Int. J. Environ. Sci. Tech.
© Summer 2005, Vol. 2, No. 2, pp. 129-132

Comparative efficacy of brown, green and red seaweeds in the control of root infecting fungi and okra

[1]V. Sultana, [2]S. Ehteshamul-Haque, [3]J. Ara and [4]M. Athar

[1]Department of Biochemistry, University of Karachi, Karachi, Pakistan

[2]Department of Botany, University of Karachi, Karachi, Pakistan

[3]Department of Food Science & Technology, University of Karachi, Karachi, Pakistan

[4]California Department of Food & Agriculture, Sacramento, USA

Abstract

The effect of soil amendment by brown, green and red seaweeds was studied in controlling the root rot infecting fungi of okra seedlings in the greenhouse. The soil amendment with seaweeds *Stokeyia indica, Padina pavonia* (brown), *Solieria robusta* (red), at 1% w/w reduced *Macrophomina phaseolina, Rhizoctonia solani* and *Fusarium solani* infection on okra roots. *Codium iyengarii* (green) at 0.5 % w/w was effective against *F. solani*, while at 1% w/w was found phytotoxic. *S.robusta* showed better control of *F. solani* infection when used with *Pseudomonas aeruginosa* than either used alone. *S. robusta* produced better plant height and fresh weight of shoot than *P. aeruginosa*. Results of the present study suggest that the use of brown seaweeds *S. indica* and *P. pavonia* alone and *S. robusta* alone or in combination with *P. aeruginosa* have great potential to control root-infecting fungi of okra with enhancement of plant growth. These seaweeds alone or in combination with *P. aeruginosa* may be utilized as biological control of root infecting fungi of okra.

Key words: *Seaweeds, Pseudomonas aeruginosa, root infecting fungi, okra, biocontrol*

**Corresponding Author, E-mail:* ataritariq@cdfa.ca.gov

Introduction

Seaweeds are rich and varied source of bioactive natural products and have been studied as potential biocidal and pharmaceutical agents (Ara, *et al.*, 1998, 1999, 2002a and 2002b). Seaweeds are also known to aid and stimulate growth of vegetables, fruits and other crops (Blunden, 1991; Crouch, *et al*., 1994 and Washinton, *et al.*, 1999). They contain all major and minor plant nutrients as well as biocontrol properties and contain many organic compounds such as auxins, gibberellins and precursor of ethylene and betaine which affect plant growth (Wu, *et al.*, 1997). Liquid concentration of brown algae *Ecklonia maxima* significantly reduced the root knot infestation and increased growth of tomato plant. Antimicrobial activity of Canary species of Phaeophyta and Chlorophyta has been reported (Febles, *et al*., 1995). Seaweeds occurring at Karachi, Pakistan coast have also shown cytotoxic (Ara, *et al*., 1999), nematicidal and fungicidal (Ara, *et al*., 1998) hypoglyceamic (Ara, *et al*., 2002a) and antibacterial (Ara, *et al*., 2002b) activities. Soil amendment with brown seaweeds *Stoechospermum marginatum* and *Sargassum tenerrimum* with or without rhizobia significantly reduced root knot nematode (*Meloidogyne javanica*) and root infecting fungi infections (Ehteshamul-Haque, *et al.*, 1996). The present Study describes the efficacy difference among the brown, red and green seaweeds in the control of root infecting fungi and growth of okra seedlings used alone or in combination with a plant growth promoting rhizobacterium *Pseudomonas aeruginosa*. The resaerch was conducted at Karachi University, Karachi, Pakistan during 2003.

Materials and Methods

Seaweeds *Stokeyia indica, Padina pavonia* (brown), *Codium iyengarii* (green) and *Solieria robusta* (red) collected from Buleji, Karachi under low tide. Seaweeds exposed on sands and rocks were collected in polyethylene bags and brought to the laboratory. Seaweeds were washed under tap water and air dried under shade and powdered in an electric blender. Powdered seaweeds were mixed in sandy loam soil, pH 8.05 at 0.5% and 1% w/w. The soil mixture (350 g.) was transferred in 8 cm diam. plastic pots and kept at 50% water holding capacity by watering daily. The soil had a natural infestation of 4-13 sclerotia of *Macrophomina phaseolina* g^{-1} of soil as determined by wet sieving and dilution techniques, 5-12 % colonization of *Rhizoctonia solani* on sorghum seeds used as baits and 3,500 cfu of mixed population of *Fusarium solani* and *F. oxysporum* as assessed by soil dilution technique. After two weeks, an aqueous suspension of *Pseudomonas aeruginosa* (10^8 cfu m/l) multiplied on nutrient agar was drenched in each pot at 25 ml/pot. Five seeds of okra (*Abelmoschus esculentus* (L.) Moench.) were sown in each pot. Each treatment was replicated four times and the pots were randomized on a screen house bench. Pots without seaweed or *P. aeruginosa* served as control. After germination four seedlings were left in each pot. *C. iyengarii* at 1% w/w was found phytotoxic and was excluded from the experiment. Plants were uprooted after six weeks growth and data on height and fresh weight of shoot were recorded. Incidence of fungi on roots was examined, using method of Short, *et al.* (1980). Roots were washed under tap water and five one cm long root pieces were cut from tap root of each plant. Root pieces were surface sterilized with 1% Ca $(OCl)_2$ for 3 minutes and transferred onto potato dextrose agar plates containing penicillin (100,000 units/l) and streptomycin (0.2 gm/l). After incubation for 5 days at 28°C incidence of root infecting fungi *M. phaseolina*, *R. solani* and *Fusarium* spp., were recorded. Data was analyzed statistically to least significant differences. The experiment was repeated to confirm the results.

Results

A significant (($p<0.05$) control of *M. phaseolina* infection was observed where *P. pavonia*, *S. robusta* at 1% w/w and *C. iyengarii* at 0.5% were used alone or where seaweeds were used in combination with *P. aeruginosa*. Infection of *R. solani* was completely controlled where *P. aeruginosa* and *S. robusta* were used alone or where *P. pavonia* at 0.5% and 1% w/w, *S. indica* and *C. iyengarii* at 0.5% w/w and *S. robusta* at 1% w/w were used in combination with *P. aeruginosa*. A significant ($p<0.05$) control of *F. solani* infection was found where seaweeds were used alone or with *P. aeruginosa* (Table 1). *S. indica*, *P. pavonia* and *S. robusta* significantly ($p<0.05$) enhanced plant height. Plant height was increased where *P. pavonia* was used with *P. aeruginosa*. Use of *C. iyengarii* at 0.5% w/w showed maximum fresh weight of shoot when used in combination with *P. aeruginosa* as compared to untreated control (Table 2). *C. iyengarii* at 1% w/w showed phytotoxicity during this study. Incidence of fungi on roots and plant growth data recorded after 6 weeks showed that *S. indica*, *P. pavonia* and *S. robusta* significantly ($p<0.05$) reduced *M. phaseolina* infection (at 0.5 and 1% w/w). *C. iyengarii* was also found effective against *M. phaseolina* at 0.5% w/w. Infection of *R. solani* was significantly ($p<0.05$) reduced by *S. indica*, *P. pavonia* and *S. robusta* at 1% w/w.

Table 1: Effect of brown, green and red seaweeds in the control of *Macrophomin'a phaseolina, Rhizoctonia solani* and *Fusarium solani* infecting okra roots

Treatments	M. phaseolina,		R. solani		F. solani	
	1st. Expt	2nd. Expt	1st. Expt	2nd. Expt	1st. Expt	2nd. Expt
			Infection %			
Control	100	81	37	25	68	50
Pseudomonas aeruginosa (PA)	25	31	0	6	25	18
Stokeyia indica at 0.5%	81	81	18	6	18	6
S. indica at 1%	75	50	31	0	6	6
Padina pavonia at 0.5%	87	62	6	25	6	18
P. pavonia at 1%	68	56	6	6	6	6
Codium iyengarii at 0.5%	62	68	31	6	18	31
Solieria robusta at 0.5%	75	68	0	6	31	25
S robusta at 1%	62	50	0	0	25	18
S. indica at 0.5% + PA	43	75	0	6	12	00
S .indica at 1% + PA	50	68	18	6	31	6
P. pavonia at 0.5% + PA	75	50	0	0	12	6
P. pavonia at 1% + PA	62	68	0	18	18	12
C. iyengarii at 0.5% + PA	43	62	0	0	0	0
S. robusta at 0.5% + PA	68	75	6	0	6	12
S. robusta at 1% +PA	75	50	0	0	6	6
LSD $_{p<0.05}$	Treatments = 18.1				Pathogens = 7.8	

Use of seaweeds with *P. aeruginosa* also significantly ($p<0.05$) controlled *R. solani* infection. A significant control of *F. solani* infection was observed where seaweeds were used alone or with *P. aeruginosa* (Table 1). Plant height was increased where *P. pavonia* and *S. robusta* were used at 1% w/w. Maximum fresh weight of shoot was observed where *S. robusta* was used at 1% w/w followed by *S. indica* at 1% w/w used with *P. aeruginosa* (Table 2).

Table 2: Effect of brown, green and red seaweeds on growth of okra plant

Treatments	Plant height (cm.)		Fresh weight of shoot (g.)	
	1st.	2nd.	1st.	2nd.
	Experiment		Experiment	
Control	22	23	2.1	1.9
Pseudomonas aeruginosa (PA)	24	30	2.5	2.1
Stokeyia indica at 0.5%	30	29	2.4	1.9
S.indica at 1%	29	31	2.8	2
Padina pavonia at 0.5%	29	27	2.6	2
P.pavonia at 1%	27	29	2.7	2.1
Codium iyengarii at 0.5%	21	27	2.7	1.9
Soleiria robusta at 0.5%	30	28	3.1	2.9
S.robusta at 1%	31	32	3.3	3.8
S. indica at 0.5% + PA	24	28	2.2	2
S.indica at 1% + PA	28	28	2.9	3
P. pavonia at 0.5% + PA	34	24	2.4	2.1
P.pavonia at 1% + PA	25	29	2.3	2.3
C. iyengarii at 0.5% + PA	26	27	4.1	2.1
S. robusta at 0.5% + PA	26	25	2.3	2.4
S.robusta at 1% +PA	25	24	2.3	2.3
LSD $_{P<0.05}$	5.1	5.6	1.1	0.6

be antagonistic to soil-borne plant pathogens (Siddiqui *et al.*, 2000; Siddiqui and Ehteshamul-Haque, 2001). The production of certain antibiotics (Leavy, *et al.*, 1992) and siderophores (Buysens, *et al.*, 1996) by *P. aeruginosa* has been regarded as one of the mechanism involved in antagonism. Raajimaker and Weller, (1998) reported role of 2, 4-diacetylphloroglucinol an antifungal metabolite from species of fluorescent *Pseudomonas* in plant root disease suppression. Van Peer, *et al.* (1991) reported

Discussion and Conclusion

The marine environment has great potential for the discovery of lead compounds that could be used against infectious diseases and parasites. In the present study soil amendment with *S. indica, P. pavonia, C. iyengarii* and *S. robusta* significantly reduced infection of *M. phaseolina, R. solani* and *F. solani* infection on okra.

In the present study use of *S. robusta* with *P. aeruginosa* showed better control of *F. solani* infection than either used alone. Plant growth promoting rhizobacteria that colonize roots have been reported to improve plant growth either through direct stimulation of the plant by producing growth regulators or by suppression of pathogens (Raaijmaker, *et al.*, 2002; Weller, *et al.*, 2002). Of the various rhizosphere bacteria, the one belonging to the fluorescent *Pseudomonas* which colonizes roots of a wide range of crop plants are reported to induced resistance in carnation against *Fusarium* wilt by a strain of *Pseudomonas* sp. Species of *Pseudomonas* are also reported to induce systemic resistance in cucumber against *Pythium aphanidermatum* (Zhou and Paulitz, 1994).

These characteristics make these species good candidates to use as biocontrol against soil-borne plant pathogens. Results of the present study suggest that the use of brown seaweeds *S. indica* and *P. pavonia* alone and *S. robusta* alone or in combination with *P. aeruginosa* have great potential to control root-infecting fungi of okra with enhancement of plant growth.

Acknowledgements

This work was funded by a research grant from the Office of Naval Research (ONR), USA, which is sincerely acknowledged.

References

Ara, J., V. Sultana, S. Ehteshamul-Haque, S. A. Qureshi and V.U. Ahmad, Bioactivity of seaweeds against soil borne plant pathogens. Phytologia, ***85****: 292-299, 1998*

Ara, J., V. Sultana, S. Ehteshamul-Haque, R. Qasim. and V. U. Ahmad, Cytotoxic activity of marine macro-algae on Artemia salina. Phytother. Res., ***13****: 304-307,1999*

Ara, J., V. Sultana, R. Qasim and V. U.Ahmad, Hypolipidaemic activity of seaweeds from Karachi coast. Phytother. Res., ***16****: 479-483, 2002a*

Ara, J., V. Sultana, S. Ehteshamul-Haque, M. Athar and R. Qasim, Antibacterial activity of marine macro-algae from Karachi coast. Bull. Polish Acad. Sci., ***50****: 199-206, 2002b*

Blunden, G., Agricultural uses of seaweeds and seaweed extracts. In: M.D. Guiry and G. Blunden, (eds.), Seaweed Resources in Europe:Uses and Potential. John Wiley & Sons, Chichester, pp. 65-81, 1991

Buysens, S., K. Heungens, J. Poppe and M. Hofte, Involvement of pyochelin and pyoverdin in suppression of Pythium-induced damping-off of tomato by Pseudomonas aeruginosa 7NSK2. Appl. Environ. Microbiol., ***62****: 865-871, 1996*

Crouch, I. J., J. Van Staden, J. Van. and J. Van Staden, Commercial seaweed products as biostimulants in horticulture. J. Home Consum. Hort., ***1****: 19-76, 1994*

Ehteshamul-Haque, S., M. Abid, V. Sultana, J. Ara and A. Ghaffar, Use of organic amendments on the efficacy of biocontrol agents in the control of root rot and root knot disease complex of okra. Nematol. medit., ***24****: 13-16, 1996*

Febles, C. I., A. Arias, A. Hardisson and A. S. Lopez, Antimicrobial activity of extracts from Canary species of Phaeophyta and Chlorophyta. Phytotherapy Res., ***9****: 385-387, 1995*

Leavy, E., Z. Eyal, I. Chet and A. Hochman, Resistance mechanisms of Septoria tritici to antifungal products of Pseudomonas. Physiol. Mol. Pl. Pathol., ***40****: 163-171, 1992*

Raaijimaker, J. M. and D. M. Weller, Natural plant protection by 2, 4-diacetylphloroglucinol producing Pseudomonas spp. in takeall decline soils. Mol. Plant-Microbe Interact. ***11****: 144-152, 1998*

Raaijimaker, J. M., M. Vlami and J. T. de Souza, Antobiotic production by bacterial biocontrol agents. Antonie van Leeuwenkoek, ***81****: 537-547, 2002*

Siddiqui, I. A., S. A. Qureshi, V. Sultana, S. Ehteshamul-Haque and A. Ghaffar, Biological control of root rot-root knot disease complex of tomato. Plant Soil, ***227****: 163-169, 2000*

Siddiqui, I. A. and S. Ehteshamul-Haque, Multiplication of Pseudomonas aeruginosa on talc-based formulation for use in the control of root rot and root knot disease in tomato. Trop. Sci., ***41****: 163-167, 2001*

Short, G. E., T. D. Wyllie and P. R. Bristow, Survival of Macrophomina phaseolina in soil and in residue of soybean. Phytopath., ***70****: 13-17, 1980*

Van Peer, R., G. J. Niemann and B. Schipper, Induced resistance and phytoalexin accumulation in biological control of Fusarium wilt of carnation by Pseudomonas sp., strain WCS417r. Phytopath., ***81****: 728-734, 1991*

Washington, W. S., S. Engleitner, G. Boontjes and N. Shanmuganathan, Effect of fungicides, seaweed extracts, tea tree oil and fungal agents on fruit rot and yield in strawberry. Aust. J. Exp. Agric. ***39****: 487-494, 1999*

Weller, D. M., J. M. Raaijimakers, B. B. M. Gardener and L. S. Thomashow, Microbial population responsible for specific soil suppressiveness to plant pathogens. Annu. Rev. Phytopathol., ***40****: 309-348, 2002*

Wu, Y., T. Jenkins, G. Blunden, C. Whapham and S. D. Hankins, The role of betains in alkaline extracts of Ascophyllum nodosum in reduction of Meloidogyne javanica and M. incognita infestations of tomato plants. Fund. Appl. Nematol., ***20****: 99-102, 1997*

Zhou, T., and T. C. Paulitz, Induced resistance in the biocontrol of Pythium aphanidermatum by Pseudomonas spp., on cucumber. J. Phytopath., ***142****: 51-63, 1994*