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MANAGEMENT OF ROOT ROT FUNGI OF CROP PLANTS BY *MORINGA OLEIFERA* LAM.

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Abstract

The present study was conducted to evaluate the fungicidal effectiveness of *Moringa oleifera* Lam. plant parts (leaves, stem, fruit and seed) against root infecting fungi as well as improving the growth of cow pea and mash bean plants. *In vitro*, leaves extract used @ 75, 50 and 25% v/v concentrations showed significant inhibition in the growth of *Macrophomina phaseolina* (Tassi) Goid, *Rhizoctonia solani* (Kühn) and *Fusarium oxysporum* (Schlecht) in comparison with other parts extracts by using agar well and paper disc diffusion methods. Leaves extract and powder used as seed treatment, soil drenching and soil amendment with different concentrations showed a profound effect in controlling the colonization of root infecting fungi, and enhanced the weight and height of leguminous plants, whereas stem extract and powder improved plant growth and showed maximum inhibition of root rot fungi on tested crops under greenhouse condition.

Key words: *Moringa oleifera*, Concentrations, Root infecting fungi, Extract and powder.

Introduction

Plant pathogens recognized as the major threats to crop production (Fravel, 2005) especially root infecting fungi which include; *Macrophomina phaseolina, Rhizoctonia solani, Aphanomyces euteiches, Sclerotium rolfsii* and *Fusarium* spp. are reported to infect an extensive ubiquitous threat to all agricultural crops (Ghaffar, 1988; Abdel-Kader *et al*., 2002; Infantin *et al*., 2006). *F. solani* and *R. solani* causing root rot and damping off diseases on large variety of crop plants (Abu-Taleb *et al*., 2011) occurs both in the field and greenhouse condition (Hartman & Fletcher, 1991). *M. phaseolina* found throughout the world (Hoes, 1985) causing damping off, charcoal rot, leaf and stem blight, wilt and dry rot diseases (Cowan, 1999). The principle of controlling plant disease is to get better growth of crop plants (Stephan *et al*., 1988) which can be controlled by using fungicidal applications (Perez *et al*., 2004) but fungicides are known to cause environmental hazards and human health risks (Mancini *et al*., 2008). Recently, environment friendly methods are being made to control root rot fungi either by using plant drugs (Hanif & Dawar, 2015) or plant extracts (Rafi *et al*., 2015) reported as antifungal activity and also improved crop growth and yield providing as a natural fertilizer (Raghavendra *et al*., 2002; Sayeeda & Ahmad, 2005) due to the presence of several constituents which includes; tannins, alkenyl phenols, sesquiterpenes lactones, terpenoids, phorbol esters, saponins, flavonoids and glycoalkaloids (Tiwar & Singh, 2004). The plant extract significantly inhibited fungal pathogens and successfully devised as fungicides (Babu *et al.,* 2008).

Moringa oleifera (moringaceae) is best known for miracle/wonder tree (Fuglie, 1999) and widely distributed all over the world (Lockelt *et al*., 2000) is a fast-growing, drought resistant and are regarded as a nutritional powerhouse (Elevitch, 2011). This plant has been studied extensively due to its pharmacological activities (Dashputra *et al*., 1977). It is rich in glucoseinolates, isothiocyanates, carotenoids, kaempferom, zeatin, quercetin and many other phytochemicals and also an outstanding source of vitamin (A, B and C) calcium, iron, potassium, protein and the fruit contain oil rich in β-carotene, sterols and lecithin (Anwar *et al*., 2007). The oil comprises unusual fatty acids among naturally occurring plant growth stimulants having cytokinin compounds due to the presence of 4-alpha-L-rhamnosyloxybenzyl isothiocyanate in the seeds of *M. oleifera*. After oil extraction, the remaining seed cake is used as a fertilizer, purify well water and to remove salt from sea water (Shaheen *et al.,* 1998). *M. oleifera* seeds are considered as a cheap bio-absorbent eliminating heavy metals (Sharma *et al*., 2006). Leaves of this plant are reported containing anti-pyretic, ant-inflammatory, anti-ulcer (Pal *et al*., 1995), anti-tumour (Makonnen *et al*., 1997), anti-spasmodic (Caceres *et al*., 1992), diuretic (Morton, 1991), cholesterol lowering (Mehta *et al.,* 2003), hepatoprotective, anti-oxidant, anti-diabetic (Ruckmani *et al*., 1998), anti-hypertensive (Dahot, 1988), anti-bacterial and anti-fungal activities (Nickon *et al*., 2003) due to the presence of 4-(α-L-rhamnopyranosyloxy) benzyl isothiocyanate, 4-(4'-O-acetyl-α-L-rhamnopyranosyloxy) benzyl isothiocyanate, 4-(α-L-rhamnopyranosyloxy) benzyl glucosinolate, niazimicin, pterygospermin and benzyl isothiocyanate (Nepolean *et al*., 2009). *M. oleifera* is being employed for the treatment of various ailments in the indigenous system of medicine, generally in South Asia (Farooq *et al*., 2007).

Present study was carried out to explore the fungicidal effectiveness of *M. oleifera* on growth and inhibition of root infecting fungi on crop plants.

Materials and Methods

Collection of material: Unblemished leaves, stem, fruit and seeds of *Moringa oleifera* Lam. were collected from the campus of University of Karachi. All plant parts were dried and powdered by using an electric grinder and stored each plant powder in glass jar respectively.

Extract preparation: 10g of *M. oleifera* plant parts (stem, leaves, fruit and seeds) were soaked in 90 mL distilled water, separately and left it for overnight. The concentration of the extract thus prepared was used as stock solution (100% v/w). The suspension was filtered through Whatman's filter paper No.1 into 250 mL Pyrex

flask. The filtrate was further diluted with distilled water to prepare 75, 50 and 25% v/w concentrations.

***In vitro*:** Paper disc and agar well diffusion methods were used to study the inhibition of *M. phaseolina*, *R. solani* and *F. oxysporum* with aqueous extracts of different concentrations of plant parts. In the paper disc method, sterilized filter paper disc (6mm in diameter) were soaked in 25, 50 and 75% v/w concentrations of stem, leaves, fruits and seed extracts respectively. Three different concentrations of discs were placed on three sides of Petri plate. The fourth disc containing distilled water served as control (Nair *et al*., 2005). The disc of each root rot fungus (5mm in diameter) was placed in the center, respectively. Similarly, in agar well diffusion method, four wells (5mm in diameter and 2.5mm deep) were made on the surface of the agar medium using a sterilize borer. Three wells were filled with 50 µL of different concentrations (25, 50, 75 % v/w) of aqueous extracts of *M. oleifera* stem, leaves, fruits and seeds respectively, whereas forth one well with distilled water serve as control. A disc of each test fungus was placed in center respectively. Each root infecting fungus replicated thrice and plates were incubated for 5-6 days at room temperature (27-33ºC) and then measured the zone of inhibition in millimeters (Ghazala *et al.,* 2003). The percent growth inhibition over control was determined (Lokesha & Benagi, 2007).

Soil properties*:* Soil was obtained from an experimental plot of Department of Botany (University of Karachi), sieved to remove pebbles and was filled in the pots (8 cm diameter) containing 300g. Soil was sandy loam containing (sand 72%, silt 16% and clay 12%), total nitrogen 0.083% (Mackenzie & Wallace, 1954), pH 7.2, moisture holding capacity 47% (Keen & Rakzowski, 1922), 4-8 sclerotia/g of *M. phaseolina* (Sheikh & Ghaffar, 1975), 12-15% of *R. solani* (Wilhelm, 1955) and *Fusarium* spp., 2700 cfu/ g (Nash & Synder, 1962).

***In vivo*:** Cowpea (*Vigna unguiculata* (L.) Walp cv. Lobia-2000) and mash bean (*Vigna mungo* (L.) Hepper cv. NM-97) seeds were sterilized in 1% $Ca(OCl)_2$ for 2-3 minutes, washed twice in sterilized distilled water to remove entire dust particles. Consequently washed seeds were treated with 25, 50 and 75% v/w extracts of plant parts (stem, leaves, fruits and seeds), respectively, for 5-10 minutes and then air dried for ≥ 3 hours in the laminar flow chamber, whereas untreated seeds served as control. In soil drenching, plant extracts of stem, leaves, fruits and seeds with the concentrations of 25, 50 and 75 % v/w drenched (20 mL) separately in each pot, soil without extracts served as control. Similarly, plant parts (stem, leaves, fruit and seeds) powdered at 0.1, 1.0 and 2.5% w/w were amended in the soil and watered 2-3 days for the decomposition of organic substrate. Soil without amendment regarded as control. Each treatment was replicated thrice and four seeds were sown in each pot. The pots were randomly placed in the screen house of the Department of Botany (KU) and data was recorded after one month.

Estimation of growth parameters and incidence of root rot fungi: After 30 days of germination, plants were carefully uprooted and growth parameters recorded in terms of shoot length and weight, root length and weight, number of nodules. Roots were washed thrice in sterilized water and surface sterilized by 1% $Ca(OCl)_2$ for 2-3 minutes and each root was cut into five pieces. Transferred each root pieces on poured potato dextrose agar (PDA) supplemented with antibiotics, penicillin @ 100,000/L and streptomycin @ 200 mg/L to inhibit bacterial growth. Incubate the Petri plate for one week at room temperature (32-36°C). Colonization percentage of root rot fungi was recorded (Short *et al*., 1980).

Statistical analysis: The data were analyzed for three way analysis (ANOVA) as per experimental design. Means were separated using Duncan's multiple range test (DMRT) at $p<0.05$ (Sokal & Rohlf, 1995) using "Statistica" software. Significant differences within the means of treatments and controls were calculated using the LSD statistical test.

Result

In vitro, the experiment was performed to observe antifungal activity of *M. oleifera* parts by using the paper disc and well methods. Most effective result was achieved by leaves extract using all concentrations showed excellent inhibition of root rot fungi by both methods. Maximum inhibition in the control of *M. phaseolina*, *R. solani* and *F. oxysporum* was recorded by stem extract when used at 75% v/w followed by 50 and 25% v/w concentrations. However, seed extract showed least inhibition of *F. oxysporum* at 75 and 50% v/w concentrations, whereas it was failed to inhibit *M. phaseolina* and *R. solani* mycelium as compared to control. No zone of inhibition of root rot fungi was observed by fruit extract used in all concentrations. Both paper disc and well methods showed effective fungicidal results in the screening of *M. oleifera* parts using different concentrations (Table 1 and Fig. 1).

In vivo complete germination of cowpea and mash bean plants showed by *M. oleifera* leaves when used in seed treatment and soil drenching methods in 25 and 50% w/w and amended in soil at 0.1 and 1.0% v/w. Seeds of cowpea and mash bean when treated with 75% v/w leaves extract of *M. oleifera* showed better growth parameters followed by stem extract at 25% v/w, whereas the highest number of nodules was recorded by both stem and leaves extracts used at 25% v/w concentrations. Complete suppression of root rot fungi was shown by leaves extract used in 25 and 50% v/w concentrations. Maximum inhibition of *R. solani*, *M. phaseolina* and *Fusarium* spp. colonization was noticed by the stem extract in all concentrations on both crop plants. Plant growth of cow pea and mash bean were enhanced when leaves powder amended in soil at 0.1% w/w but stem powder showed better plant growth when amended in soil at 1.0% w/w. Colonization of *M. phaseolina*, *Fusarium* spp. and *R. solani* was completely suppressed by *M. oleifera* leaves powder amended in soil at 1.0 and 2.5% w/w on mash bean plant, but in

cowpea it showed at 2.5% w/w. Stem powder amended in soil at 0.1,1.0 and 2.5% w/w showed significant inhibition of root rot fungi. In case of soil drenching method, shoot length and weight, root length and weight, number of nodules of cowpea and mash bean plants increases due to the *M. oleifera* leaves and stem extracts drenched at 25% v/w in the soil followed by 50 and 75% v/w concentrations recorded in both crop plants. Excellent control of root rot fungi on both crop plants were observed by all concentrations of leaves extract drenched in soil followed by stem extract (Fig. 2). It was noticed that when the seed and fruit extracts and powders of *M. oleifera* used as soil amendment, seed treatment and soil drenching methods showed poor plant growth and unable to inhibit the colonization of *Fusarium* spp., *R. solani* and *M. phaseolina* on cowpea and mung bean plants (Tables 2 and 3).

Among all *M. oleifera* plant parts, leaves powder and extract had shown fungicidal effects in controlling remarkably root rot fungi, and progressively improved plant growth when used in seed treatment, soil drenching and soil amendment methods.

Table 1. *In vitro*, inhibition of root rot fungi by aqueous extracts *Moringa oleifera* parts of with different concentrations by using paper disc and well diffusion methods.

Treatments	Concentrations/ Growth inhibition (MIC)											
	***Macrophomina phaseolina* (%) (mm)**				***Fusarium oxysporum* (%) (mm)**				***Rhizoctonia solani* (%) (mm)**			
	Control	**A**	**B**	**C**	**Control**	**A**	**B**	**C**	**Control**	**A**	**B**	**C**
	Paper disc method											
Seed extract	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	7.30 ± 1.53	2.22 ± 1.73	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Fruit extract	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Leaves extract	0.0 ± 0.0	80.00 ± 2.65	68.90 ± 1.00	62.22 ± 1.00	0.0 ± 0.0	93.33 ± 1.00	84.44 ± 1.00	79.30 ± 1.53	0.0 ± 0.0	97.80 ± 1.00	97.11 ± 0.58	95.60 ± 1.00
Stem extract	0.0 ± 0.0	53.30 ± 4.58	40.00 ± 1.00	32.70 ± 2.08	0.0 ± 0.0	26.67 ± 1.00	22.22 ± 1.00	17.04 ± 2.08	0.0 ± 0.0	42.90 ± 2.09	23.71 ± 1.53	18.44 ± 1.53
	Well method											
Seed extract	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.80 ± 1.53	8.90 ± 1.00	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Fruit extract	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Leaves extract	0.0 ± 0.0	72.60 ± 0.58	62.90 ± 1.53	54.00 ± 1.53	0.0 ± 0.0	97.11 ± 0.58	94.00 ± 1.53	92.70 ± 2.31	0.0 ± 0.0	95.6 ± 0.57	93.30 ± 1.00	86.70 ± 2.65
Stem extract	0.0 ± 0.0	63.70 ± 4.93	57.04 ± 1.53	44.44 ± 1.00	0.0 ± 0.0	32.70 ± 1.53	24.44 ± 1.00	13.33 ± 1.00	0.0 ± 0.0	51.80 ± 2.52	38.44 ± 3.79	31.80 ± 2.08
$LSD_{0.05}$: Concentration =			0.911			0.823				0.715		
Plant parts =			0.911			0.823				0.715		
Methods =			0.842			0.596				0.523		

Where; **MIC**=Minimum inhibitory concentration, **±** Standard deviation and Concentrations of plant extracts: **A**=75% v/v, **B**= 50% v/v, **C**= 25% v/v

Discussion

M. oleifera parts, especially leaves powder and extract revealed pronounced effect and possess antifungal activity against *M. phaseolina*, *R. solani* and *F. oxysporum* both *in vitro* and *in vivo* experiments and were found to be best in all concentrations. *M. oleifera* leaves contain a number of phytochemicals such as; saponins, flavonoids, phenolic and tannins compounds exhibit antimicrobial activities (Sato *et al*., 2004; Cushine & Lamb, 2005; Mboto *et al*., 2009). Due to this, it would suggest that it exert anti-fungal activities observed in this research could be attributed to such compounds. Leaves extract of *M. oleifera* was found to be effective in controlling growth of fungi such as *Basidiobolus haptosporus* and *Basidiobolus ranarums* (Nwosu & Okafor, 1995). Leaves extract in chloroform showed positive suppression against *Escherichia coli* (MTCC 443), *Pseudomonas aeruginosa*, *Staphylococcus aureus* (MTCC 3160), *Streptococcus pyogenes* (MTCC 442), *Aspergillus niger* (MTCC 1781) and *Candida albicans* (MTCC 181) as compared to petroleum ether which was failed to inhibit bacterial and fungal strains (Devendra *et al*., 2011). *M. oleifera* leaves in aqueous and ethanol extracts possess antibacterial activity by producing zone of inhibition using disc diffusion method against *Escherichia coli*, *Proteus vulgaris* and *Salmonela typhi* respectively, whereas acetone and chloroform extracts did not show any antibacterial activity (Gomashe *et al*., 2014). Leaves of *M. oleifera* showed excellent fungicidal activity against root rot fungi when used at 0.1, 1.0, 2.5% w/w amended in soil and treated with seeds or drenched in soil at 75, 50 and 25% v/w concentrations but also improve the growth parameters of cow pea and mash bean plants. Growth of crop plants increased when *M. oleifera* leaves were applied because it exhibit plant growth regulators (Foidle *et al*., 2001) containing rich source of ascorbate, calcium, potassium, zeatin and phenolic compounds (Basra *et al*., 2011) considered as natural crop growth enhancer. Ikram & Dawar (2013) reported that using *Prosopis juliflora* leaves and stem powder @ 1.0% w/w were effective in the inhibition of root rot fungi and in the improvement of all growth parameters of cowpea and mung bean plants. Organic amendments are usually used for the improvement of crop plants and increasing agricultural productivity by suppressing plant parasitic nematode and fungi (Alam, 1990; Stone *et al*., 2003). Application of organic amendments to soil is considered as a key point to improve the quality and health of soil by supplying important micronutrients (Timsina &

Conner, 2001). Physically organic amendments addition brought changes in water retention, permeability, drainage, water infiltration, structure and aeration of soil (Davis & Wilson, 2005). Seed treatment is an effective method as it protects seed from seed-borne and soil-borne pathogens and enables the seed to germinate and become established as a healthy seedling (Chang & Kommedahl, 1968). Using seed treatment and soil drenching methods, all parts of *M. oleifera* extracts have positive potential in improving plant growth and germination as well as reduced root infecting fungi, but seed extract resulted in minimum suppression of root infecting fungi at 75% v/w concentration when drenched in soil. Seed extracts of *M. oleifera* showed antimicrobial activity against *Aspergillus niger* and *Candida albicans* (Abdulmoneim & Abu-Zaid, 2011) but in our research it failed to suppress root rot fungi particularly *R. solani, Fusarium* spp. and *M. phaseolina.* Soil drenching with garlic extract increases summer squash flower number (Helmy, 1992). Similarly, Mohanta *et al*. (2007) reported that using aqueous and organic solvent extracts of the *Semecarpus anacardium* Linn. possess inhibitory effect against *Staphylococcus aureus.* Mangang & Chhetry (2012) investigated that cold water extracts of *Artemisia vulgaris, coix lacryma jobi, Lantana camera, Michelia champaka, Passiflora foetida, punica granatum and Strobilanthes flaccidifolius* showed 50% or more mycelial inhibition of *R. solani.* Amendment of *Avicennia marina* stem and leaves powder pellets extensively controlled root rot diseases caused by pathogenic fungi in cowpea and brinjal plants (Tariq & Dawar, 2011). Similarly, Akhter *et al*. (2006) observed that the extracts of *Adhatoda vasica* and *Zingiber officinale, Piper betle, Azadirachta indica* and *Vinca rosea* in combination with cow dung and *Calotropis procera* (leaf) extract in combination with cow urine possess high ability to inhibit conidial germination of *Bipolaris sorokiniana.* Suleiman & Emua (2009) reported that among *Zingiber officinale, Aloe ve*ra, *Garcinia kola* and *Azadirachta indica* extracts, *Aloe ve*ra showed 60% inhibition of mycelial growth of *Pythium aphanidermatum.* Extracts of *Polyalthia longifolia* showed antifungal activity against *Macrophomina phaseolina* (Datar, 1999).Therefore, different methods of formulation using plant extract possess antifungal activity to control soil borne pathogens (Hadar *et al*., 1992; Chung & Miller, 1995; Muchovej & Pa-covsky, 1997; Ahmed & Nimer, 2002).

Chemical control of plant pathogens has proved effective, but the majority of these agrochemicals is extremely costly and exhibit lethal effects. Present research showed antifungal effect of *M. oleifera* leaves remarkably control root rot fungi caused by *Fusarium* spp., *R. solani* and *M. phaseolina* but also enhanced plant growth. Hence, by using plant resources for its antifungal activity is good for the development of viable mode of agriculture in an organic farming system and more improvement in crop yield on cheaper bases can easily be done. For that reason, it is suggested that *M. oleifera* leaves needs to be introduced into fields on a large scale which represent an environment friendly strategy for controlling root rot fungi as a substitute for chemical fungicides. One more advantage of using the aqueous leaves extract that, it can easily use and is affordable to resource-limited farmers.

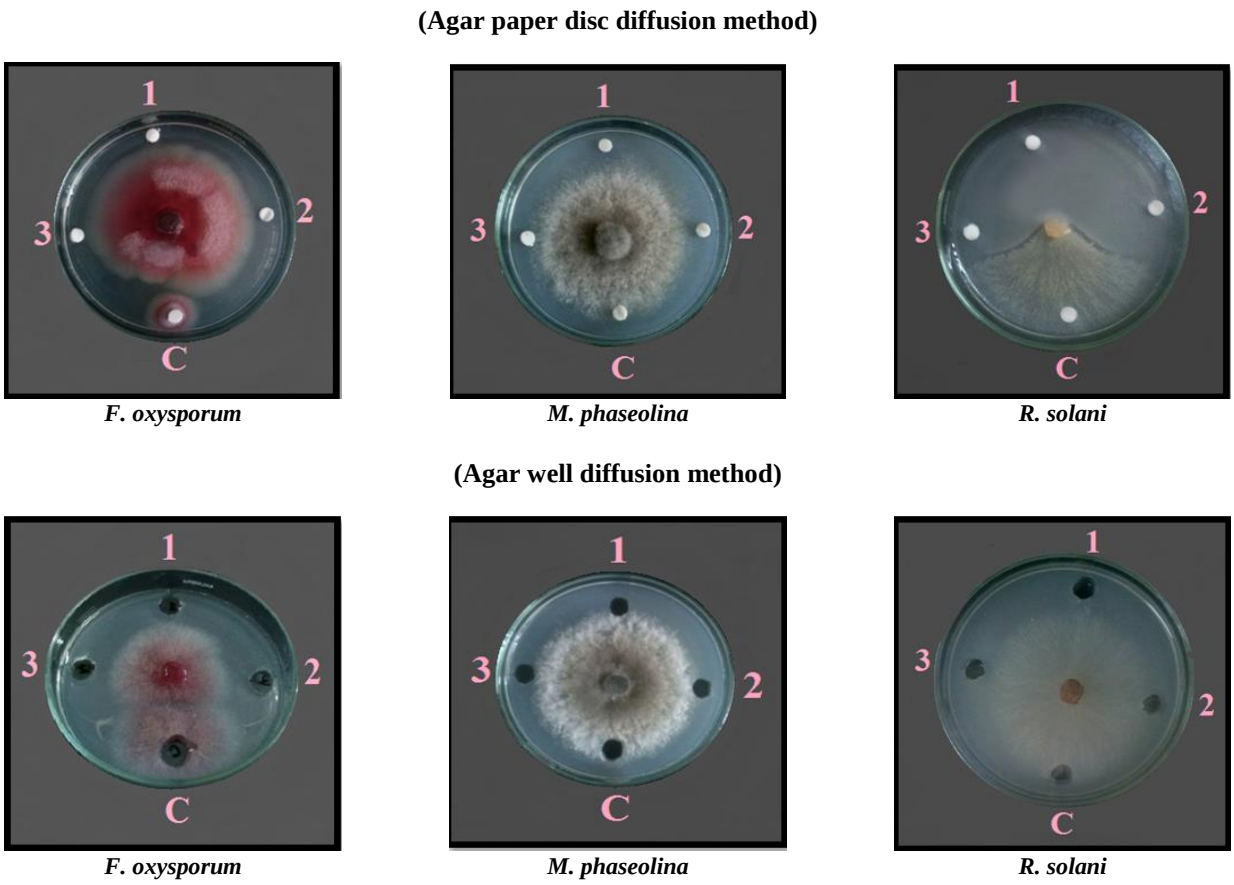

Fig. 1. *In vitro*, inhibition of root rot fungi by aqueous extracts of *Moringa oleifera* leaves using paper disc and well diffusion methods. where, **1**= 75% v/w concentration; **2**=50% v/w concentration; **3**= 25% v/w concentration; **C**= Control

Table 2. Methods of application by using *Moringa oleifera* parts on growth parameters of cowpea plant.

Methods	Treatments	Conc. (%)	Germination (%) ± SD	Shoot length (cm) ± SD	Shoot weight (g) ± SD	Root length (cm) ± SD	Root weight (g) ± SD	Number of nodules ± SD
Soil amendment	Control	0.0	53.00±11.53	14.46±1.84	0.57±0.34	10.09±5.03	0.48±0.22	11±4.58
	Seed powder	0.1	73.00±11.54	20.06±1.38	1.44±0.31	16.23±1.56	0.66±0.19	18±2.51
		1.0	40.00±20.00	15.90±2.59	1.22±0.71	10.29±1.96	0.41±0.11	03±2.51
		2.5	26.67±11.54	5.16±3.91	0.49±0.39	4.70±1.73	0.17±0.07	04±2.00
	Fruit powder	0.1	60.00±20.00	20.20±1.60	1.46±0.52	15.81±1.59	0.73±0.05	15±1.52
		1.0	40.00±20.00	16.69±4.88	1.01±0.23	12.87±0.32	0.68±0.03	13±2.64
		2.5	40.00±20.00	14.17±4.67	0.71±0.17	8.33±0.85	0.27±0.04	05±3.05
	Leaves powder	0.1	100±0.0	27.65±4.83	2.01±0.07	18.39±0.83	0.97±0.05	25±2.08
		1.0	100±0.0	21.12±1.29	2.68±0.26	15.58±2.58	0.57±0.05	24±4.00
		2.5	86.70±11.54	20.13±5.50	1.08±0.04	9.04±1.90	0.34±0.09	15±2.00
	Stem powder	0.1	100±0.0	25.40±1.27	2.09±0.13	13.50±2.71	0.57±0.09	18±1.52
		1.0	86.70±11.54	17.58±5.42	1.66±0.56	16.04±2.02	0.54±0.03	22±5.56
		2.5	40.00±20	15.09±1.14	0.54±0.12	9.91±2.48	0.35±0.18	13±4.72
Seed treatment	Control	0.0	40.00±20	17.10±2.95	0.51±0.06	11.22±1.22	0.29±0.06	14±4.93
	Seed extract	75	73.33±30.55	16.46±3.01	0.51±0.18	12.28±1.50	0.20±0.07	12±2.52
		50	86.67±23.09	15.12±1.23	0.62±0.30	13.29±0.87	0.21±0.03	14±1.53
		25	100±0.0	21.81±0.93	1.93±0.77	15.25±0.43	0.42±0.04	26±2.52
	Fruit extract	75	33.33±11.54	14.35±2.88	0.43±0.19	12.50±1.34	0.11±0.03	13±1.53
		50	73.33±11.54	15.80±2.02	0.66±0.16	14.29±1.13	0.18±0.01	14±1.53
		25	93.33±11.54	20.63±3.31	0.95±0.03	17.53±0.62	0.24±0.04	17±1.53
	Leaves extract	75	93.33±11.54	29.67±2.00	3.24±0.62	15.53±0.70	0.62±0.02	28±6.00
		50	100±0.0	30.68±0.86	3.99±0.65	20.10±0.62	0.77±0.06	33±5.00
		25	100±0.0	34.56±4.62	5.10±0.69	19.57±1.24	0.90±0.15	48±8.72
	Stem extract	75	46.70±11.55	16.20±2.17	0.75±0.29	11.50±2.59	0.32±0.04	14±2.00
		50	73.33±30.75	21.13±5.47	2.05±0.55	18.32±2.32	0.42±0.04	28±5.51
		25	100±0.0	25.57±3.86	2.89±0.45	20.12±4.43	0.56±0.04	56±5.86
Soil drenching	Control	0.0	66.67±11.55	15.86±0.4	1.03±0.34	9.15±1.19	0.22±0.08	12±4.93
	Seed extract	75	13.33±11.54	6.20±5.60	0.41±0.36	6.10±5.37	0.05±0.04	02±1.53
		50	20.00±20.00	9.70±8.40	0.45±0.39	8.11±7.39	0.07±0.07	03±3.00
		25	80.00±20.00	16.20±3.54	0.61±0.083	9.70±1.21	0.15±0.03	07±1.53
	Fruit extract	75	73.33±11.55	12.77±0.96	0.41±0.07	9.22±0.68	0.097±0.03	09±0.58
		50	66.67±11.54	14.07±0.47	0.48±0.06	10.14±0.77	0.16±0.02	10±2.08
		25	73.33±11.54	18.53±1.72	0.56±0.02	12.36±2.03	0.17±0.02	12±1.53
	Leaves extract	75	86.67±11.55	22.44±1.26	1.08±0.04	13.83±0.93	0.35±0.04	43±1.00
		50	100±0.0	25.21±1.39	1.63±0.13	14.93±0.56	0.36±0.02	48±4.00
		25	100±0.0	28.34±1.78	2.83±0.30	17.61±0.65	0.44±0.04	54±2.00
	Stem extract	75	66.67±23.09	18.44±1.49	0.92±0.06	14.76±2.92	0.29±0.03	25±3.00
		50	80±0.0	20.79±1.35	1.07±0.05	12.15±1.60	0.37±0.05	35±3.00
		25	100±0.0	26.36±2.33	1.99±0.24	16.04±1.54	0.62±0.03	44±2.08
	$LSD_{0.05}$: Concentrations=		6.842	1.438	0.160	1.169	0.046	1.770
	Plant parts=		6.842	1.438	0.160	1.169	0.046	1.770
	Methods=		5.926	1.246	0.138	1.013	0.039	1.533

Where; Conc. = Concentrations, SD = ± Standard deviation

Table 3. Methods of application by using *Moringa oleifera* parts on growth parameters of mash bean plant.

Methods	Treatments	Conc. (%)	Germination (%) ± SD	Shoot length (cm) ± SD	Shoot weight (g) ± SD	Root length (cm) ± SD	Root weight (g) ± SD	Number of nodules ± SD
Soil amendment	Control	0.0	73.33±11.55	13.57±1.46	0.26±0.03	12.12±2.34	0.16±0.03	06±3.10
	Seed powder	0.1	93.33±11.55	20.81±1.63	0.30±0.12	14.09±3.73	0.24±0.075	10±5.51
		1.0	86.67±11.54	19.52±1.38	0.39±0.03	8.44±0.72	0.24±0.055	03±1.0
		2.5	66.67±30.55	9.57±2.62	0.04±0.01	3.48±1.77	0.06±0.015	00±0.0
	Fruit powder	0.1	86.67±23.09	19.78±1.45	0.43±0.056	12.55±4.18	0.20±0.04	13±20.0
		1.0	93.33±11.55	18.56±3.15	0.39±0.067	14.93±0.29	0.23±0.071	17±6.43
		2.5	73.33±11.54	14.87±0.98	0.28±0.04	9.21±0.62	0.15±0.026	10±2.08
	Leaves powder	0.1	100±0.0	20.91±3.92	0.47±0.056	16.85±1.43	0.35±0.03	18±1.0
		1.0	100±0.0	28.13±0.78	1.04±0.057	21.14±1.35	0.59±0.076	34±2.08
		2.5	100±0.0	21.14±0.55	0.45±0.09	15.17±4.33	0.28±0.04	26±2.08
	Stem powder	0.1	100±0.0	18.24±0.61	0.52±0.035	14.29±1.18	0.26±0.015	23±10.07
		1.0	100±0.0	20.39±1.74	0.65±0.031	16.25±2.54	0.33±0.042	24±2.0
		2.5	93.33±11.54	16.65±1.41	0.33±0.05	9.64±5.76	0.24±0.053	15±2.52
Seed treatment	Control	0.0	80.00±20.0	15.73±0.69	0.51±0.04	9.30±2.62	0.14±0.02	11±3.2
	Seed extract	75	93.33±11.55	17.23±0.39	0.72±0.21	12.18±1.94	0.11±0.026	14±2.65
		50	100±0.0	18.31±0.45	0.60±0.072	8.69±1.77	0.15±0.015	15±1.0
		25	100±0.0	17.93±0.17	0.52±0.032	10.05±2.56	0.16±0.038	16±2.08
	Fruit extract	75	73.33±11.55	14.65±0.54	0.54±0.015	8.45±0.46	0.13±0.042	09±2.0
		50	80±20.00	15.84±0.89	0.51±0.026	7.49±0.15	0.07±0.021	05±1.53
		25	93.33±11.55	20.33±0.98	0.46±0.021	7.81±0.52	0.10±0.02	10±1.0
	Leaves extract	75	100±0.0	22.93±1.42	1.88±0.038	19.94±1.26	0.76±0.021	41±2.05
		50	100±0.0	27.07±0.61	1.85±0.03	20.54±2.71	0.87±0.05	48±3.51
		25	100±0.0	28.17±0.72	1.78±0.06	25.78±1.47	0.86±0.02	46±1.0
	Stem extract	75	100±0.0	20.02±0.35	1.44±0.11	19.81±0.43	0.41±0.03	32±3.52
		50	100±0.0	21.61±0.78	0.96±0.015	18.41±1.11	0.35±0.021	25±1.53
		25	100±0.0	17.15±1.64	0.91±0.031	17.58±1.94	0.31±0.076	20±2.08
Soil drenching	Control	0.0	80.00±0.0	16.07±1.81	0.28±0.04	10.67±0.89	0.13±0.032	07±3.21
	Seed extract	75	40.00±20.00	13.81±1.67	0.25±0.015	9.93±1.35	0.07±0.026	04±1.53
		50	26.67±11.54	14.93±2.27	0.21±0.03	6.49±2.63	0.09±0.035	08±2.08
		25	73.33±11.54	17.12±0.52	0.31±0.026	11.39±0.85	0.15±0.025	14±1.53
	Fruit extract	75	33.33±11.54	12.33±0.89	0.29±0.03	6.29±0.54	0.07±0.01	03±0.58
		50	53.33±11.54	13.64±0.54	0.29±0.038	9.01±1.16	0.09±0.036	06±1.0
		25	66.67±11.54	16.33±0.66	0.26±0.01	8.89±0.42	0.12±0.026	12±1.53
	Leaves extract	75	86.67±11.55	23.93±1.68	1.03±0.02	23.46±2.18	0.68±0.038	25±2.65
		50	100±0.0	26.77±2.00	1.45±0.32	20.53±0.79	0.73±0.04	44±7.21
		25	100±0.0	33.60±1.63	2.02±0.04	24.66±1.13	0.83±0.04	52±3.51
	Stem extract	75	66.67±11.55	19.05±1.85	0.71±0.03	12.46±0.91	0.36±0.015	18±3.0
		50	80±20.00	20.86±1.82	0.89±0.03	13.42±0.84	0.42±0.035	22±2.65
		25	100±0.0	26.54±1.09	1.09±0.06	15.94±0.83	0.47±0.02	28±3.51
	$LSD_{0.05}$: Concentrations=		5.569	0.723	0.033	0.960	0.017	1.504
	Plant parts=		5.569	0.723	0.033	0.960	0.017	1.504
	Methods=		4.823	0.626	0.029	0.832	0.014	1.302

Where; Conc. = Concentrations, SD = ± Standard deviation

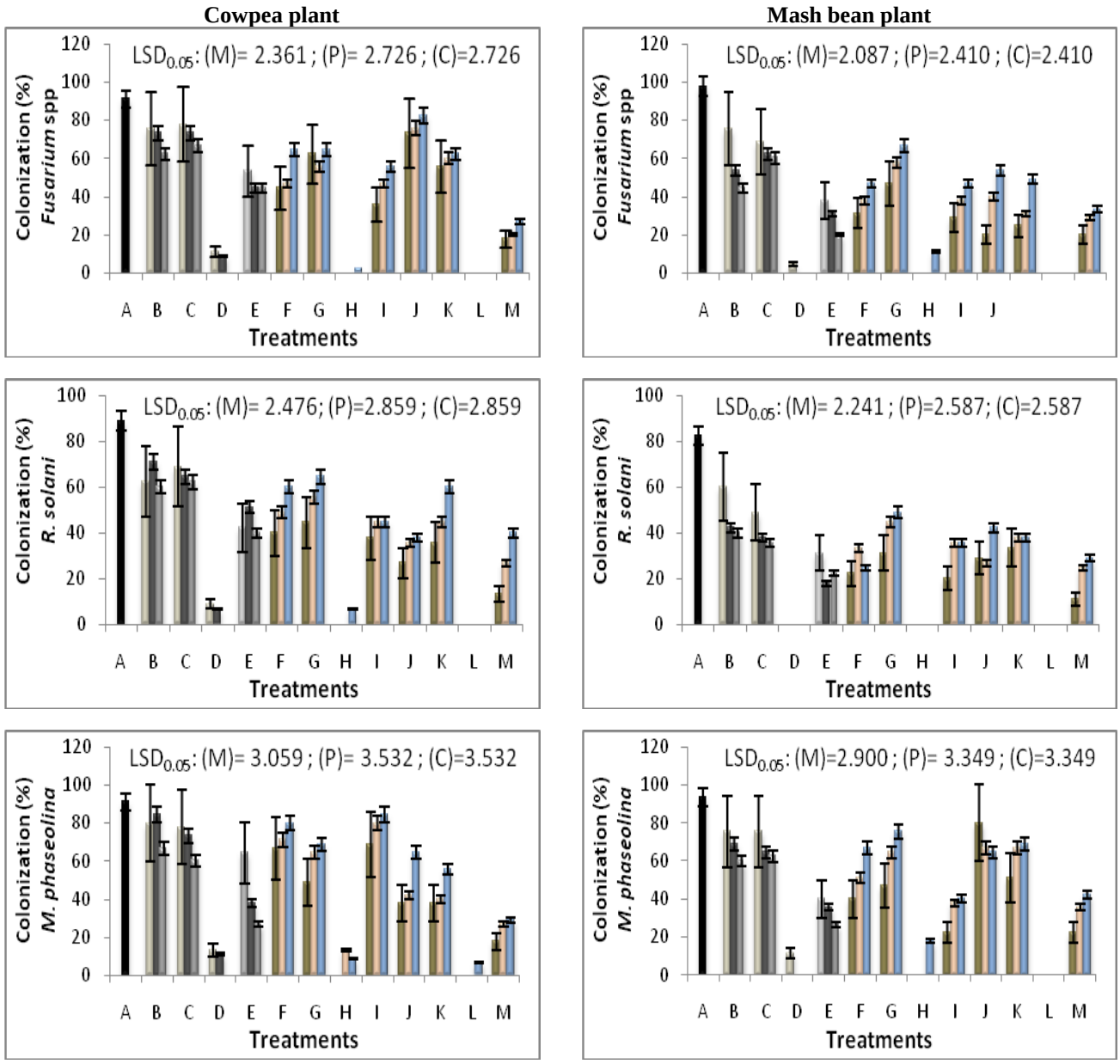

Fig. 2. Methods of application by using *Moringa oleifera* parts in the control of root rot fungi on crop plants.
Control Soil amendment: 0.1% 1.0% 2.5% w/w concentrations;
Seed treatment and soil drenching: 75% 50% 25% v/w concentrations.
(M)= Methods, (P) = Plant parts, (C) = Concentrations

where, **A**= Control, **B**= Soil amended with 0.1%; 1.0 and 2.5% w/w *M. oleifera* seed powder, **C** = Soil amended with 0.1%; 1.0 and 2.5% w/w *M. oleifera* fruit powder, **D**= Soil amended with 0.1%; 1.0 and 2.5% w/w *M. oleifera* leaves powder, **E**= Soil amended with 0.1%; 1.0 and 2.5% w/w *M. oleifera* stem powder, **F**= Seed treated with 75%; 50% and 25% v/w *M. oleifera* seed extract, **G**= Seed treated with 75%; 50% and 25% v/w *M. oleifera* fruit extract, **H** = Seed treated with 75%; 50% and 25% v/w *M. oleifera* leaves extract, **I** = Seed treated with 75%; 50% and 25% v/w *M. oleifera* stem extract, **J**=Soil drenched with 75%; 50% and 25% v/w *M. oleifera* seed extract, **K**= Soil drenched with 75%; 50% and 25% v/w *M. oleifera* fruit extract, **L**=Soil drenched with 75%; 50% and 25% v/w *M. oleifera* leaves extract, **M**= Soil drenched with 75%; 50% and 25% v/w *M. oleifera* stem extract.

References

Abdel-Kader, M.M., N.S. El-Mougy and A.M.A. Ashour. 2002. Suppression of root rot incidence in faba bean fields by using certain isolates of *Trichoderma*. *Egyptian Journal of Phytopathology*, 30(2):15-25.

Abdulmoneim, M.S and I.E. Abu-Zaid. 2011. An *In vitro* antimicrobial activity of *Moringa oleifera* L. seed extracts against different groups of microorganisms. *Australian Journal of Basic and Applied Sciences*, 5(5): 129-134.

Abu-Taleb, A.M, El-D. Kadriya and O.Al-O. Fatimah. 2011. Assessment of antifungal activity of *Rumex vesicarius* (L.) and *Ziziphus spina-christi* (L.) wild extracts against two phytopathogenic fungi. *African Journal of Microbiology Research*, 5(9):1001-1011.

Ahmed, D.M. and A.M. Nimer. 2002. Effects of *Acacia Senegal* (L.) Wild. on sandy soils: A case study of El Damokya Forest, Northern Kordofan State. *University of Khartoum Journal Agricultural Sciences* 10(1):106-118.

Akhter, N., F. Begum, S. Alam and M. Alam. 2006. Inhibitory effect of different plant extracts cow dung and cow urine on conidial germination of *Bipolarissorokiniana*. *Journal of bio-science*, 14: 87-92.

Alam, M. 1990. Neem in nematode biocontrol (Aspects and prospects): M.S. Jairajpuri, M.M. Alam and I. Ahmed. BS Publishers and Distributors (Pvt) Ltd. Dehli-110032, India. 51-55.

Anwar F, S. Latif, M. Ashraf and A.H. Gilan. 2007. *Moringa oleifera*: A Food plant with Multiple Medicinal uses. *Phytotherapy Research*, 21: 17-25.

Babu, J., D.A. Muzafar and K. Vinod. 2008. Bioefficacy of plant extracts to control *Fusarium solani* F. Sp. *Melongenae* of Brinjal wilt, *Global Journal of Biotechnology and Biochemistry*, 3(2): 56-59.

Basra, S.M.A., M.N. Iftikhar and I. Afzal. 2011. Potential of Moringa (*Moringa oleifera*) leaf extract as priming agent for hybrid maize seeds. *International Journal of Agriculture and Biology*, 13: 1006-1010.

Caceres, A., A. Saravia, S. Rizzo, L. Zabala, E.D. Leon and F. Nave. 1992. Pharmacological properties of *Moringa oleifera* 2: Screening for anti-spasmodic, anti-inflammatoy and diuretic activity. *Journal of Ethnopharmacology*, 36: 233-237.

Chang, I. and T. Kommedahl. 1968. Biological control of seedling blight of corn by coating kernels with antagonistic micro-organisms. *Phytopathology*, 58: 1395-1401.

Chung, I.M. and D.A. Miller. 1995. Effect of alfalfa plant and soil extracts on germination and growth of alfalfa. *Agronomy Journal*, 87: 762-767.

Cowan, M. 1999. Plant products as anti-microbial agents. *Clinical Microbiology Review*, 12: 564-582.

Cushine, T.P.T. and A.J. Lamb. 2005. Antimicrobial activity of flavonoids. *International Journal of Antimicrobial Agents*, 26(5): 343-356.

Dashputra, P.G., S.D. Dharmadhikari and A.S. Bkore, 1977. Pharmacology of *Moringa oleifera*. *Indian Journal of Pharmacology*, 9: 48-82.

Datar, V.V. 1999. Bioefficacy of plant extracts against *Macrophomina phaseolina* (Tassi) Gold, the incitant of charcoal rot of sorghum. *Journal of Mycology and Plant Pathology*, 29: 251-253.

Davis, J.G. and C.R.Wilson. 2005. Choosing a Soil Amendment. Colorado State University. *Cooperative Extension Horticulture*, 7: 235.

Dahot, M.U. 1988. Vitamin contents of flowers and seeds of *M. oleifera. Pakistan. Journal of Biochemistry*, 21: 1-24.

Devendra, B.N., N. Srinivas, V.S.S.L.P. Talluri and P. S. Latha. 2011. Antimicrobial activity of *M. oleifera* LAM, leaf extract against selected bacterial and fungal strains. *International Journal of Pharma and Biosciences*, 2(3): 13-18.

Elevitch, C.R. 2011. (ed). Specialty Crops for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Honolulu, Hawaii.pp.171.

Farooq, A., L. Sajid, A. Muhammad and G. Anwarul Hassan. 2007. *Moringa oleifera*: a food plant with multiple medicinal uses. *Phytotherapy Research*, 21: 17-25.

Foidle, N., H.P.S. Makkar and K.Becker. 2001. The potential of *Moringa oleifera* for agricultural and industrial uses. In: (Ed.): Fuglie, L.J. The Miracle Tree: The Multiple Attributes of Moringa, pp: 45-76. Wageningen, The Netherlands.

Fravel, D. 2005. Commercialization and implementation of biocontrol. *Annual Review of Phytopathology*, 43: 337-359.

Fuglie LJ. 1999. The Miracle Tree: *Moringa oleifera*: Natural Nutrition for the Tropics. Church World Service, Dakar, pp. 68; revised in 2001 and published as The Miracle Tree: The Multiple Attributes of Moringa, pp. 172

Ghaffar, A. 1988. Soil borne diseases research centre. Final research report. Department of Botany, University of Karachi, Karachi-75270, Pak. pp.111.

Ghazala, B., M. Shameel, M.I. Choudhary, S. Shahzad and S.M. Leghari. 2003. Phycochemistry and bioactivity of certain fresh water green algae of Sindh. *Pakistan Journal of Botany*, 35(5): 695-704.

Gomashe, A.V., P.A. Gulhane, M.P. Junghare and N.A. Dhakate. 2014. A ntimicrobial activity of Indian medicinal plants: *Moringa oleifera* and *Saraca indica. International Journal of Current Microbiology and Applied Science*, 3(6): 161-169.

Hader, Y., R. Mandelbaum and B. Gorodecki. 1992. Biological control of soil borne plant pathogens by suppressive compost. In: Biological Control of Plant Diseases, (Eds.): E.C. Tjamos, G.C. Papavizas and R.J. Cook. Plenum Press, New York, NY, USA: 79-83.

Hanif, A. and S. Dawar. 2015. Use of homeopathic drugs in combination with fertilizers for the control of root rot fungi. *Pak. J. Bot.*, 47(6): 2455-2462.

Hartman, J.R. and J.T. Fletcher. 1991. *Fusarium* crown and root rot of tomato in UK. *Plant Pathology*, 40(1): 85-92.

Helmy, E.M.S. 1992. Response to summer squash application methods of fresh garlic extracted by different solvents. *Alexandria Journal of Agricultural Physiological Studies on Research*, 37: 125-142.

Hoes, J.A. 1985. *Macrophomina phaseolina*: causal agent of charcoal rot of sunflower and other crops. Agric. Canada Research station, *Modern Manitoba*, pp.9.

Ikram, N. and S. Dawar. 2013. Effect of *Prosopis juliflora* (Sw.) DC. in the control of root rot fungi of cowpea (*Vigna unguiculata* L.) and mungbean (*Vigna radiata* (L.) Wilczek). *Pakistan Journal of Botany*, 45(2): 649-654.

Infantin, A., M. Kharrat, L. Riccioni, C.J. Coyne, K. McPhee, J. Niklaus and N.J. Grunwald. 2006. Screening techniques and sources of resistance to root diseases in cool season food legumes. *Euphytica*, 147: 201-221.

Keen, B.A and H. Rakzowski. 1922. Clay contents and certain physical properties of soil. *Journal of Agricultural Science*, 11: 441-449.

Lockelt, C.T., C.C. Calvet and L.E. Grivetti. 2000. Energy and micronutrient composition of dietary and medicinal wild plants consumed during drought. Study of rural Fulani, northeastern Nigeria. *International Journal of Food Science and Nutrition*, 51(3): 195-208.

Lokesha, N.M. and V.I. Benagi. 2007. Biological management of pigeon pea dry root rot caused by *Macrophomina phaseolina*. *Karnataka. Journal of Agricultural Science*, 20: 54-56.

Makonnen, E., A. Hunde and G. Damecha. 1997. Hypoglycaemic effect of *M. stenopetala* aqueous extract in rabbits. *Phytotherapy Research*, 11:147-148.

Mackanzie, H.A. and H.S. Wallace. 1954. The kjeldahl determination of nitrogen. A critical study of digestion conditions, temperature, catalyst and oxidizing agents. *Australian Journal of Chem*istry, 7: 55-70.

Mancini, F., A.J. Termorshuizen, J.L.S. Jiggins and A.H.C. Bruggen. 2008. Increasing the environmental and social sustainability of cotton farming through farmer education in and hra Pradesh, India. *India Agricultural System*, 96:16-25.

Mangang, H. and G. Chhetry. 2012. Antifungal properties of certain plant extract against *Rhizoctonia solani* causing root rot of French Bean. *International Journal of Scientific and Research*. Publications, 2(5): 1-4.

Mboto, C.I., M.E. Eja, A.A. Adegoke, G.D. Iwatt, B.E. Asikong, I. Takon, S.M. Udo and M. Akeh. 2009. Phytochemical properties and antimicrobial activities of combined effect of extracts of the leaves of *Garcinia Kola*, *Vernonia amygdalina* and honey on some medically important microorganisms. *African Journal of Microbiology Research*, 3(9): 557-559.

Mehta, L.K., R. Balaraman, A.H. Amin, P.A. Baffa and O.D. Gulati. 2003. Effects of fruits of *M. oleifera* on the lipid profile of normal and hypercholesterolaemic rabbits. *Journal of Ethnopharmacology*, 86: 191-195.

Mohanta, T.K., J.K. Patra, S.K. Rath, D.K. Pal and H.N. Thatoi. 2007. Evaluation of antimicrobial activity and phytochemical screening of oils and nuts of *Semecarpus anacardium*. *Scientific Research and Essay*, 2(11): 486-490.

Morton, J.F. 1991.The horse radish tree: *M. pterigosperma* (Moringacea). A boon to arid lands. *Economic Botany*, 45: 318-333.

Muchovej, R.M.C. and R.S. Pacovsky. 1997. Future directions of by-products and wastes in agriculture. In: Agricultural uses of By-Products and Wastes. (Eds.): J.E. Rechcigl and G.C. MacKinnon. ACS Symposium Series, American Chemical Society Washington, DC, USA: 1-19.

Nair, R., T. Kalariya and C. Sumitra. 2005. Antibacterial activity of some selected Indian medicinal flora. *Turkish Journal of Biology*, 29:41-47.

Nash, S.M. and W.C. Synder. 1962. Quantitative estimations by plate counts of propagules of the bean root rot, *Fusarium* in field soils. *Phytopathology*, 52: 567-572.

Nepolean, P., J. Anitha and R.R. Emilin. 2009. Isolation, analysis and identification of phytochemicals of antimicrobial activity of *Moringa oleifera* Lam. *Current Biotica*, 1(3): 33-39.

Nickon, F., Z.A. Saud, M.H. Rehman and M.E. Haque. 2003. *In vitro* antimicrobial activity of the compound isolated from chloroform extract of *M. oleifera Lam. Pakistan Journal of Biological Science*, 22: 1888-1890.

Nwosu, M.O. and J.L. Okafor. 1995. Preliminary studies of the antifungal activities of some medicinal plants against *Basidiobolus* and some other pathogenic fungi. *Mycoses*, 38:191-195.

Pal, S.K., P.K. Mukherjee and B.P. Saha. 1995. Studies on the antiulcer activity of *M. oleifera* leaf extract on gastric ulcer models in rats. *Phytotherapy Research*, 9: 463-465.

Pérez, M.L., O.L.J. Durán, M.R. Ramírez, P.J.R. Sánchez and P.V. Olalde. 2004. Sensibilidad *In vitro* de aislados del hongo Phytophthora capsici a funguicidas. Memorias Primera Convención Mundial del Chile. León, Guanajuato, México. *Resumen,* pp. 144-150.

Rafi, H., S. Dawar and M.J. Zaki. 2015. Seed priming with extracts of *Acacia nilotica* (L.) Willd. Ex Delile and *Sapindus Mukorossi* (L.) plant parts in the control of root rot fungi and growth of plants. *Pakistan Journal of Botany*, 47(3): 1129-1135.

Raghavendra, M.P., S. Satish and K.A. Raveesha. 2002. *Prosopis juliflora* Swartz: A Potential plant for the management of fungal diseases of crops. *In: Asian Cong. Mycol. Pl. Pathol.,* Indian Soc. University of Mysore (Abst) Oct. 1-4, pp: 136.

Ruckmani, K., S. Kavimani, R. Anandan and B. Jaykar. 1998. Effect of *Moringa oleifera* Lam on paracetamol – induced hepatoxicity. *Indian Journal of Pharmaceutical Science*, 60: 33-35.

Sato, Y., H. Shibata, T. Arai, A. Yamamoto, Y. Okimura, N. Arakaki and T. Higuti. 2004. Variation in synergistic activity by flavones and its related compounds on the increased susceptibility of various strains of methicillin-resistant *Staphylococcus aureus* to β-lactam antibiotics. *International Journal of Antimicrobial Agents*, 24(3): 226-233.

Sayeeda, F. and M.U. Ahmad. 2005. Comparative efficacy of some organic amendments and a nematicide (furad N-3G) against root knot on two local varieties of groundnut. *The Plant Pathology Journal*, 4: 54-57.

Shaheen, F., B.S. Siddigui, R. Saleen, K. Aftab, F. Shaheen and A. Gilani. 1998. Hypotensive constituents from the pods of *M.oleifera*. *Planta Medica*, 64: 225-228.

Sharma, P., P. Kumari, M.M. Srivastava and S. Srivastava. 2006. Removal of cadmium from aqueous system by shelled *M. oleifera* Lam. seed powder. *Bioresource Technology*, 97: 299-305.

Sheikh, A.H. and A. Ghaffar. 1975. Population study of sclerotia of *Macrophomina* p*haseolina* in cotton field. *Pakistan Journal of Botany*, 7: 13-17.

Short, G.E., T.D. Wyllie and A. Bristow. (1980). Survival of *Macrophomina phaseolina* in soil and residue of soya bean. *Phytopathology*, 7: 13-17.

Stephan, Z.A., I.K. Al-Mamoury and B.G. Antoon.1988. The efficiency of nematode, solar heating and the fungus *Paecilomyces lilacinus* in controlling root knot nematode *Meloidogyne javanica* in Iraq. *Zanco*, 6: 69-76.

Stone, A.G., G.E. Vallad, L.R. Cooperband, D.R. Ro-tenburg, H.M. Darby, W.R. Stevenson, R.M. Goodman. 2003. Impact of annual organic amendment on disease incidence in a three year vegetable rotation. *Plant Disease*, 87: 1037-1042.

Sokal, R. and F.J. Rohlf. 1995. Biometry: The Principals and Practices of Statistical in Biological Research, Freeman, New York. pp. 887.

Suleiman, N. and S. Emua. 2009. Efficacy of four plant extracts in the control of root rot disease of cowpea (*Vigna unguiculata* [L.] Walp). *African Journal of Biotechnology*, 8(16): 3806-3808.

Tariq, M. and S. Dawar. 2011. Formulation of *Avicennia marina* and its application in controlling root diseases in leguminous and non leguminous plants. *Pakistan Journal of Botany*, 43(2): 1411-1415.

Timsina, J. and D.J. Conner. 2001. Productivity and management of rice-wheat cropping system: issue and challenges. *Field crops Research*, 69:93-132.

Tiwar, S. and A. Singh. 2004. Toxic and sub-lethal effects of *oleadrin* on biochemical parameters of freshwater air breathing murrel, Chant punctatus (Bloch.). *Indian Journal of Experimental Biology*, 42: 413-418.

Wilhelm, S. 1955. Longevity of the *Verticillium* wilt fungus in the laboratory and field. *Phytopathology*, 45: 180-181.

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