Greenhouse evaluation of *Bacillus licheniformis* SB3086 for control of Rhizoctonia on Impatiens and Geraniums and Phytophthora on Marigolds.

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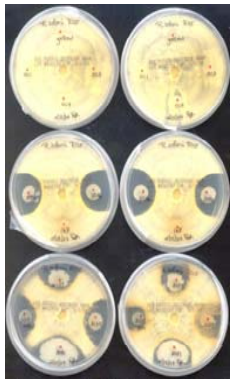
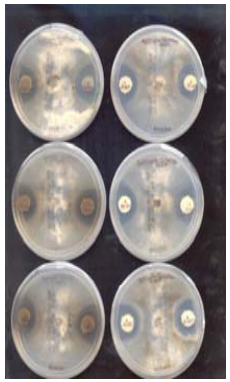
Introduction

Damping-off, root rot and blight diseases caused by soilborne (*Rhizoctonia solani*, and *Phytophthora* spp.) are primary pest concerns of the greenhouse industry in North America. The use of fungicides has presented a number of problems. The development of pathogen resistance to fungicides, the inability of seed-treated fungicides to protect the roots of mature plants, and a requirement for repeated applications have given impetus to alternative remedies. One approach to address this challenge is the use of naturally occurring and environmentally safe biologicals (EcoGuard) which can be used alone or in conjunction with integrated pest management strategies. EcoGuard-f showed significant control of these diseases in 2004 and this study is a follow up to refine rate and application recommendations.



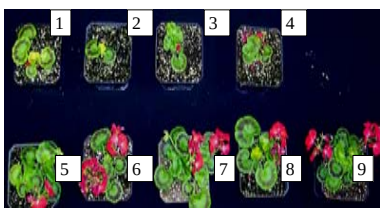


Methods

All seedlings were obtained from California and transplanted into 4" pots. Innoculum of each disease was grown up and then applied with common methods for each disease. Each treatment was replicated 8 times. Plants were arranged in a completely randomized design on a bench in a controlled growth chamber maintained at 20°C with 80% RH and photo period of 14 -10 h day and night, respectively.

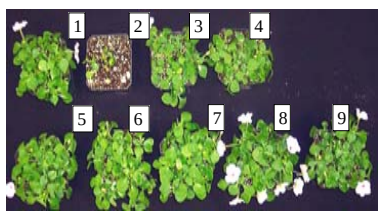
All data were subjected to analysis of variance (ANOVA). The treatment means were separated by Student-Newman-Keuls least significant difference test at p=0.10. All analyses were conducted with ARM 7 software (Gylling Data Management).

Rhizoctonia on Geranium



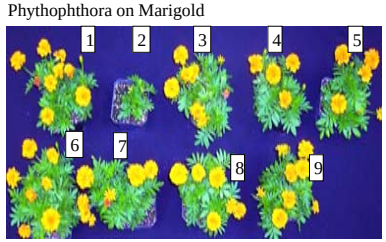
1.Healthy control
2.Pathogen control
3.Endorse
4.Decree
5. EcoGuard-f at 16 fl oz
6. EcoGuard-f at 32 fl oz
7. EcoGuard-f at 64 fl oz
8. Endorse + Eco at 16 fl oz
9. Decree + Eco at 16 fl oz

Rhizoctonia on Impatiens



1.Healthy control
2.Pathogen control
3.Subdue Max
4.Contrast
5. EcoGuard-f at 16 fl oz
6. EcoGuard-f at 32 fl oz
7. EcoGuard-f at 64 fl oz
8. Subdue + Eco at 16 fl oz
9. Contrast + Eco at 16 fl oz

Phythophthora on Marigold



1.Healthy control
2.Pathogen control
3.Subdue Max
4.Biophos
5. EcoGuard-f at 16 fl oz
6. EcoGuard-f at 32 fl oz
7. EcoGuard-f at 64 fl oz
8. Subdue + Eco at 16 fl oz
9. Biophos + Eco at 16 fl oz

Results

Results – (Tables 1 & 2):

- All treatments significantly improved the vigor of seedlings compared to inoculated control. Similarly, all the treatments significantly reduced pre- and post-emergence damping-off and root rot severity caused by *Rhizoctonia* in Geranium and Impatiens seedlings except Endorse and EcoGuard-f at the 16 oz. (low) rate.
- EcoGuard-f showed a consistent rate response trend with 64 oz. rate having lower mortality both pre- and post-emergent, lower root rot ratings and higher vigor ratings than the 16 oz. rate.
- EcoGuard-f at the low rate (16oz.) rotated with the chemical controls, lowered or maintained mortality compared to any of the chemicals tested alone. This is a critical point for resistance management.
- High rate of EcoGuard-f (64 oz.) alone controlled mortality at least as well as any of the other standard fungicide controls. The EcoGuard-f 64 oz. rate also improved vigor ratings compared to the fungicides alone.

Results – (Table 3):

- All treatments significantly improved the vigor of seedlings compared to *Phytophthora* control. Only roatation treatments with EcoGuard-f significantly reduced pre-emergence damping-off caused by *Phytophthora* in Marigold seedlings. Treatments with EcoGuard-f at 32 fl oz, 64 fl oz and also BioPhos rotated with EcoGuard-f at 16 fl oz significantly reduced post-emergence damping-off caused by *Phytophthora* compared to the control. All treatments significantly reduced root rot severity.
- Low rate (16 oz.) of EcoGuard-f rotated with control fungicides maintained or improved mortality ratings, root rot ratings, and significantly improved vigor ratings compared the control fungicides used alone.
- Rate response apparent between the 16 oz. and 64 oz. rate of EcoGuard-f for all response variables.
- EcoGuard-f alone (64 oz. rate) controlled Phytophthora at least as well as both Subdue and Biophos alone and improved vigor compared to the chemical alone treatments.

Table 1. Effect of EcoGuard-f for control of *Rhizoctonia* on Geranium seedlings under controlled conditions.

Pest Name	Rhizoctonia sp.		Rhizoctonia sp.		Rhizoctonia sp.			Rhizoctonia sp.		
Crop Name	Geranium		Geranium		Geranium			Geranium		
Rating Data Type	Post-Emerge		Pre-Emerge		Root rot			VIGOR		
Rating Unit	% mortality	%	% mortality	%	0-5			0-5		
No. Treatment Name		Control		Control			Control			StDev
1 Healthy Control	25 b	66.7	12.5 b	83.3	0.13 b			4.73 ab		0.3
2 Rhizoctonia Control	75 a	0.0	75 a	0.0	4.5 a			1.68 d		0.3
3 Endorse	50 ab	33.3	12.5 b	83.3	1.25 b		72.2	4.34 bc		0.4
4 Decree	37.5 b	50.0	12.5 b	83.3	1.88 b		58.2	4.01 c		0.2
5 EcoGuard-f 16	50 ab	33.3	37.5 b	50.0	2.75 ab		38.9	4.28 c		0.4
6 EcoGuard-f 32	25 b	66.7	25 b	66.7	1.5 b		66.7	4.7 ab		0.2
7 EcoGuard-f 64	37.5 b	50.0	12.5 b	83.3	2 b		55.6	4.72 ab		0.4
8 Endorse /EcoGuard-f 16	37.5 b	50.0	0 b	100.0	2.5 ab		44.4	5 a		0
9 Decree /EcoGuard-f 16	25 b	66.7	0 b	100.0	1.25 b		72.2	5 a		0
LSD (P=.10)	22.5		23.0				1.7			0.2
Treatment F	2.9		5.7				2.8			77.5
Treatment Prob(F)	0.009		0.0001				0.01			0.0001

- Means followed by same letter do not significantly differ (P=.10, Student-Newman-Keuls)
- Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.
- Mean 8 replications per treatment, one seedling per replication.
- Pre-emergence damping-off was rated 30 days after transplanting. Post-emergence was rated 45 days after transplanting.
- Root rot severity rated on a numerical scale of 0-5; 0 = healthy, symptomless plants; 1 = 1-10% root slightly discolored; 2 = 11-30% root rotted with moderate discoloration of tissues; 3 = 31-50 root rotted with dark discoloration of tissues; 4 = 51-80% root rotted or completely collapsed; 5 = all of root rotted and (or) plant killed.

Table 2. Effect of EcoGuard for control of *Rhizoctonia* on Impatiens seedlings under controlled conditions.

Pest Name	Rhizoctonia sp.		Rhizoctonia sp.		Rhizoctonia sp.			Rhizoctonia sp.		
Crop Name	Impatiens		Impatiens		Impatiens			Impatiens		
Rating Data Type	Post-Emerge		Pre-Emerge		Root Rot			Vigor		
Rating Unit	% mortality	%	% mortality	%	0-5			0-5		
No. Treatment Name		Control		Control			Control			StDev
1 Healthy Control	12.5 b	85.7	12.5 b	83.3	0.25 b			4.44 ab		0.5
2 Rhizoctonia Control	87.5 a		75 a		4 a			1.56 c		0.4
3 Subdue	37.5 b	57.1	25 b	66.7	1.25 b		68.8	3.69 b		0.6
4 Contrast	37.5 b	57.1	37.5 b	50.0	1.88 b		53	3.75 b		0.6
5 EcoGuard-f 16	37.5 b	57.1	12.5 b	83.3	2.75 ab		31.3	3.94 ab		0.7
6 EcoGuard-f 32	25 b	71.4	25 b	66.7	1.5 b		62.5	4.25 ab		0.4
7 EcoGuard-f 64	37.5 b	57.1	25 b	66.7	1.5 b		62.5	4.25 ab		0.5
8 Subdue /EcoGuard-f 16	37.5 b	57.1	0 b	100.0	2 b		50	4.63 a		0.4
9 Contrast /EcoGuard-f 16	25 b	71.4	12.5 b	83.3	0.62 b		84.5	4.69 a		0.3
LSD (P=.10)	26.1		29.0				1.4			0.4
Treatment F	3.5		3.0				3.1			22.3
Treatment Prob(F)	0.002		0.005				0.005			0.0001

- Means followed by same letter do not significantly differ (P=.10, Student-Newman-Keuls)
- Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.
- Mean 8 replications per treatment, one seedling per replication.
- Pre-emergence damping-off was rated 30 days after transplanting. Post-emergence was rated 45 days after transplanting.
- Root-rot severity rated on a numerical scale of 0-5; 0 = healthy, symptomless plants; 1 = 1-10% root slightly discolored; 2 = 11-30% root rotted with moderate discoloration of tissues; 3 = 31-50 root rotted with dark discoloration of tissues; 4 = 51-80% root rotted or completely collapsed; 5 = all of root rotted and (or) plant killed.

Table 3. Effect of EcoGuard-f for control of *Phytophthora* on Marigold seedlings 6 weeks after transplanting.

Pest Name	Phytophthora sp.		Phytophthora sp.		Phytophthora sp.			Phytophthora sp.		
Crop Name	Marigold		Marigold		Marigold			Marigold		
Rating Data Type	Post-Emerge		Pre-emerge		root rot			vigor		
Rating Unit	% mortality	%	% mortality	%	0-5			0-5		
No. Name		Control		Control			Control			StDev
1 Healthy Control	37.5 ab	40.0	0 b	100.0	0.2 c			4.56 ab		0.5
2 Rhizoctonia Control	62.5 a	0.0	62.5 a	0.0	4.5 a			1.45 c		0.4
3 Subdue	37.5 ab	40.0	25 ab	60.0	2.1 bc		53.3	3.95 ab		0.7
4 BioPhos	25 ab	60.0	25 ab	60.0	1.7 bc		62.2	3.81 b		0.5
5 EcoGuard-f 16	37.5 ab	40.0	50 ab	20.0	2.6 b		42.2	4.13 ab		0.5
6 EcoGuard-f 32	12.5 b	80.0	25 ab	60.0	2.1 bc		53.3	4.44 ab		0.5
7 EcoGuard-f 64	12.5 b	80.0	25 ab	60.0	1.7 bc		62.2	4.69 a		0.4
8 Subdue /EcoGuard-f 16	25 ab	60.0	12.5 ab	80.0	1.6 bc		64.4	4.69 a		0.5
9 BioPhos /EcoGuard-f 16	0 b	100.0	12.5 ab	80.0	1.1 bc		75.6	4.56 ab		0.7
LSD (P=.10)	24.1		30.4				1.2			0.4
Treatment F	3.2		2.2				4.8			25.0
Treatment Prob(F)	0.004		0.03				0.0001			0.0001

- Means followed by same letter do not significantly differ (P=.10, Student-Newman-Keuls)
- Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.
- Mean 8 replications per treatment, one seedling per replication.
- Pre-emergence damping-off was rated 30 days after transplanting. Post-emergence was rated 45 days after transplanting.
- Root rot severity rated on a numerical scale of 0-5; 0 = healthy, symptomless plants; 1 = 1-10% root slightly discolored; 2 = 11-30% root rotted with moderate discoloration of tissues; 3 = 31-50 root rotted with dark discoloration of tissues; 4 = 51-80% root rotted or completely collapsed; 5 = all of root rotted and (or) plant killed.

Conclusion

This study is a follow up to a series of trials conducted in 2004 in which EcoGuard-f showed strong promise as a greenhouse disease control candidate. These data confirm the previous successes and provide application guideline information for the use of the biocontrol alone or in rotation with other biologicals or chemicals. Based on these and other data, the EcoGuard-f formulation has been submitted to the EPA for a label expansion (EcoGuard is labeled for turf uses) for use in greenhouses. This product should be available for greenhouse use by 2007.