plant Trial Finish Treatments, Week 4 to Week 9 of Production.

	Treat. #1	Treat. #2	Treat. #3	Treat. #4	Treat. #5	Treat. #6
AEM(1:500)		A[1]				A[1]
GrMedia[2]	B[3]	B[3]	B[3]			
ProMix				B[3]	B[3]	B[3]
RootShield			A[1]		A[1]	A[1]

[1]Treatment was applied weekly to plants during demonstration trial.
[2] Treatment was mixed into planting medium at beginning of demonstration trial.
[2] Grower Media

Table 9: Mean Percent Flat Loss by Bedding Plant Finish Treatment

	Propagation Treatment[1]	Finish Treatment	Percent of Flat Loss	Quality Measure
Salvia	PGX[2]+RS[3]	GrMedia[4]	6	5
	PGX	GrMedia	0	5
	GrMedia+AEM[5]	GrMedia	1	3.5
	GrMedia+AEM	GrMedia+AEM	23	1.5
	GrMedia+AEM	PGX+AEM+RS	1	5
	GrMedia+AEM	PGX+RS	0	4.8
	GrMedia+AEM	PGX	2	5
	GrMedia+AEM	GrMedia+RS	42	2.8
Vinca	GrMedia+AEM	GrMedia	2	2.7
	GrMedia+AEM	GrMedia+AEM	2	3.2
	GrMedia+AEM	GrMedia+RS	3	2.5
	PGX+RS	GrMedia	2	3.2
	PGX+RS	GrMedia+AEM	1	2.6
	PGX+RS	GrMedia+RS	7	3.6
	PGX+AEM+RS	GrMedia	1	3.2
	PGX+AEM+RS	GrMedia+AEM	0	2.7
	PGX+AEM+RS	GrMedia+RS	0	3.6
Pansy	GrMedia+AEM	GrMedia	0	3.7
	GrMedia+AEM	PGX+RS	0	3.3
	GrMedia+AEM	GrMedia+AEM	0	3.8
	GrMedia+AEM	GrMedia+RS	0	3.4
	PGX+AEM+RS	GrMedia	1	3
	PGX+AEM+RS	GrMedia+AEM	1	3.7

[1] Propagation treatments were applied during the first three weeks after seeds were sown.
[2] PGX= ProMix PGX.
[3] RS= RootShield.
[4] GrMedia= Grower Media
[5] AEM= Activated Effective Microorganism.

The highest percentage of production loss during the finish stage was in Salvia. Specifically, Salvia that was propagated in the grower's media mix with AEM application and then finished in the grower's media mix with AEM or RootShield applications experienced the highest percentage of loss. Finished Salvia that was either propagated or finished in the PGX mix had the lowest percentage of crop loss and the highest crop quality ratings. Neither Vinca nor Pansy had significant crop loss and all plants finished at a quality level high enough to be considered a marketable product.

Table 9: Treatment Costs for Propagation and Finish of Bedding Plants

	Propagation Treatment[1]	Cost per Plug Flat[2]	Finish Treatment[3]	Cost per Sellable Flat[4]	Quality Measure
Salvia	PGX[5]+RS[6]	$3.45	GrMedia[7]	$0.87	5
	PGX	$3.05	GrMedia	$0.87	5
	GrMedia+AEM[8]	$3.91	GrMedia	$0.93	3.5
	GrMedia+AEM	$3.91	GrMedia+AEM	$1.14	1.5
	GrMedia+AEM	$3.91	PGX+AEM+RS	$1.32	5
	GrMedia+AEM	$3.91	PGX+RS	$1.30	4.8
	GrMedia+AEM	$3.91	PGX	$1.04	5
	GrMedia+AEM	$3.91	GrMedia+RS	$1.99	2.8
Vinca	GrMedia+AEM	$6.85	GrMedia	$0.96	2.7
	GrMedia+AEM	$6.85	GrMedia+AEM	$0.96	3.2
	GrMedia+AEM	$6.85	GrMedia+RS	$1.23	2.5
	PGX+RS	$4.54	GrMedia	$0.92	3.2
	PGX+RS	$4.54	GrMedia+AEM	$0.96	2.6
	PGX+RS	$4.54	GrMedia+RS	$1.17	3.6
	PGX+AEM+RS	$5.61	GrMedia	$0.93	3.2
	PGX+AEM+RS	$5.61	GrMedia+AEM	$0.93	2.7
	PGX+AEM+RS	$5.61	GrMedia+RS	$1.19	3.6
Pansy	GrMedia+AEM	$4.81	GrMedia	$0.89	3.7
	GrMedia+AEM	$4.81	PGX+RS	$1.33	3.3
	GrMedia+AEM	$4.81	GrMedia+AEM	$0.90	3.8
	GrMedia+AEM	$4.81	GrMedia+RS	$1.19	3.4
	PGX+AEM+RS	$5.34	GrMedia	$0.91	3
	PGX+AEM+RS	$5.34	GrMedia+AEM	$0.91	3.7

[1] Propagation treatments were applied during the first three weeks after seeds were sown.
[2] Estimated cost per flat of plugs represents material and labor costs to plant and propagate one acre of 288-cell plug flats for three weeks using the specified treatment. Production losses during the three-week propagation phase are reflected in the final cost per flat estimate.
[3] Finish treatments were applied for the next six weeks after plug transplant.
[4] Cost per sellable flat represents the cost to transplant plugs into one acre of 36-cell finish flats plus the material and labor costs to grow the flat over the final six weeks. Production losses during the six-week finish stage are reflected in the final cost per flat estimate.
[5] PGX= ProMix PGX.
[6] RS= RootShield.
[7] GrMedia= Grower Media
[8] AEM= Activated Effective Microorganism.

The lowest cost treatment combination for Salvia was propagation in the ProMix media and finish in the grower's media mix. The costs of treatment for an acre of production, combined with the loss of crops resulted in a flat cost estimate of $0.87. This combination also produced the highest possible quality product. For Vinca there was not a significant difference across the combinations of propagation and finish treatments with respect to quality of flat. Given the

similarity in quality, the lowest cost treatment combination was propagation in ProMix media with weekly RootShield application and finish in the grower's media. Pansy was the only demonstration crop that had the highest quality and lowest cost per flat using grower's media mix in both propagation and finish.

IPM in Color Container Production

Demonstration Trial #1: Root Disease in Lavender

This color container IPM demonstration was conducted over an 8-week growing cycle in September and October 2010 at the Center for Applied Horticulture Research in Vista, CA. The purpose of this demonstration was to compare the grower's standard treatment for root disease in Lavender with two IPM treatments.

The normal grower response to root disease is to use the product Aliette® WDG (aluminum phosphonate). In this demonstration Aliette® WDG (aluminum phosphonate) was compared with two IPM approaches for managing 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 plugs were planted into one-quart containers using a peat-based media. Treatments were developed and assessed by the collaborating grower. All plants were grown in the same peat-based media.

Table 10: Treatments for Color Container Production of Lavender

	IPM Treatment #1	IPM Treatment #2	Grower Standard
AEM (1:500)	A[1]		
AEM (1:1000)	A[1]		
Xeroton-3 (1:500)		A[1]	
Xeroton-3 (1:2500)			
Aliette WDG			B[2]
Heritage			C[3]

[1]Treatment was applied every irrigation or weekly to plants during demonstration trial.
[2]Treatment was applied every 28 days to plants during demonstration trial.
[3]Treatment was applied every 14 days to plants during demonstration trial.

At the end of the trial period all plants were observed and measured for presence of root disease and distribution of the root ball. Measurements were done on a scale of one to five (Table 11).

Table 11: Scale Measurements of Presence of Root Disease and Root Ball Distribution.

Scale	Percent of Root System Diseased	Uniformity of Root Distribution
1	More than 75%	Poor root distribution
2	51%-75%	Limited Root Distribution
3	26%-50%	Average root distribution
4	1%-25%	Good Root Distribution
5	No disease present	Roots uniformly distributed

The lack of disease in the control suggests that the irrigation water is not a source of pathogens for this crop. Results from the demonstration trials showed no significant difference across the treatments with respect to presence of root disease or distribution of the root ball. The treatment of Xeroton-3 (1:500) applied weekly was the only treatment to show root disease in more than 50 percent of production. The remaining treatments had less than 25 percent of production displaying root disease.

Lavender receiving The Xeroton-3 (1:500) also had the poorest distribution of roots. Among the remaining treatments there were no significant differences in root distribution with all remaining plants showing good distribution. Given the results from the trials, the weekly application of AEM at a concentration of 1:1000 was the most cost effective treatment for root disease in the production of Lavender (Table 12).

Table 12: Treatment Costs for Controlling Root Disease in Lavender Production Over an Eight-Week Growing Cycle[1]

	Total Cost per Acre Per Treatment Assuming Weekly Application	Total Cost per Acre Per Treatment Assuming Daily Application with Irrigation
AEM (1:500)	$301.63	$2,111.42
AEM (1:1000)	$261.70	$1,831.87
Xeroton-3 (1:500)	$485.95	$3,401.66
Xeroton-3 (1:2500)	$274.60	$1,922.19
Aliette WDG / Heritage	$495.82[2]	NA

[1] Cost estimates were calculated for applying treatments to one acre of lavender production.
[2] Costs estimates were calculated for one application of Aliette WDG every 28 days and one application of Heritage every 14 days.

Demonstration Trial #2: Powdery Mildew on Gerbera

This demonstration was conducted over a four-week period in April 2011 at the Center for Applied Horticulture Research in Vista, CA. The purpose of this demonstration was to evaluate options for control of the foliar disease powdery mildew on Gerbera daisy 'Festival Orange.' Propagated plugs 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. The IPM team developed treatments and assessments were made by the collaborating grower (Table 13).

Table 13: Treatments for Powdery Mildew in Color Container Production of Gerbera

Treatment Components	IPM Treatment #1	IPM Treatment #2	Grower Standard
AEM (1:250)	Weekly		
AEM (1:500)	Weekly		
Regalia SC (*Reynoutria sachalinensis*)		Weekly	
Compass® O (*trifloxystrobin*)			Weekly

During the four-week demonstration trial the plants were observed and evaluated for the effects of powdery mildew exposure. Every seven days the percent disease severity was assessed (Table 14). Results indicate that the Regalia SC treatment was the most effective at mitigating damage from powdery mildew. The least effective, outside of non-treatment, was the grower standard of weekly application of Compass O.

Table 14: Mean Percent Disease Severity of Powdery Mildew on Gerbera Daisy by Number of Days After Transplant.

Treatment Components	Day 7	Day 14	Day 21	Day 28
AEM (1:250)	0	0.88	23	61.25
AEM (1:500)	0	0.25	15.5	51.25
Regalia SC	0	0	0.88	6.25
Compass® O	0	0.25	6.37	70.63
No Treatment	0	1.25	48.13	84.38

Although Regalia SC proved to be most effective at treating powdery mildew on Gerbera Daisy, it comes at a cost. Estimates for the same treatment over a one-acre production plot of Gerbera Daisy for four weeks was just over $266 (Table 15). Although this was over 50 percent less costly than the grower standard of Compass O, it was also significantly more expensive than either of the AEM treatments.

Table 15: Treatment Costs for Controlling Powdery Mildew in One Acre of Gerbera Daisy Production Over an Four Week Growing Cycle

Treatment Components	Total Cost Per Acre
AEM (1:250)	$39.94
AEM (1:500)	$79.87
Regalia SC	$266.24
Compass O	$406.40

Demonstration Trial #3: Root Rot in Gardenia veitchii and *Genista racemosa*

Herbaceous cuttings of Genista and Gardenia 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 (Table 16).

Table 16: Treatments for Root Rot in Color Container Production of Genista and Gardenia

	Treatment #1	Treatment #2	Treatment #3
AEM (1:500)	A[1]		
RootShield		A[1]	
Subdue MAXX			B[2]
Grower Standard			

[1]Treatment was applied weekly to plants during demonstration trial.
[2]Treatment was applied once to plants during demonstration trial.

Five weeks after transplant, trays were divided in two groups, one of the groups remained in the initial location and the other was placed in a separate bench in the same greenhouse. Both groups continued receiving the above treatments and 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 was counted once a week. Rooting was determined twice during the trial on a scale of 1 (no roots) to 5 (roots distributed throughout the cell) in one plug per tray per treatment. Plant mortality was determined by counting the number of dead cuttings per tray per treatment, tray quality was assessed visually on a scale of 1(no salable plugs) to 10 (all plugs healthy looking and marketable quality). Once plugs reached marketable size, one random plug per tray per treatment was selected and plug height and diameter in two directions were measured, growth index was calculated according to the formula GI=(H+(D1+D2)/2)/2 (where GI = growth index, H = height, and D1 and D2 are diameter measured in two directions). A fresh and dry weight of shoots and roots was taken.

Results

Five weeks after initial transplant, and before separation into two groups, all treatments applied to Gardenia resulted in trays with similar mortality rate and plugs with good root distribution

and quality (Table 17). For Genista, plants treated with AEM had significantly less plant mortality the five-week stage (Table 17). On average Genista treated with AEM had about 70 percent less plant loss then the next most effective treatment. Overall tray quality was also greater in plants treated with AEM.

Table 17. Mean Number of Dead Plants, Root Distribution and Tray Quality of *Genista racemosa and Gardenia veitchii* Five Weeks After Transplant and Split into Two Groups.

Species	Treatment	Mean Number of Dead Plants[1]	Root Distribution[2]	Tray Quality[3]
Genista	Standard	7.5	1.5	4.9
	AEM	2	1.2	8.3
	RootShield	7.1	1.1	6.5
	Subdue MAXX	6.7	1.2	6
Gardenia	Standard	0	2.5	9.6
	AEM	0	2.9	9.5
	RootShield	0.3	3	8.8
	Subdue	0	3.3	8.6

[1] Number of dead plants observed per 50-cell tray.
[2] Root distribution was measured on a scale of one to five. A score of one means no roots and five means roots distributed throughout the tray cell.
[3] Tray quality was assessed visually on a scale of one to ten. A score of one means no saleable plugs and ten means all plugs are healthy and of marketable quality.

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 AEM at 1:500 once a week while a second group of 10 plants per treatment received water only. Eight weeks after transplant height and diameter in two directions were measured. The number of flowers and flower buds were counted and quality, root distribution and disease incidence were assessed on a scale of one (not salable, no roots visible, no disease symptoms) to 5 (excellent quality, roots throughout the container, most disease).

Readings after the introduction of Hypoaspis Miles displayed the same results. The interactive effects of introducing Hypoaspis Miles were not significant. In the later observations of Genista, AEM treated plants continued to have lower mortality and a higher overall tray quality compared to the other treatments (Table 18). The positive effects of AEM on Gardenia are also apparent in the measurements of height, size and growth index (Table 19) as well as in weight of root and shoot (Table 20). With respect to the presence of fungus gnat larvae, there was no difference across the treatments and the introduction of Hypoaspis Miles had no effect.

Table 18 . Mean Number of Dead Plants, Root Distribution and Tray Quality of *Genista racemosa and Gardenia veitchii* after Week-5 Hypoaspis Miles Release.

Species	Treatment	Number of Dead Plants[2]	Root Distribution[3]	Tray Quality[4]
Genista[1]	Standard	26.6	4	5.6
	AEM	16.4	4.1	7.2
	RootShield	25.7	4.5	5.5
	Subdue MAXX	24.3	4.6	5.7
	Standard+Hypoaspis Miles	30.6	3.6	4.9
	AEM+Hypoaspis Miles	16.6	4.3	7.7
	RootShield+Hypoaspis Miles	29.5	4.4	5.2
	Subdue MAXX+Hypoaspis Miles	27.5	4.2	4.6
Gardenia[5]	Standard	0.5	4.1	9.7
	AEM	0.3	4.2	9.8
	RootShield	0.8	3.9	9.3
	Subdue	0.6	3.9	9.2
	Standard+Hypoaspis Miles	0.5	4.1	9.7
	AEM+Hypoaspis Miles	0.6	3.6	9.3
	RootShield+Hypoaspis Miles	0.5	3.5	9
	Subdue+Hypoaspis Miles	0.5	4.2	9.4

[1] Measurements for Gardenia veitchii were taken eight weeks after transplant.
[2] Number of dead plants observed per 50 cell tray.
[3] Root distribution was measured on a scale of one to five. A score of one means no roots and five means roots distributed throughout the tray cell.
[4] Tray quality was assessed visually on a scale of one to ten. A score of one means no saleable plugs and ten means all plugs are healthy and of marketable quality.
[5] Measurements for Genista racemosa were taken eleven weeks after transplant.

Table 19. Mean Height, Diameter and Growth Index of *Gardenia veitchii*[1] and *Genista racemosa*[2]

Species	Treatment	Height cm	Diameter cm	Diameter 2 cm	Growth Index
Genista	Standard	12.3	10.3	7.8	10.69
	AEM	15.5	11.2	8.7	12.75
	RootShield	13.7	11.0	9.2	11.88
	Subdue MAXX	12.8	11.0	8.7	11.31
	Standard +Hyp	13.4	12.0	9.2	12.00
	AEM+Hyp	13.9	12.1	10.3	12.56
	RootShield+Hyp	13.3	11.9	10.2	12.15
	Subdue MAXX+Hyp	14.0	11.1	7.4	11.62
Gardenia	Standard	10.2	13.6	11.2	11.34
	AEM	11.4	15.1	11.8	12.41
	RootShield	9.9	14.3	11.9	11.50
	Subdue MAXX	12.8	11.0	8.7	11.54
	Standard +Hyp	10.1	13.8	11.2	11.31
	AEM+Hyp	11.8	17.1	13.2	13.49
	RootShield+Hyp	9.3	13.8	11.6	11.03
	Subdue +Hyp	10.2	13.9	11.2	11.35

[1] Measurements for Gardenia veitchii were taken eight weeks after transplant.
[2] Measurements for Genista racemosa were taken eleven weeks after transplant.

Table 20. Mean Shoot and Root Weight of *Gardenia veitchii*[1] and *Genista racemosa*[2]

Species	Treatment	Shoot Fresh Weight	Shoot Dry Weight	Root Fresh Weight	Root Dry Weight
Genista	Standard	2.89	0.77	1.36	1.69
	AEM	3.93	0.89	1.99	0.23
	RootShield	3.75	0.88	2.03	0.23
	Subdue	3.47	0.91	1.69	0.20
	Standard+Hyp	2.98	0.69	1.06	0.15
	AEM+Hyp	4.46	1.11	2.10	0.24
	RootShield+Hyp	3.51	0.88	1.75	0.20
	Subdue MAXX+Hyp	3.09	0.78	1.61	0.19
Gardenia	Standard -Hyp	8.06	1.81	2.70	0.42
	AEM-Hyp	9.92	2.45	3.56	0.56
	RootShield	8.14	1.91	2.79	0.41
	Subdue MAXX	3.47	0.91	1.69	0.20
	Standard +Hyp	7.78	1.78	2.66	0.40
	AEM+Hyp	10.89	2.69	3.26	0.54
	RootShield+Hyp	7.81	1.96	2.45	0.40
	Subdue MAXX+Hyp	6.56	1.47	2.85	0.38

[1] Measurements for Gardenia veitchii were taken eight weeks after transplant.
[2] Measurements for Genista racemosa were taken eleven weeks after transplant.

The effectiveness of the AEM treatment at reducing plant mortality and increasing growth and robustness of Genista comes at a low cost (Table 21). The cost of treating one acre of production is considerably less than either of the other two primary treatments. Although the effect of Hypoaspis Miles was not significant, the added cost of including this biological control in a treatment program is minimal.

Table 21. Treatment Costs for Controlling Fungus Gnats in One Acre of *Gardenia veitchii* and *Genista racemosa* From Propagation Through Finish Production

	With Hypoaspis Miles	Without Hypoaspis Miles
AEM (1:500)	$199.87	$79.87
RootShield	$8,178.60	$8,058.60
Subdue MAXX	$664.50	$544.50
Post Propagation Phase Added Costs for Trials with AEM	NA	$79.87

Conclusions

From a cost perspective the use of AEM as an alternative form of disease control had mixed results. In the propagation trials, links to lower mortality and increased robustness of plant growth were inconclusive. In propagation bedding plant demonstration trial #1, the application

of AEM proved less costly in the Salvia production but more costly in the propagation of Vinca. In the second propagation trial there was no significant difference in mortality or quality across the treatments, while the initial cost per unit indicated the non-IPM labeled treatments were less expensive. This result was also observed in the bedding plant finish demonstration trial. This trial was conducted in two parts. First plugs were propagated in 288-cell trays. The initial costs per transplantable plug that resulted showed AEM treatment to again be the higher cost treatment. This also carried over into the second part of the trial where the plugs were finished in 36-cell finish trays. Those plants that received AEM treatment were not the lowest cost solution.

The color container demonstration trial #1 and demonstration trial #2 examined the effectiveness of treatments on root disease, the development of the root ball and the spread of powdery mildew. No mortality data was collected. Therefore costs were estimated to reflect treatment over an acre of production for the length of the trial.

The first trial examined root disease and development in Lavender. In this trial there were not significant differences across the treatments with respect to controlling for disease or encouraging root development. As such, AEM proved to be the least costly alternative in this trial.

The second trial focused on the effectiveness of each treatment at controlling the spread of powdery mildew. In this trial the cost of the AEM treatment was significantly less than the two alternative treatments Regalia SC and Compass O. The Regalia SC treatment was far more effective at controlling powdery mildew but at an initial cost that is 70 percent higher than the more concentrated application of AEM. The cost effectiveness of AEM compared to Regalia SC would be dependent on how the presence of powdery mildew decreased the marketability of the product.

In the final demonstration trial, AEM showed to have the lowest initial costs of the four treatments and was most effective at controlling root rot in Gardenia and Genista. This trial, in conjunction with the other demonstration trials, indicates that AEM is more cost effective at controlling disease during the finish stage than initial propagation of product.

APPENDIX: Information For Products Used in IPM Bedding and Container Color Plant Alliance Demonstrations.

Product	Active Ingredient	Cost per unit	Use Rate per acre	Purpose
Activated Effective Microorganism (AEM)	Yeast, Photosynthetic Bacteria, and Lactic Acid Bacteria.	$2.38/gal	5 gal	Plant Growth Promoter
RootShield	Trichoderma harzianum Rifai strain KRL-AG2	$3.70/oz	136 oz	Biofungicide
ProMix PGX with Subtilex	Bacillus subtilis, strain MBI 600	$220/cu.yd.	72 cu.yd.	Biofungicide
Pageant	Pyraclostrobin and Boscalid	$6.50/oz	12 oz	Biofungicide
Xeroton-3	Hydrogen Peroxide Peroxyacetic Acid Octanoic Acid	$1.29/oz	25.6 oz @1:500 12.8 oz @1:2500	Disinfectant
Aliette® WDG	Aluminum Phosphonate	$1.49/oz	16.6 oz	Fungicide
Heritage®	Azoxystrobin	$19.72/oz	5.2 oz	Fungicide
Regalia SC	Reynoutria Sachalinensis	$.52/oz	128 oz	Biofungicide
Compass O ®	Trifloxystrobin	$25.40/oz	4 oz	Fungicide
Subdue MAXX®	Mefenoxam	$5.00/oz	108.9 oz	Fungicide
Hypoaspis miles	Live bug	$20.00/liter	3 to 6 liter	Biological control of fungas gnats