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COMPARATIVE EFFICACY OF A RED ALGA *SOLIERIA ROBUSTA*, CHEMICAL FERTILIZERS AND PESTICIDES IN MANAGING THE ROOT DISEASES AND GROWTH OF SOYBEAN

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Abstract

Application of seaweed as soil amendment for the control of soilborne plant diseases has increased in recent years due to their environment friendly role. In screen house study, a red seaweed *Solieria robusta* used as soil amendment showed better suppressive effect on root rotting fungus *Fusarium solani* than Topsin-M, a fungicide, but was found less effective than Topsin-M against *Macrophomina phaseolina* and *Rhizoctonia solani* on soybean. *Solieria robusta* showed similar suppressive effect on root knot nematode as did carbofuran, a nematicide. Seaweed showed slightly better effect on plant growth than urea or potash by producing taller plants, better root length and number of flowers per plant. However, mixed application of *S.robusta* and Topsin-M produced greater number of flowers per plant and tallest plants.

Introduction

Soybean (*Glycine max* (L.) Merrill.) is an important nitrogen-fixing leguminous crop cultivated in several parts of the world for food and feed (Pimental *et al*., 2006). Soybean oil, soymilk and soymeal are some of the important products of soybean. Among the soybean diseases, *Fusarium* spp., *Rhizoctonia solani, Macrophomina phaseolina* and *Pythium* spp., are considered as major soybean seedling pathogens which contribute to stand reduction (Sinclair & Backman, 1989). In Pakistan soybean crop has not so far been able to meet local requirement, where many soil-borne root-infecting fungi have been reported to attack soybean crop (Ehteshamul-Haque & Ghaffar 1994, Qureshi *et al*., 2004). *Fusarium* spp., *Macrophomina phaseolina* and *R. solani* were found serious pathogens of soybean causing much loss, where *F. solani* alone caused 35% yield losses (Enteshamul-Haque *et al*., 2007). Besides, rhizobial inoculation, mineral fertilizers are still widely applied to maintain the yield, nutritional quality and aesthetic value of crops. Application of fertilizers are known to suppress some soilborne diseases, besides improving plant growth (Huber, 1980ab, Datnoff *et al*., 2007; Parveen *et al*., 2008), whereas use of fungicides and nematicides are common practice to protect the roots of emerging seedlings from seedborne and soilborne pathogens (Sultana *et al*., 2009).

Application of seaweeds as organic soil amendment, has increased in recent years due to raising awareness about the adverse effect of chemical pesticides (Sultana *et al*., 2007, 2008, 2009; Hoitink & Boehm, 1999; Mazzola, 2004). Seaweeds contain elaborated secondary metabolites that play a significant role in the defense of the host against predators and parasites (Paracer *et al*., 1987; Ara *et al*., 2005). In our previous study we have reported the suppression of root rotting fungi and root knot nematode of chili by a red alga *Solieria robusta* (Sultana *et al*., 2008). The present report describes the comparative efficacy of *Solieria robusta* with chemical fertilizers (urea and potash) and pesticides (Carbofuran and Topsin-M).

Materials and Methods

Seaweed *Solieria robusta* collected from Buleji beach, Karachi was used in this experiment alone and with urea and potash, the chemical fertilizers. Dry powder of the seaweed *S. robusta* was mixed into sandy loam soil (pH 8.05) at 0.5% w/w. The soil was naturally infested with 3-7 sclerotia of *Macrophomina phaseolina* g^{-1} of soil as determined by wet sieving and dilution plating (Sheikh & Ghaffar 1975), 2-6% colonization of *Rhizoctonia solani* on sorghum seeds used as baits (Wilhelm, 1955) and 3000 cfu g^{-1} of soil of a mixed population of *Fusarium oxysporum* and *F. solani* as determined by soil dilution technique (Nash & Snyder, 1962). The amended soil was transferred in 12 cm diam., clay pot at 1 Kg per pot. The pots were watered daily to allow the decomposition of the organic substrate. After 2 weeks of amendment, pots were saturated with aqueous solution of sulphate of potash (K_2SO_4) @ 0.1 g/kg soil and urea @ 0.15 g/kg. A set of pots containing seaweeds and fertilizers were also kept for comparison. Soil without seaweeds or fertilizer served as control. Topsin-M served as positive control against root rotting fungi, while carbofuran served as positive control against root knot nematode. Six seeds of soybean (*Glycine max*) were sown in each pot. After germination (one week) four seedlings were kept in each pots and excess were removed. Each pots were inoculated with *Meloidogyne javanica* eggs/juveniles at 2000/pot. There were four replicates of each treatments and the pots were randomized on a screen house bench and kept at 50% W.H.C. (Keen & Raczkowiski, 1921).

To determine the efficacy of seaweed, fertilizers and pesticide on the root pathogens and plant growth, plants were uprooted after six weeks of nematode inoculation. The data on plant height, fresh shoot weight, root length, root weight, and number of flowers and pods per plant were recorded. Nematode infection was recorded by counting the number of galls per root system, while the nematode population in soil around the roots was determined by using the Baermann funnel method (Schindler, 1961). To examine the incidence of root infecting fungi, roots were washed in running tap water, five one cm long root pieces from tap roots were surface disinfected with 1% Ca $(OCl)_2$ and placed on to Potato Dextrose Agar plates supplemented with penicillin (100000 units/ litre) and streptomycin (0.2 g/litre). The dishes were incubated for 5 days and incidence of fungi grown were recorded. The experiment was conducted twice. Data were subjected to analysis of variance (ANOVA) and means were separated using the least significant difference (LSD) according to Gomez & Gomez (1984).

Results

Application of *S. robusta,* urea, potash and Topsin-M alone caused significant ($p<0.05$) reduction in *M. phaseolina* infection *Solieria robusta,* Topsin-M, carbofuran, urea and potash used alone or where *S. robusta* was used with fertilizers or pesticides caused significant reduction in *R. solani* infection (Table 1). Mixed application of *S. robusta* with potash or with both potash and urea completely suppressed *R. solani* Highest reduction in *F. solani* infection was achieved by the use of *S. robusta.* Topsin-M, carbofuran, urea and potash or mixed use of urea and potash also significantly ($p<0.0$) reduced *F. solani* (Table 1).

Table 1. Effect of seaweed *Solieria robusta*, chemical fertilizers and pesticides on the infection of root rotting fungi *Macrophomina phaseolina*, *Rhizoctonia solani* and *Fusarium solani* infecting soybean roots after 45 days of nematode inoculation.

Treatments	Infection %		
	M. phaseolina	***R. solani***	***F. solani***
Control	68.7	50	87.5
Topsin-M	12.5	12.5	56.2
Carbofuran	56.2	25	50
Urea	25	18.7	62.5
Potash	18.7	6.2	62.5
Urea + Potash	37.5	31.2	37.5
Solieria robusta	37.5	18.7	31.2
S. robusta + Topsin-M	25	12.5	56.2
S. robusta + Carbofuran	81.2	6.2	50
S. robusta + Urea	43.7	6.2	37.5
S. robusta + Potash	68.7	0	37.5
S. robusta + Urea + Potash	56.2	0	56.2

$LSD_{0.05}$, Treatments = 22.6[1], Pathogens = 11.8[2]

[1]Mean values in column showing differences greater than LSD values are significantly different at p<0.05

[2]Mean values in rows showing differences greater than LSD values are significantly different at p<0.05

Table 2. Effect of seaweed *Solieria robusta*, chemical fertilizers and pesticides on the infection of root knot nematode *Meloidogyne javanica* and root nodulation of soybean plants after 45 days of nematode inoculation.

Treatments	**No. of knots**	**Soil nematode (per 100 g soil)**	**No. of nodules per plant**
Control	6.6	897	1.3
Topsin-M	2.2	175	1.8
Carbofuran	0.8	195	0
Urea	1.6	155	0.6
Potash	0.1	195	0.6
Urea + Potash	0.5	888	0.5
Solieria robusta	0.8	790	0.3
S. robusta + Topsin-M	3.9	1130	0.7
S. robusta + Carbofuran	0.2	485	0.7
S. robusta + Urea	0	1350	0.1
S. robusta + Potash	0.5	395	0.3
S. robusta + Urea + Potash	0.2	690	0.5
$LSD_{0.05}$	**2.8[1]**	**ns**	**ns[1]**

[1]Mean values in column showing differences greater than LSD values are significantly different at p<0.05

Soil amendment with *Solieria robusta* alone or with fertilizers or pesticides significantly (p<0.050 reduced nematode infection by reducing the gall formation on soybean roots (Table 2). Chemical fertilizers or pesticides were also found effective against root knot nematode by reducing knot formation on roots, whereas nematode's population in soil showed non-significant difference among the treatments (Table 2).

Table 3. Effect of seaweed *Solieria robusta*, chemical fertilizers and pesticides on the growth of soybean plants after 45 days of nematode inoculation.

Treatments	Flowers/ plant	Pods / plant	Shoot length (cm)	Fresh shoot weight (g)	Root length (cm)	Root weight (g)
Control	6.7	0.2	26.8	4.5	22.1	0.9
Topsin-M	13.5	2.3	42.6	6.2	26.6	1.2
Carbofuran	10.5	0.2	49.5	4.9	24.6	1.1
Urea	10.9	1.7	44.3	4.7	27.0	1.3
Potash	10.9	1.9	34.7	4.8	24.8	1.1
Urea + Potash	10.2	1.4	45.2	5.3	24.2	1.0
Solieria robusta	12.2	1.3	52.8	5.5	31.9	1.4
S. robusta + Topsin-M	15.6	0.7	56.3	5.2	25.1	1.1
S. robusta + Carbofuran	10.6	0.5	53.2	4.9	25.0	1.0
S. robusta + Urea	12.5	1.0	47.4	5.3	22.8	1.1
S. robusta + Potash	12.5	0.6	51.6	4.5	28.0	1.0
S. robusta + Urea + Potash	10.6	0.5	51.6	5.0	23.8	2.7
$LSD_{0.05}$	**6.1[1]**	**1.1[1]**	**15.2[1]**	**0.8[1]**	**8.4[1]**	**1.2[1]**

[1]Mean values in column showing differences greater than LSD values are significantly different at $p<0.05$

Topsin-M used with *S. robusta* or alone significantly increased number of flowers per plant. Greater shoot length was achieved by the application of *S. robusta* used with Topsin-M followed by *S. robusta* with carbofuran (Table 3). Maximum fresh shoot weight was produced by Topsin-M followed by *S. robusta* used alone. *Solieria robusta* also produced greater root length followed by *S. robusta* used with potash (Table 3). Mixed application of *S. robusta* with Topsin-M increased numbers of flowers per plant in seven week old plants as compared to untreated control, whereas urea, potash and *S. robusta* treated plants showed significantly greater number of pods per plant than untreated control after six weeks of nematode inoculation (Table 3).

Discussion

Considerable evidence has been accumulated in recent years to support and identify the benefits associated with the use of seaweed in crop production systems. In this study, *Solieria robusta* showed more or less similar suppressive effect on root infecting fungi and root knot nematode like. Topsin-M (fungicides) and carbofuran (nematicide). Seaweed extracts have been reported to increase plant resistant to pests and diseases, improve plant growth, yield and quality (Jolivet *et al*., 1991; Verkleij, 1992; Pardee *et al*., 2004). Application of seaweed to plants can result in decreased levels of nematode attack (Ara *et al*., 1997; Wu *et al*., 1997; 1998) and root rotting fungi (Sultana *et al*., 2007, 2008, 2009). Presumably the presence of easily degradable organic matter of seaweed provided the food base for the multiplication of the antagonistic bacteria, which increased their population in the rhizosphere, or the alginate of seaweed directly suppressed the pathogens. Alginate pellets developed as carrier material for biocontrol agents have been reported to reduce multiplication of cysts nematode and *Rhizoctonia* disease in potato (Jacobs *et al*., 2003) and inhibited virus infectivity in plants (Pardee *et al*., 2004).

In this study, *Solieria robusta*, a seaweed was also found as effective as chemical fertilizers like urea and potash in improving the plant growth. Marine bioactive substances extracted from seaweeds have been used for several decades to enhance plant growth and productivity. Application of these substances is often performed by foliar spraying and it has been reported that they induce higher yields and a better nutrient use efficiency (Mooney & Van Staden, 1986; Rathore *et al*., 2009). The stimulatory effect of the marine bioactive substances has been ascribed to the presence of biologically active cytokinins and auxin (Stirk & Van Staden, 1997). But many other organic and inorganic molecules have been found in crude algal extracts used for foliar spray (Verkleji, 1992). It has also been reported that the application of these extracts can stimulate nitrogen uptake and metabolism in the treated plants (Jolivet *et al*., 1991). Presumably, protection of plant roots from pathogens and stimulation of plant growth is due to presence of growth regulators in seaweed.

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