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MANGROVE FORMULATIONS FOR THE MANAGEMENT OF *MELOIDOGYNE JAVANICA* (TREUB) CHITWOOD UNDER FIELD CONDITIONS

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Abstract

Six months field experiment were set up from June to November in Department of Botany, University of Karachi to investigate the influence of mangroves (*Avicennia marina, Rhizophora mucronata*) parts separately or combined parts for the control of *Meloidogyne javanica* (Treub.) Chitwood. Mangroves parts including leaves, stem, pneumatophore and combined parts were applied to field in form of powder at rate of 60 g/plot, capsules and pellets at 120 g/plot. Results pertaining to seed germination percentage, plant length, plant weight and yield showed outstanding improvement in both okra and mung bean when combined parts pellets of *A. marina* and *R. mucronata* were used. All parts of *A. marina, R. mucronata* pellets and powder were effective in controlling of *M. javanica* infection but maximum reduction in root knot nematode were obtained by the amendment of mangrove combined parts powder.

Key words: *Avicennia marina* and *Rhizophora mucronata*, Capsules, Pellets, Root knot nematodes.

Introduction

Mangrove forests also called as 'tidal forest', 'coastal woodlands' or 'oceanic rainforest', are woody and halophytic plants which grow in tropical and subtropical latitudes along the landsea interface, bays, estuaries, lagoons, backwaters, rivers reaching to a point where the water still remains saline. These plants formed a community in which they are associated with plants and animals including, trees, palms, shrubs, grasses, epiphytes, ground ferns, crabs, oysters, shrimps, fishes, prawn and lobsters (Qasim, 1998; Kathiresan & Bingham, 2001). Total area covered by mangroves forests in Pakistan is 167,500 ha which considered to split between the two provinces Sindh (area covered approximately 160,000 ha) and Baluchistan (area is about 7,500 ha) (Mirza *et al*., 1988; Miles *et al*., 1999). Two most common species of mangrove, *Avicennia marina* (Forssk.) Vierh., which was reported to be dominated by 95 % of mangrove forest and the other one with less population is *Rhizophora mucronata* Lam. (Saifullah *et al*., 1994).

Meloidogyne species (*M. javanica, M. arenaria, M. incognita, M. hapla*), plant parasitic nematodes are major pests recorded worldwide (Eisenback & Triantaphyllou, 1991). Severity of damage caused by nematode infection depends upon population densities of nematode (Webster, 1969). It causes highly destructive losses in crop production all over the world estimated about $ 125 billion/year (Chitwood, 2003). In Pakistan, about 100 plants have been found to be infected with root knot nematodes from different cultivated zones of Pakistan and these *Meloidogyne* spp., root knot nematodes are identified as important parasites of vegetable crops (Maqbool, 1988; Zaki, 2000). These root knot nematodes substantially reduced the nutrient and water uptake, because of damaged root system, as a result of which plants become weak and low yielding with the characteristics of typical root gall formation (Abad *et al*., 2003). Infective stage of nematode is the second-stage juvenile (J2) which penetrates the roots and go through three successive moults and become adult females or males. The oesophageal glands of the nematode initiate secretions for the development of feeding structures which results in formation of binucleate cell. In the absence of cytokinesis, rapid divisions of the nuclei results to several large multinucleate cells. The surrounding cells divide and produce characteristic galls called as 'root knots' (Gheysen & Fenoll, 2002; Davis *et al*., 2000; Williamson & Kumar, 2006). These root knot nematodes produce measurable changes in physiology and morphology of the host (Williamson & Gleason, 2003).

As the environmental and health responses concerned about extensively use of pesticides and other chemicals, there is considerable interest in finding alternatives means for disease management of crop plants (Raupach & Kloepper, 1998; Papavizas & Lumsden, 1980). It includes organic matter-based soil amendments (animal and green manures, and/or composts made from organic waste), biological control agents and plant/seaweed extracts and/or other compounds which caused resistance effect on plants (Noble & Coventry, 2005; Xiao *et al*., 1998; Matthiessen & Kirkegaard, 2006). The addition of organic materials demonstrated as improvement of physical properties of soil including its water retension, permeability, water infiltration, drainage, aeration, structure and provide better environment to roots (Davis & Wilson, 2005). Several reports on application of organic amendment showed promising results in improvement of plant growth and effectively reduces/suppress certain soil borne plant pathogens or the disease they cause including fungi, bacteria and nematodes (Ali *et al*., 2001; Ikram & Dawar, 2013). *A. marina* and *R. mucronata* when applied to soil as organic amendment at different ratios, not only enhances plant growth parameters but also reduces the severity of root diseases causing by plant parasitic nematode and root infecting fungi when assessed on different crops (Tariq *et al*., 2007; 2008). It was observed that various active principles present in plants showed efficacy against plant pathogens (Kabeh & Jalingo, 2007). The objective of our study was to evaluate mangrove species as management

programme with different formulations for suppression of *M. javanica* infection and to increase yield of okra and mung bean.

Materials and Methods

Collection of mangrove: Leaves, stem, pneumatophore of *A. marina* and *R. mucronata* were collected from coastal area of Pakistan. These plant samples were washed with tap water, air dried under shade and ground in an electric grinder. Dried powder was used to fill capsules and preparation of pellets.

Nematode inoculum and extraction: Populations of *M. javanica* obtained from infected roots of eggplants and identified with the help of perennial pattern as described by Taylor & Netscher (1974). Eggs were extracted by using 2% sodium hypochlorite solution (McClure *et al*., 1973). The eggs suspension was poured onto a submerged cotton-wool filter and incubated. After 72 hours juveniles emerged were collected and used as inoculum. The population of *M. javanica* was multiplied and maintained by culturing on tomato (*Lycopersicon esculentum* L.) or egg plant (*Solanum melongenosa* L.) roots in a green house at Department of Botany, University of Karachi.

Preparation of mangrove pellets and capsule filled mangrove parts: Pellets were prepared following method of Tariq & Dawar (2011) where equal amount of leaves, stem, pneumatophore powder of mangrove (*A. marina, R. mucronata*) separately with pyrophyllite were mixed separately using sterilized distilled water. Pellets were prepared with the help of multiple pellet sampler of equal size and weight (1 g pellet containing 0.5 g powder and 0.5 g pyrophyllite). These pellets were air dried in a laminar air flow hood. Empty shells capsule were filled with mangrove parts powder (0.5 g in each capsule).

Experimental setup: Field was properly leveled and designed as 2x2 microplots at the Department of Botany, University of Karachi. *A. marina, R. mucronata* parts namely leaves, stem, pneumatophore separately and combined parts in the form of powder (60 g/plot), capsules (120 /plot), pellets (120 /plot) were mixed with sandy loam soil of field (sand, silt, clay; 72, 18, 10% respectively) of pH 7.8, electrical conductivity (EC) 0.61 dS m^{-1}, Na^{+} ion 7.5 µg g^{-1}, K^{+} ion 1.0 µg g^{-1} and organic matter, 1.2 %. Plots were watered regularly for the decomposition of organic matter. After 15 days of amendment, ten mung bean (*Vigna radiata* L. cv. NM-2006) and okra (*Abelmoschus esculentus* (L.) Moench cv. Arka anamika) seeds were sown in 4-feet furrows which after sowing, covered with soil. Freshly hatched second stage juveniles of *M. javanica* were inoculated near roots of 1-week-old seedlings of each treatment. Plot without treatment was regarded as control and field experiment was conducted from June 2009 to November 2009. Each treatment was replicated four times randomly within blocks.

Estimation of data: Experiment was terminated after 52 days of nematode inoculation. The growth parameters including germination percentage, plant length (cm), plant weight (g), yield/plot were recorded. The data on number of galls formed on whole root system, egg masses/root system, eggs/egg mass, nematode population/g root were also examined. The number of galls and number of egg masses developed on the entire root system by *M. javanica* were counted under a low magnification (x 6, 10). For observation of eggs/egg mass, egg masses (10) from a treatment (all replicates) were randomly selected from root and each egg mass were crushed using a drop of sodium hypochlorite solution (0.01%). By this gelatinous matrix was dissolve and observe under light microscope (De Leij, 1992). Penetrated nematode in infected roots was recorded by method of Bridge *et al*. (1982) in which 1 g blotted dry roots was taken, cut into small segments and wrapped in a muslin cloth. Dip muslin cloth for 3-4 minutes in boiling fuchsin stain (0.25%) in lactic acid. Roots were then washed in running tap water to remove excess stain and cooled in vials containing 1:1 ratio of glycerol: water with a few drops of lactic acid. These roots were macerated in an electric grinder (45 s) and suspended in water (100 ml). *M. javanica* females and juveniles were counted with the aid of a low power microscope (x 6).

Statistical analysis: Data of measurements were analyzed to two way analysis (ANOVA) as per experimental design. Means of significant at 5 % level was separated using Duncan's multiple range test (DMRT) through computer software STATISTICA 9.0 programme (StatSoft Inc., Tulsa, USA). Germination percentage data were arcsine transformed. All means are displayed as mean ± standard error (SE).

Results

Field experiment with *A. marina* parts: Field experiment was conducted to study efficacy of *A. marina* plant parts namely leaves, stem, pneumatophore in the form of powder, capsules and pellets for the control of root knot nematode on large scale. *A. marina* combined parts powder used at 60 g/plot significantly ($p<0.001$, 0.01) enhanced plant length and plant weight of mung bean and okra while germination of seeds was maximum when *A. marina* combined parts pellets and powder amended in soil followed by 120 *A. marina* capsules/plot. Yield/plot of okra and mung bean was observed to enhance in all treatments applied to soil. However, maximum yield of both crops was increased by inoculation of *A. marina* combined parts pellets (Tables 1 & 2). Interaction between formulations and parts for yield/plot was significant in both mung bean and okra ($p<0.001$). *A. marina* combined parts powder at 60 g/plot when amended in soil significantly ($p<0.001$, 0.01) reduced number of galls/root system produced by *M. javanica*, number of egg masses, eggs/egg mass and nematode population/g root on okra and mung bean roots. The present results showed that *A. marina* combined parts capsules at 120 /plot, *A. marina* pneumatophore and leaves powder at 60 g/plot and *A. marina* pneumatophore, leaves pellets at 120/plot also affected root knot infection caused by *M. javanica.* However, 120 capsules contained stem powder of *A. marina* showed least effect on reduction of galls formation (Tables 1 & 2).

Table 1. Effect of *Avicennia marina* parts separately and combined parts on growth parameters and root knot infection of mung bean.

Treatments		Growth parameters				Root knot infection			
Parts	**Formulations**	**Germination (%)**	**Plant length (cm)**	**Plant weight (g)**	**Yield/plot**	**Number of galls/root system**	**Number of egg masses**	**Eggs /egg masses**	**Nematode/ g root**
Control	-	56.94 ± 2.58	28.77 ± 1.25	19.47 ± 0.69	48.6 ± 1.71	178 ± 16.1	175 ± 16.7	839 ± 31.5	711 ± 37.1
Leaves	Powder	85.39 ± 4.60	45.92 ± 1.14	24.62 ± 0.35	62.7 ± 0.92	57 ± 3.34	45 ± 2.79	553 ± 46.0	420 ± 27.9
Leaves	Capsules	78.75 ± 6.70	33.17 ± 1.00	21.57 ± 0.93	60.4 ± 0.92	75 ± 4.17	67 ± 4.55	755 ± 45.5	669 ± 38.4
Leaves	Pellets	83.35 ± 6.64	47.42 ± 1.53	24.70 ± 1.08	55.8 ± 0.60	47 ± 0.85	39 ± 1.60	533 ± 27.8	421 ± 17.3
Stem	Powder	90.00 ± 0.00	31.10 ± 1.65	22.37 ± 1.07	67.7 ± 0.62	60 ± 2.01	52 ± 2.41	543 ± 18.8	421 ± 28.3
Stem	Capsules	78.75 ± 6.70	31.40 ± 1.35	20.65 ± 0.88	58.8 ± 0.49	80 ± 1.84	72 ± 3.02	794 ± 30.7	710 ± 16.8
Stem	Pellets	74.14 ± 5.62	35.05 ± 1.26	24.25 ± 0.81	56.9 ± 0.62	61 ± 3.17	53 ± 1.95	656 ± 19.0	549 ± 29.4
Pneumatophore	Powder	78.75 ± 6.70	51.40 ± 1.66	27.47 ± 0.98	50.2 ± 0.72	46 ± 3.17	36 ± 2.92	434 ± 33.9	311 ± 28.3
Pneumatophore	Capsules	85.39 ± 4.60	39.42 ± 1.18	26.52 ± 1.16	64.6 ± 0.59	50 ± 2.71	42 ± 3.37	521 ± 22.3	449 ± 29.4
Pneumatophore	Pellets	83.35 ± 6.64	50.02 ± 1.37	29.27 ± 0.54	65.0 ± 1.24	52 ± 1.25	47 ± 1.08	560 ± 19.3	461 ± 17.5
A. marina combined parts	Powder	75.05 ± 8.73	57.60 ± 1.16	30.00 ± 0.73	58.3 ± 0.45	26 ± 3.56	18 ± 3.19	345 ± 22.7	228 ± 21.0
A. marina combined parts	Capsules	85.39 ± 4.60	48.40 ± 1.07	27.37 ± 0.71	53.6 ± 0.86	45 ± 2.46	37 ± 3.30	319 ± 19.7	403 ± 31.5
A. marina combined parts	Pellets	90.00 ± 0.00	59.70 ± 0.88	30.57 ± 0.95	69.1 ± 0.77	39 ± 1.93	31 ± 2.01	446 ± 38.3	333 ± 18.8
$LSD_{0.05}$ Parts		7.496	1.812	1.232	1.448	10.186	10.629	44.756	41.571
Formulations		7.496	1.812	1.232	1.448	10.186	10.629	44.756	41.571

Mean ± Standard error

Table 2. Effect of *Avicennia marina* parts separately and combined parts on growth parameters and root knot infection of okra.

Treatments		Growth parameters				Root knot infection			
Parts	**Formulations**	**Germination (%)**	**Plant length (cm)**	**Plant weight (g)**	**Yield/plot**	**Number of galls/root system**	**Number of egg masses**	**Eggs /egg masses**	**Nematode/ g root**
Control	-	50.83 ± 2.40	20.75 ± 0.43	5.47 ± 0.20	64.7 ± 1.25	96 ± 3.66	93 ± 4.36	865 ± 34.7	819 ± 16.6
Leaves	Powder	83.35 ± 6.64	29.72 ± 1.16	12.32 ± 0.94	72.4 ± 0.41	41 ± 3.35	33 ± 2.56	500 ± 29.4	365 ± 30.6
Leaves	Capsules	74.14 ± 5.62	25.20 ± 1.15	10.45 ± 0.92	71.5 ± 0.48	51 ± 2.73	41 ± 2.68	586 ± 43.4	450 ± 31.0
Leaves	Pellets	75.05 ± 8.73	29.80 ± 1.14	14.60 ± 0.78	68.7 ± 0.37	46 ± 3.12	38 ± 3.34	498 ± 32.2	414 ± 25.4
Stem	Powder	85.39 ± 4.60	28.60 ± 0.79	8.87 ± 0.74	75.2 ± 0.93	54 ± 3.63	45 ± 3.58	585 ± 35.6	470 ± 34.2
Stem	Capsules	70.44 ± 7.18	21.77 ± 0.93	6.42 ± 0.63	71.4 ± 1.02	63 ± 2.13	55 ± 2.97	624 ± 37.9	561 ± 25.2
Stem	Pellets	66.75 ± 7.90	26.27 ± 1.21	9.67 ± 0.93	69.6 ± 0.79	51 ± 4.09	44 ± 4.00	569 ± 32.5	458 ± 36.5
Pneumatophore	Powder	75.05 ± 8.73	28.42 ± 0.91	11.27 ± 0.72	68.6 ± 0.97	48 ± 2.78	39 ± 2.52	521 ± 30.3	419 ± 18.5
Pneumatophore	Capsules	85.39 ± 4.60	21.55 ± 0.99	8.52 ± 0.73	73.1 ± 0.66	44 ± 3.37	36 ± 3.39	524 ± 16.8	406 ± 21.1
Pneumatophore	Pellets	85.39 ± 4.60	29.77 ± 0.56	11.07 ± 1.18	73.6 ± 0.98	40 ± 2.21	33 ± 2.21	490 ± 20.5	366 ± 12.9
A. marina combined parts	Powder	78.75 ± 6.70	31.82 ± 1.04	13.55 ± 1.06	72.2 ± 0.65	23 ± 3.27	16 ± 2.56	325 ± 23.4	210 ± 24.7
A. marina combined parts	Capsules	77.09 ± 8.04	28.22 ± 0.76	11.82 ± 0.80	68.2 ± 0.93	36 ± 2.90	28 ± 2.10	443 ± 30.9	324 ± 17.0
A. marina combined parts	Pellets	90.00 ± 0.00	33.52 ± 1.10	16.25 ± 0.63	80.8 ± 0.65	30 ± 3.19	23 ± 2.94	373 ± 36.1	288 ± 27.3
$LSD_{0.05}$ Parts		8.310	1.261	1.039	0.956	4.138	4.277	40.737	33.545
Formulations		8.310	1.261	1.039	0.956	4.138	4.277	40.737	33.545

Mean ± Standard error

Table 3. Effect of *Rhizophora mucronata* parts separately and combined parts on growth parameters and root knot infection of mung bean.

Treatments		Growth parameters				Root knot infection			
Parts	**Formulations**	**Germination (%)**	**Plant length (cm)**	**Plant weight (g)**	**Yield/plot**	**Number of galls/root system**	**Number of egg masses**	**Eggs /egg masses**	**Nematode/ g root**
Control	-	56.94 ± 2.58	29.27 ± 0.90	27.02 ± 1.49	48.0 ± 0.70	193 ± 20.42	190 ± 22.9	793 ± 43.6	680 ± 43.2
Leaves	Powder	80.78 ± 5.32	43.32 ± 1.44	31.55 ± 1.93	56.4 ± 0.75	80 ± 2.59	71 ± 2.32	705 ± 38.5	590 ± 35.8
Leaves	Capsules	90.00 ± 0.00	31.95 ± 1.04	30.65 ± 1.13	58.4 ± 0.99	87 ± 4.17	79 ± 4.13	751 ± 31.7	630 ± 28.5
Leaves	Pellets	90.00 ± 0.00	48.52 ± 1.08	30.67 ± 1.37	61.2 ± 0.86	76 ± 4.53	68 ± 5.28	680 ± 40.6	555 ± 40.9
Stem	Powder	78.75 ± 6.70	51.50 ± 0.87	33.87 ± 0.65	53.7 ± 0.55	57 ± 3.56	49 ± 3.19	510 ± 33.2	399 ± 35.6
Stem	Capsules	78.75 ± 6.70	40.32 ± 1.40	34.25 ± 0.82	55.8 ± 0.56	71 ± 4.32	64 ± 4.60	633 ± 38.7	521 ± 37.1
Stem	Pellets	85.39 ± 4.60	50.47 ± 1.04	35.62 ± 0.92	60.2 ± 0.84	58 ± 4.36	50 ± 4.26	520 ± 37.6	406 ± 35.6
R. mucronata combined parts	Powder	83.35 ± 6.64	54.82 ± 1.09	37.50 ± 0.87	56.5 ± 0.63	31 ± 2.58	23 ± 2.13	290 ± 21.7	168 ± 19.2
R. mucronata combined parts	Capsules	85.39 ± 4.60	48.27 ± 0.77	37.0 ± 0.81	59.0 ± 1.08	44 ± 1.93	36 ± 1.82	394 ± 19.3	276 ± 19.3
R. mucronata combined parts	Pellets	90.00 ± 0.00	58.17 ± 1.16	38.42 ± 0.85	64.2 ± 0.66	37 ± 2.52	29 ± 2.39	328 ± 14.7	203 ± 15.4
$LSD_{0.05}$ Parts		5.036	1.592	1.622	1.032	13.537	14.980	52.090	49.708
Formulations		5.816	1.838	1.873	1.192	15.631	17.298	60.148	57.398

Mean ± Standard error

Table 4. Effect of *Rhizophora mucronata* parts separately and combined parts on growth parameters and root knot infection of okra under field conditions.

Treatments		Growth parameters				Root knot infection			
Parts	**Formulations**	**Germination (%)**	**Plant length (cm)**	**Plant weight (g)**	**Yield/plot**	**Number of galls/root system**	**Number of egg masses**	**Eggs /egg masses**	**Nematode/ g root**
Control	-	53.97 ± 3.95	29.70 ± 1.12	11.75 ± 0.81	65.7 ± 1.42	144 ± 5.54	138 ± 5.61	825 ± 18.4	693 ± 15.4
Leaves	Powder	74.14 ± 5.62	33.70 ± 1.06	13.67 ± 0.91	70.2 ± 0.80	61 ± 2.72	51 ± 2.90	538 ± 24.5	420 ± 22.6
Leaves	Capsules	77.09 ± 8.04	34.90 ± 0.85	12.75 ± 1.36	73.5 ± 0.48	66 ± 3.37	58 ± 3.70	588 ± 29.5	466 ± 26.7
Leaves	Pellets	90.00 ± 0.00	37.77 ± 0.83	15.50 ± 1.01	76.8 ± 0.65	61 ± 3.65	53 ± 3.96	489 ± 47.4	379 ± 47.3
Stem	Powder	62.14 ± 3.50	38.62 ± 0.85	18.67 ± 0.76	70.6 ± 0.49	40 ± 2.65	29 ± 2.58	386 ± 22.0	265 ± 22.0
Stem	Capsules	77.09 ± 8.04	35.87 ± 0.79	18.20 ± 0.86	71.2 ± 0.58	45 ± 3.42	37 ± 1.93	399 ± 16.7	289 ± 33.2
Stem	Pellets	85.39 ± 4.60	37.67 ± 0.97	20.05 ± 0.67	73.4 ± 1.14	40 ± 1.75	31 ± 3.96	359 ± 16.6	246 ± 13.9
R. mucronata combined parts	Powder	65.84 ± 3.57	39.15 ± 0.74	21.95 ± 1.14	70.5 ± 0.44	26 ± 2.52	18 ± 2.32	269 ± 23.3	158 ± 24.8
R. mucronata combined parts	Capsules	74.14 ± 5.62	37.95 ± 0.90	21.30 ± 0.81	74.6 ± 0.86	38 ± 2.86	30 ± 2.56	341 ± 24.9	231 ± 26.1
R. mucronata combined parts	Pellets	90.00 ± 0.00	39.95 ± 0.64	24.55 ± 0.81	77.3 ± 0.74	32 ± 2.50	24 ± 2.08	288 ± 13.9	170 ± 17.9
$LSD_{0.05}$ Parts		6.666	1.345	1.264	1.304	5.311	5.498	36.190	36.991
Formulations		7.698	1.554	1.460	1.506	6.132	6.349	41.788	42.714

Mean ± Standard error

Field experiment with *R. mucronata* parts: Another field experiment was carried out with *R. mucronata* parts namely leaves, stem and combined parts in the form of powder, pellets and capsules on okra and mung bean. Germination of okra and mung bean seeds was increased by the application of *R. mucronata* combined parts pellets and powder at 120 and 60 g/plot where parts and formulations were significant ($p<0.001$). Following to *R. mucronata* combined parts pellets, *R. mucronata* stem pellets also showed enhancement in germination of okra seeds (Table 4). Plant length and weight of okra and mung bean were significantly ($p<0.001$, 0.05) increased by the incorporation of *R. mucronata* combined parts pellets followed by *R. mucronata* combined parts powder and *R. mucronata* capsule at 120/plot. All parts used separately with different formulations showed increased in plant length as compared to control. However, *R. mucronata* stem powder gave better results in increment of plant length followed by *R. mucronata* stem pellets (Tables 3 & 4). Yield/plot of okra and mung bean was significantly increased ($p<0.001$, 0.05) due to inoculation of *R. mucronata* combined parts pellets followed by *R. mucronata* leaves pellets and stem powder. It was noticed that number of galls/ root system, number of egg masses, eggs/egg mass and nematode population/g root on okra and mung bean roots were reduced by incorporation of *R. mucronata* combined parts powder. *R. mucronata* stem powder also reduced infection of *M. javanica* by reducing the number of galls on okra and mung bean plants.

Combined parts powder of *A. marina* and *R. mucronata* were more effective in the control of root knot nematode while pellets showed maximum increment in growth parameters of okra and mung bean plants.

Discussion

In the present study, all the formulations of mangrove combined parts or its part separately when inoculated in soil showed improvement in plant growth of okra and mung bean. Of the three formulations used, pellets and powder amendment gave equal results in growth enhancement as compared to capsule formulations. Powder and pellets when amended in soil and watered daily for decomposition process, easily spread in soil, breaks down and releases nutrients and toxicants into soil. This toxicant helps in prevention against infection of root knot nematodes on mung bean and okra while nutrients of mangrove tend to improve the plant length and weight. On the other hand, capsules when introduced in soil, the powder inside it has a covering of gelatin around it which takes time to disintegrate and release in soil. By this it was not evenly distributed in soil which might be the reason for less effectiveness of capsules over comparison of powder and pellets.

It was interesting to note that both *A. marina* and *R. mucronata* combined parts when applied to soil in the form of pellets, enhanced plant length and weight of okra and mung bean while powder amendment showed greater reduction in galls formation by *M. javanica*. Tariq & Dawar (2012); Hajihassani *et al.,* (2013) reported that the juveniles when infest to roots of plant caused loss in yield. Root knot nematodes, *Meloidogyne* spp., produced severe damage to crops by producing galls on roots and nematode is able to feed. Due to this fact supply of water and nutrients from soil is limited and the plants showed stunted growth which later tends to wilting. Various control measures were taken for these nematodes including nematicides application, chemical treatments, organic amendments or other physical controls. Application of organic amendment has some advantages because of improvement in plant nutrients, permeability, soil biological activity and aeration (D'Addabbo, 1995). Akhtar (1998) reported that organic amendments affects the chemical mineralization, releasing ammonia and increased nitrogen and carbondioxide level. Healthy condition of the host plant is important for the establishment and resistancy against plant parasities (Tyler, 1933).

A certain level of tolerance was adopted by the host plants against nematode attack due to decomposition of organic material being incorporated in soil (Oka *et al*., 2007) and increased the nutritional requirements of host (Karssen & Moens, 2006). Powder amendment to soil was helpful in enhancing the activity of antagonistic fungi which may destroy nematode population to a safe level leads to reduced gall formation. Present results agree with those by Sasanelli & D'Addabbo (1993), Pandey *et al*., (1997). As the mangroves was halophytic plants containing NaCl in their tissues which will degrade during decomposition by chelating with organic acids and nullifies NaCl present in the tissues. Dropkin *et al.* (1958) reported that as the concentration of electrolytes like NaCl, KCl increased there was a reduction in *M. javanica* egg hatching. Nutrient contents in halophytes were more as compared to green manure/glycophytes (Cuevas, 1997).

Mangroves have been reported to contain some nematicidal components like terpenoids, phenols which have delirious effect on phytonematodes (Alam *et al*., 1978; Shaukat *et al*., 2004). It is concluded that formulations of mangrove combined parts pellets and powder when used in soil releases nematicidal compounds which may reduce activity caused by *M. javanica* to test plants and thus enhanced plant growth and promotes crop productivity.

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