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COMBINED EFFECT OF SOIL AMENDMENT WITH OIL CAKES AND SEED PRIMING IN THE CONTROL OF ROOT ROT FUNGI OF LEGUMINOUS AND NON-LEGUMINOUS CROPS

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Abstract

Organic amendments of soil help in proper aeration, rising of temperature and water holding capacity which results in better uptake of nutrients with root system gets extensive establishment. In this study, effects of soil amendment with oil seed cakes including mustard (*Brassica campestris* L.), cotton (*Gossypium hirsutum* L.), almond (*Prunus amygdalus* L.) and black seed (*Nigella sativa* L.) cakes @ 0.1 and 1% w/w and priming of seeds with *Acacia nilotica* (L.) Willd. ex Delile and *Sapindus mukorossi* (L.) leaves extracts and microbial antagonists (*Trichoderma harzianum* and *Rhizobium melilotii*) was observed on the growth of plants and in the suppression of root infecting fungi. The results obtained showed that combined effect of bio-priming of seeds with *T. harzianum* spore suspension and amendment of soil with mustard cake @ 1% was found to be most effective for the growth of leguminous and non-leguminous crop plants (peanut, chickpea, okra and sunflower) and for the reduction of root infecting fungi like *Macrophomina phaseolina*, *Fusarium* spp followed by *R. meliloti* primed seeds in combination with cotton, almond and black seed cakes amendment respectively as compared to control (non treated seeds and soil).

Key words: Seed priming, Oil seed cakes, Root infecting fungi, Leguminous and non-leguminous crops.

Introduction

Soil borne diseases cause heavy losses to most agricultural crops. Repeated planting of a crop in the same piece of land results in a high inoculums build up, which forces the farmers either to change the crop or the land. Thus, the search for new, effective, inexpensive and non hazardous methods for the control of soil borne diseases is a continuous one. Organic soil amendments are generally used for management and improving crops, increasing agricultural productivity and reducing soil borne diseases (Stone *et al*., 2003). Beside a wide variety of organic matters that have been tested as organic amendments for the management of plant pathogens are oil seed cakes which reduced the population of soil borne pathogens (Sharma *et al*., 1995). Oil seed cakes are actually the by-products which obtained after oil extraction from the various seeds. These cakes have been used for feed preparation as they are rich in proteins, vitamins, antioxidants, minerals, fibers (Sunil *et al.,* 2015). The soil amendments with oil cakes, saw dust, dead organic crop residue and green matter offer good management of the diseases caused by *M. phaseolina* (Radha, 1956; Raghuchandar *et al.,* 1998). Combined treatment with neemcake and straw mulch and seed treatment with *Trichoderma viride* gave higher grain yield as against untreated control (Desai *et al.,* 1997). Dwivedi and Chaube (1985) tested *Azadarichta indica* oil cake and found that it reduced recoverable propagules of *Macrophomina phaseolina*. The colonies decreased with increasing doses of oil cakes and duration of incubation.

Biopriming treatment is potentially prominent to induce profound changes in plant characteristics and to encourage more uniform seed germination and plants growth and also biologically protects the seeds from disesed producing organisms by using beneficial organisms (Reddy, 2013). Priming of leguminous non leguminous seeds using *Acacia nilotica* and *Sapindus nukorossi* resulted in reduction of root rot fungi and inproves yield of crops (Rafi *et al*., 2015). The present report gives an account on combined effect of oil cakes and seed priming with plant extracts and microbial antagonists in the control of root rot fungi and growth of plants.

Materials and Methods

Collection of material: Mustard (*Brassica campestris* L.), cotton (*Gossypium hirsutum* L.), almond (*Prunus amygdalus* L.) and black seed (*Nigella sativa* L.) cakes were purchased from local markets of Karachi, dried separately and ground in an electric grinder. Similarly, plant parts of *A. nilotica* and *S. mukorossi* were collected from University of Karachi campus, dried separately and ground in an electric grinder. Cultures of *Rhizobium meliloti* (Rm-5) and *Trichoderma harzianum* (Th-6) were obtained from the Karachi University Culture Collection (KUCC).

Extract preparation and spore/cell suspension: Aqueous leaves extracts of *A. nilotica* and *Sapindus mukorossi* plants were prepared by soaking the powder separately for whole night in distilled water (10 g powder and 90 mL distilled water). After which the suspension was filtered through Whatman's filter paper in order to get aqueous extracts for seed priming. Similarly, spore/cell suspensions of *T. harzianum* and *R. melilotii* were made in sterilized distilled water for priming of seeds.

Table 1. Effect of soil amendment with oil cakes and priming of seeds on growth parameters of peanut and control of root rot fungi.

Treatments	Growth parameters						Colonization %		
	Root length (cm)	Root weight (g)	Shoot length (cm)	Shoot weight (g)	Germination %	No. of nodules	*M. phaseolina*	*R. solani*	*Fusarium* spp.
Control (non treated seeds & soil)	19.8± 0.2	0.9±0.00	26.5±0.5	1.0±0.00	100±0.00	07±0.5	20±10.00	40±10	53.3±5.7
Amendment with mustard cake (.1%)	20.3± 0.6	0.9±0.00	27.1±0.1	1.0±0.00	93.3±11.5	05±0.00	20±0.00	30±10	50±10
Amendment with mustard cake (1%)	22.2±0.2	0.9±0.05	28.1±0.1	1.0±0.05	100±0.00	06±0.5	16.6±5.7	33.3±5.7	50±10
Amendment with cotton cake (.1%)	20.2±10	0.8±0.05	26.6±0.5	1.0±0.00	93.3±11.5	05±0.5	16.6±5.7	30±10	53.3±11.5
Amendment with cotton cake (1%)	21.4±0.4	0.8±0.05	26.7±0.4	1.0±0.00	100±0.00	05±0.00	20±10.00	33.3±11.5	50±10
Amendment with almond cake (.1%)	19.8±0.3	0.8±0.05	25.6±0.5	1.0±0.00	100±0.00	05±1.00	16.6±5.7	36.6±15.2	56.6±5.7
Amendment with almond cake (1%)	20±0.00	0.9±0.00	25.0±0.5	1.0±0.00	100±0.00	05±0.5	10±0.00	40±0.00	53.3±5.7
Amendment with Black seed cake (.1%)	19.4±0.4	0.8±0.05	25±0.00	0.9±0.05	100±0.00	04±0.5	20±0.00	36.6±5.7	46.6±5.7
Amendment with Black seed cake (1%)	20.1±0.1	0.8±0.00	26.0±0.05	1.0±0.00	100±0.00	05±0.00	20±10.00	36.6±5.7	50±17.3
priming with *A. n* leaves extract	22.9±0.1	0.9±0.05	29.1±0.1	1.0±0.05	100±0.00	7±0.5	23.3±5.7	33.3±5.7	53.3±5.7
priming with *S. m* leaves extract	23.0±0.1	0.9±0.00	29±0.1	1.0±0.00	100±0.00	7±0.00	16.6±0	26.6±5.7	50±11.5
priming with *T. h* spore suspension	23.1±0.2	0.9±0.05	29±0.00	1.0±0.00	100±0.00	8.3±0.5	16.6±5.7	26.6±5.7	50±11.5
priming with *R. m* cell suspension	23.0±0.00	0.9±0.00	28.9±0.05	1.0±0.00	100±0.00	8±0.00	20±0.00	30±10	43.3±15.2
A. n leaves extract & M. cake (.1%)	23.9±0.05	0.9±0.05	29.6±0.5	1.0±0.00	100±0.00	8.6±0.5	20±10	33.3±5.7	50±10
A. n leaves extract & M. cake (1%)	24.3±0.5	0.9±0.05	31.6±0.5	1.0±0.05	100±0.00	9±0.00	13.3±5.7	33.3±5.7	56.6±5.7
A. n leaves extract & C. cake (.1%)	23.3±0.5	0.9±0.05	29±0.00	1.0±0.00	100±0.00	8±0.00	20±5.7	33.3±5.7	120±10
A. n leaves extract & C. cake (1%)	24±0.00	0.9±0.00	30±0.00	1.0±0.00	100±0.00	9±0.5	20±10	30±10	56.6±5.7
A. n leaves extract & A. cake (.1%)	22.6±0.5	0.9±0.00	27.5±0.5	1.0±0.00	100±0.00	7±0.5	20±0.00	33.3±5.7	50±0.00
A. n leaves extract & A. cake (1%)	23.0±0.00	0.9±0.00	27.6±0.5	1.0±0.00	100±0.00	8±0.00	10±0.00	23.3±5.7	50±10
A. n leaves extract & BS. cake (.1%)	22.3±0.5	0.9±0.00	27±0.00	1.0±0.00	100±0.00	7±0.00	23.3±5.7	30±10	46.6±5.7
A. n leaves extract & BS. cake (1%)	23.2±0.4	0.9±0.00	28.0±0.05	1.0±0.00	100±0.00	8±0.5	13.3±5.7	40±5.7	46.6±11.5
S. m leaves extract & M. cake (.1%)	24.0±0.05	0.9±0.00	29.3 ± 0.5	1.0±0.00	100±0.00	8±0.5	20±10	50±0.00	43.3±15.2
S. m leaves extract & M. cake (1%)	25.3±0.5	0.9±0.05	31.0±0.00	1.0±0.05	100±0.00	9±0.5	16.6±5.7	40±10	43.3±5.7
S. m leaves extract & C. cake (.1%)	22.2±0.2	0.9±0.00	29.0± 0.00	1.0±0.00	100±0.00	8±0.00	30±0.00	33.3±5.7	50±10
S. m leaves extract & C. cake (1%)	23.0±0.05	0.9±0.00	30.1±0.1	1.0±0.00	100±0.00	9±0.00	20±10	30±0.00	60±0.00
S. m leaves extract & A. cake (.1%)	22±0.00	0.9±0.00	29.0 ±0.05	1.0±0.00	100±0.00	7±0.5	10±0.00	26.6±5.7	53.3±5.7
S. m leaves extract & A. cake (1%)	22.1±0.1	0.9±0.00	29.0±0.1	1.0±0.00	100±0.00	8±0.5	16.6±5.7	30±10	40±10
S. m leaves extract & BS cake (.1%)	21.1±0.1	0.9±0.00	29.0 ±0.00	1.0±0.00	100±0.00	7±0.00	26.6±5.7	30±10	46.6±5.7
S.m leaves extract & BS cake (1%)	22.3±0.5	0.9±0.00	28.3±0.5	1.0±0.00	100±0.00	8±0.00	16.6±5.7	30±10	56.6±5.7
T. h spore suspension & M. cake (.1%)	24±0.00	0.9±0.00	29.0±0.00	1.0±0.00	100±0.00	10±0.5	10±0.00	30±0.00	60±0.00
T. h spore suspension & M. cake (1%)	25.6±0.5	0.9±0.05	31.6±0.5	1.0±0.00	100±0.00	10±0.5	16.6±5.7	36.6±5.7	53.3±5.7
T. h spore suspension & C. cake (.1%)	22.1±0.2	0.9±0.00	28.7±0.5	1.0±0.00	100±0.00	9±0.00	30±0.00	43.3±5.7	40±10
T. h spore suspension & C. cake (1%)	25.2±0.4	0.9±0.00	29.3±0.5	1.0±0.00	100±0.00	10±0.00	20±0.00	33.3±5.7	46.6±5.7
T. h spore suspension & A. cake (.1%)	21.6±0.5	0.9±0.00	28.0±0.05	1.0±0.00	100±0.00	9±0.5	13.3±5.7	30±10	53.3±5.7
T. h spore suspension & A. cake(1%)	22.0±0.00	0.9±0.00	28.7±0.2	1.0±0.00	100±0.00	10±0.5	23.3±5.7	36.6±5.7	50±0.00
T. h spore suspension & BS cake (.1%)	21.6±0.5	0.9±0.00	25.7±0.6	0.9±0.05	100±0.00	10±0.5	20±0.00	36.6±5.7	46.6±5.7
T. h spore suspension & BS cake (1%)	22.0±0.05	0.9±0.00	28.0±0.00	1.0±0.00	100±0.00	10±0.00	16.6±5.7	33.3±5.7	53.3±5.7
R. m cell suspension & M.cake (.1%)	22.0±0.05	0.9±0.05	26.3±0.5	1.0±0.00	100±0.00	11±0.00	16.6±5.7	40±0.00	56.6±5.7
R. m cell suspension & M.cake (1%)	23.0±0.00	1.0±0.05	28.3±0.3	1.0±0.05	100±0.00	11±0.5	23.3±5.7	33.3±5.7	43.3±5.7
R. m cell suspension & C. cake (.1%)	22.0±0.1	0.9±0.00	26±0.00	1.0±0.00	100±0.00	10±0.5	36.6±5.7	20±0.00	46.6±5.7
R. m cell suspension & C. cake (1%)	22.4±0.2	0.9±0.00	26.9±0.05	1.0±0.00	100±0.00	10±0.00	23.3±5.7	36.6±5.7	46.6±5.7
R. m cell suspension & A .cake (.1%)	21.0±0.05	0.8±0.05	25.9±0.1	0.9±0.05	100±0.00	10±0.5	16.6±5.7	33.3±5.7	50±0.00
R. m cell suspension & A .cake (1%)	22.0±0.05	0.8±0.05	26.0±0.00	1.0±0.00	100±0.00	9±1.10	10±0.00	46.6±5.7	53.3±5.7
R. m cell suspension & BS cake (.1%)	21.1±0.1	0.9±0.00	25.1±0.2	1.0±0.00	100±0.00	10±1.00	23.3±5.7	30±10	43.3±5.7
R. m cell suspension & BS cake (1%)	22.2±0.2	0.9±0.00	26.0±0.05	1.0±0.00	100±0.00	10±0.5	26.6±5.7	36.6±5.7	56.6±5.7
$LSD_{0.05}$	2.56	0.42	0.61	0.03	3.9	0.82	9.42	11.7	13.2

A.n = Acacia nilotica; S.m = Sapindus mukorossi; T.h = Trichoderma harzianum; R.m = Rhizobium meliloti; M. cake = mustard; C. cake = cotton; A cake = almond; BS. = black seed

Table 2. Effect of soil amendment with oil cakes and priming of seeds on growth parameters of chickpea and control of root rot fungi.

Treatments	Growth parameters						Colonization %		
	Root length (cm)	Root weight (g)	Shoot length (cm)	Shoot weight (g)	Germination %	No. of nodules	*M. phaseolina*	*R. solani*	*Fusarium* spp.
Control (non treated seeds & soil)	18.2±0.2	0.7±0.05	27.9±0.1	0.9±0.05	100±0	8±0.5	40±0.00	33.3±5.7	50±10
Amendment with mustard cake (.1%)	18.2±0.3	0.8±0.00	28.5±0.4	1.0±0.00	93.3±11.5	9±0.5	36.6±5.7	30±10	56.6±5.7
Amendment with mustard cake (1%)	18.9±0.05	0.9±0.00	28.3±0.5	1.0±0.00	100±0.00	9±0.5	40±10.7	40±0.00	50±10
Amendment with cotton cake (.1%)	18.1±0.1	0.8±0.05	28±0.00	1.0±0.00	100±0.00	9±0.00	43.3±5.7	26.6±5.7	40±0.00
Amendment with cotton cake (1%)	18.8±0.3	0.8±0.05	28.3±0.5	1.0±0.00	100±0.00	10±0.5	46.6±5.7	33.3±5.7	50±0.00
Amendment with almond cake (.1%)	17.6±0.5	0.8±0.00	27.6±0.5	1.0±0.00	93.3±11.5	9±0.5	23.3±5.7	20±0.00	46.6±5.7
Amendment with almond cake (1%)	18±0.00	0.8±0.05	27.6±1.5	0.9±0.05	100±0.00	9±0.5	46.6±5.7	46.6±5.7	53.3±5.7
Amendment with Black seed cake (.1%)	17.4±0.4	0.7±0.05	27±1.00	0.9±0.05	100±0.00	8±0.00	36.6±5.7	23.3±5.7	56.6±5.7
Amendment with Black seed cake (1%)	17.8±0.2	0.8±0.00	27.4±0.4	1.0±0.00	100±0.00	9±0.5	43.3±5.7	26.6±5.7	46.6±5.7
priming with *A. n* leaves extract	18.9±0.1	0.9±0.00	29±0.00	1.0±0.00	100±0.00	9±0.5	30±10	23.3±5.7	33.3±11.5
priming with *S. m* leaves extract	18.4±0.5	0.9±0.00	28.8±0.1	1.0±0.00	100±0.00	10±0.5	30±0.00	26.6±5.7	33.3±5.7
priming with *T. h* spore suspension	19±0.00	0.9±0.00	28.6±0.5	1.0±0.00	100±0.00	10±0.5	36.6±5.7	23.3±5.7	50±10
priming with *R. m* cell suspension	18.9±0.05	0.9±0.00	28.7±0.6	1.0±0.00	100±0.00	11±0.5	43.3±5.7	20±0.00	36.6±5.7
A. n leaves extract & M. cake (.1%)	18.4±0.2	0.9±0.00	28±0.00	1.0±0.00	93.3±11.5	11±0.00	43.3±5.7	26.6±5.7	46.6±5.7
A. n leaves extract & M. cake (1%)	18.6±0.5	0.9±0.00	28.7±0.6	1.0±0.00	100±0.00	11±0.5	30±15.2	23.3±5.7	50±0.00
A. n leaves extract & C. cake (.1%)	17.9±0.05	0.9±0.00	27±0.00	0.9±0.05	100±0.00	9±0.5	40±0.00	23.3±5.7	50±10
A. n leaves extract & C. cake (1%)	18.0±0.1	0.9±0.00	28.1±0.1	1.0±0.00	100±0.00	10±0.00	40±10	26.6±5.7	50±0.00
A. n leaves extract & A. cake (.1%)	18.6±0.5	0.9±0.00	28.0±0.00	1.0±0.00	100±0.00	11±0.5	46.6±5.7	33.3±5.7	46.6±11.5
A. n leaves extract & A. cake (1%)	19.1±0.1	0.9±0.00	28.0±0.1	1.0±0.00	100±0.00	10±0.00	43.3±5.7	33.3±11.5	53.3±5.7
A. n leaves extract & BS. cake (.1%)	18±0.00	0.9±0.00	28.0±0.05	1.0±0.00	100±0.00	9±0.5	36.6±5.7	20±0.00	43.3±5.7
A. n leaves extract & BS. cake (1%)	19.0±0.1	0.9±0.00	28.1±0.2	1.0±0.00	100±0.00	9±0.5	30±0.00	30±10	46.6±11.5
S. m leaves extract & M. cake (.1%)	19±0.00	0.9±0.00	28.6±0.2	1.0±0.00	100±0.00	9±0.00	36.6±5.7	30±0.00	43.3±15.2
S. m leaves extract & M. cake (1%)	19.1±0.1	0.9±0.00	28.3±0.5	1.0±0.00	100±0.00	10±0.5	40±0.00	26.6±5.7	40±0.00
S. m leaves extract & C. cake (.1%)	18.3±0.5	0.8±0.05	27.3±0.3	1.0±0.00	100±0.00	9±0.5	43.3±5.7	26.6±11.5	33.3±5.7
S. m leaves extract & C. cake (1%)	19.1±0.1	0.9±0.00	28.0±0.05	1.0±0.00	100±0.00	10±0.00	43.3±5.7	26.6±11.5	43.3±15.2
S. m leaves extract & A. cake (.1%)	18.4±0.4	0.9±0.00	28±0.2	1.0±0.00	100±0.00	9±1.00	43.3±5.7	26.6±5.7	53.3±11.5
S. m leaves extract & A. cake (1%)	18.7±0.4	0.8±0.05	28.3±0.5	0.9±0.05	100±0.00	10±0.5	46.6±5.7	40±0.00	50±10
S. m leaves extract & BS cake (.1%)	18.2±0.05	0.8±0.05	29±0.00	1.0±0.00	100±0.00	9±0.5	36.6±5.7	40±0.00	53.3±5.7
S.m leaves extract & BS cake (1%)	19.5±0.1	0.9±0.00	29±0.05	1.0±0.00	100±0.00	11±0.5	36.6±5.7	30±17.3	60±0.00
T. h spore suspension & M. cake (.1%)	19.0±0.05	0.9±0.05	28±0.05	0.9±0.05	100±0.00	11±0.5	36.6±5.7	23.3±5.7	46.6±.7
T. h spore suspension & M. cake (1%)	19.0±0.1	0.9±0.00	28.3±0.5	1.0±0.00	100±0.00	12±0.5	36.6±5.7	26.6±11.5	43.3±5.7
T. h spore suspension & C. cake (.1%)	19±0.00	0.9±0.00	29±0.00	1.0±0.00	100±0.00	10±0.00	33.3±5.7	26.6±5.7	40±0.00
T. h spore suspension & C. cake (1%)	19.0±0.05	0.9±0.00	29.0±0.05	1.0±0.00	100±0.00	10±0.5	43.3±5.7	23.3±5.7	53.3±11.5
T. h spore suspension & A. cake (.1%)	18.8±0.2	0.9±0.00	28.1±0.1	1.0±0.00	100±0.00	10±0.00	33.3±5.7	20±10	50±10
T. h spore suspension & A. cake(1%)	18.9±0.05	0.9±0.00	28.9±0.1	1.0±0.00	100±0.00	12±0.5	40±0.00	33.3±11.5	40±10
T. h spore suspension & BS cake (.1%)	18.6±0.5	0.9±0.00	28.3±0.4	1.0±0.00	100±0.00	11±0.00	33.3±5.7	30±17.3	50±10
T. h spore suspension & BS cake (1%)	19.1±0.1	0.9±0.00	28.0±0.1	1.0±0.00	100±0.00	12±0.5	36.6±5.7	33.3±5.7	46.6±5.7
R. m cell suspension & M.cake (.1%)	19.1±0.1	0.9±0.00	28.5±0.5	1.0±0.00	100±0.00	12±0.00	26.6±5.7	20±17.3	50±0.00
R. m cell suspension & M.cake (1%)	19.2±0.2	0.9±0.00	29±0.00	1.0±1.00	100±0.00	12±0.5	46.6±5.7	30±10	30±26.4
R. m cell suspension & C. cake (.1%)	18.3±0.5	0.9±0.00	28.9±0.1	1.0±1.00	100±0.00	10±0.5	36.6±5.7	30±0.00	40±0.00
R. m cell suspension & C. cake (1%)	19.1±0.1	0.9±0.00	28.6±0.5	1.0±1.00	100±0.00	10±0.00	40±10	23.3±5.7	33.3±11.5
R. m cell suspension & A .cake (.1%)	19.0±0.1	0.9±0.00	28.2±0.4	1.0±1.00	100±0.00	10±0.5	36.6±5.7	23.3±5.7	56.6±5.7
R. m cell suspension & A .cake (1%)	19.0±0.05	0.9±0.00	28±0.00	1.0±1.00	100±0.00	9±1.00	40±0.00	33.3±5.7	46.6±5.7
R. m cell suspension & BS cake (.1%)	18.6±0.5	0.9±0.00	28.9±0.1	1.0±1.00	100±0.00	8±0.00	33.3±5.7	33.3±11.5	50±17.3
R. m cell suspension & BS cake (1%)	19.0±0.05	0.9±0.00	28.3±0.5	1.0±1.00	100±0.00	9±0.00	43.3±5.7	20±0.00	46.6±5.7
$LSD_{0.05}$	0.47	0.04	0.71	0.03	4.83	0.83	12.0	12.9	14.3

A.n = Acacia nilotica; *S.m = Sapindus mukorossi; T.h = Trichoderma harzianum; R.m = Rhizobium meliloti;* M. cake = mustard; C. cake = cotton; A cake = almond; BS. = black seed

Table 3. Effect of soil amendment with oil cakes and bio-priming of seeds on growth parameters of okra and control of root rot fungi.

Treatments	Growth parameters					Colonization %		
	Root length (cm)	Root weight (g)	Shoot length (cm)	Shoot weight (g)	Germination %	*M. phaseolina*	*R. solani*	*Fusarium.* spp
Control (non treated seeds & soil)	4.9±0.2	0.5±0.00	10.9±0.4	0.8±0.1	66.6±11.5	23.3±5.7	26.6±5.7	40±0.00
Amendment with mustard cake (.1%)	5.2±0.2	0.5±0.00	11.7±0.1	0.9±0.00	80±0.00	20±0.00	30±10	46.6±5.7
Amendment with mustard cake (1%)	5.5±0.3	0.5±0.00	12±0.1	0.9±0.00	80±0.00	33.3±5.7	30±0.00	33.3±11.5
Amendment with cotton cake (.1%)	5.1±0.4	0.5±0.00	11.0±0.1	0.9±0.00	73.3±0.00	30±10	20±0.00	50±0.00
Amendment with cotton cake (1%)	5.2±0.1	0.5±0.00	11.2±0.2	0.9±0.00	80±0.00	26.6±5.7	26.6±5.7	43.3±10
Amendment with almond cake (.1%)	4.9±0.1	0.4±0.05	10.8±0.2	0.8±0.05	73.3±11.5	33.3±11.5	30±10	43.3±5.7
Amendment with almond cake (1%)	5.4±0.2	0.5±0.00	11.2±0.3	0.9±0.00	80±0.00	36.6±5.7	26.6±11.5	56.6±5.7
Amendment with Black seed cake (.1%)	5.1±0.3	0.5±0.00	10.9±0.05	0.8±0.05	73.3±11.5	23.3±5.7	20±0.00	60±0.00
Amendment with Black seed cake (1%)	4.6±0.3	0.5±0.00	10.9±0.1	0.8±0.00	66.6±11.5	30±10	26.6±11.5	43.3±5.7
priming with *A. n* leaves extract	5.4±0.2	0.5±0.00	11.6±0.5	0.9±0.00	86.6±11.5	26.6±5.7	20±0.00	33.3±23.0
priming with *S. m* leaves extract	5.4±0.4	0.5±0.00	11.5±0.4	0.9±0.00	80±0.00	30±0.00	20±10	40±0.00
priming with *T. h* spore suspension	5.4±0.1	0.5±0.00	11.7±0.6	0.9±0.00	86.6±11.5	53.3±5.7	50±0.00	56.6±5.7
priming with *R. m* cell suspension	5.1±0.2	0.5±0.00	12±0.00	0.9±0.00	86.6±11.5	30±10	20±0.00	40±0.00
A. n leaves extract & M. cake (.1%)	5.7±0.1	0.5±0.05	12.5±0.4	0.9±0.00	86.6±11.5	30±5.7	23.3±5.7	46.6±5.7
A. n leaves extract & M. cake (1%)	5.8±0.05	0.5±0.05	13±0.1	0.9±0.00	93.3±11.5	40±0.00	26.6±11.5	46.6±11.5
A. n leaves extract & C. cake (.1%)	5.2±0.2	0.5±0.00	11.8±0.3	0.9±0.00	80±0.00	33.3±5.7	16.6±5.7	46.6±5.7
A. n leaves extract & C. cake (1%)	5.6±0.2	0.5±0.00	11.3±0.5	0.9±0.00	86.6±11.5	40±0.00	23.3±5.7	50±10
A. n leaves extract & A. cake (.1%)	5.1±0.2	0.5±0.00	11.7±0.6	0.9±0.00	86.6±11.5	33.3±5.7	20±0.00	40±0.00
A. n leaves extract & A. cake (1%)	5.2±0.1	0.5±5.1	12.1±0.1	0.9±0.00	86.6±11.5	36.6±5.7	23.3±5.7	46.6±5.7
A. n leaves extract & BS. cake (.1%)	4.9±0.05	0.5±0.00	11.9±0.05	0.8±0.05	86.6±11.5	20±0.00	16.6±5.7	40±0.00
A. n leaves extract & BS. cake (1%)	5.2±0.3	0.5±0.00	12.3±0.1	0.9±0.00	93.3±11.5	33.3±11.5	16.6±11.5	50±0.00
S. m leaves extract & M. cake (.1%)	5.6±0.4	0.5±0.05	12.3±0.2	0.9±0.00	93.3±11.5	36.6±15.2	26.6±5.7	43.3±5.7
S. m leaves extract & M. cake (1%)	5.8±0.1	0.5±0.05	12.9±0.1	0.9±0.00	93.3±11.5	30±10	23.3±5.7	53.3±11.5
S. m leaves extract & C. cake (.1%)	4.9±0.1	0.5±0.00	11.9±0.05	0.9±0.00	86.6±11.5	40±0.00	23.3±5.7	50±10
S. m leaves extract & C. cake (1%)	5.8±0.1	0.5±0.05	12.5±0.4	0.9±0.00	86.6±11.5	36.6±5.7	20±0.00	43.3±5.7
S. m leaves extract & A. cake (.1%)	4.9±0.1	0.5±0.00	12.2±0.4	0.9±0.00	80±0.00	33.3±5.7	26.6±11.5	43.3±5.7
S. m leaves extract & A. cake (1%)	5.2±0.2	0.5±0.00	12.6±0.2	0.9±0.00	86.6±11.5	36.6±5.7	33.3±11.5	46.6±5.7
S. m leaves extract & BS cake (.1%)	4.8±0.2	0.5±0.00	11.9±0.05	0.9±0.00	80±0.00	30±0.00	16.6±5.7	46.6±11.5
S.m leaves extract & BS cake (1%)	5±0.00	0.5±0.00	11.7±0.1	0.9±0.00	73.3±11.5	46.6±5.7	23.3±5.7	46.6±5.7
T. h spore suspension & M. cake (.1%)	5.5±0.3	0.5±0.00	12.0±0.1	0.9±0.00	86.6±11.5	20±0.00	30±10	56.6±5.7
T. h spore suspension & M. cake (1%)	5.8±0.1	0.5±0.05	12.3±0.4	0.9±0.00	93.3±11.5	40±0.00	20±0.00	50±0.00
T. h spore suspension & C. cake (.1%)	4.5±0.4	0.5±0.00	12.0±0.05	0.9±0.00	86.6±11.5	36.6±5.7	13.3±5.7	53.3±5.7
T. h spore suspension & C. cake (1%)	5.0±0.1	0.5±0.00	12.1±0.4	0.9±0.00	86.6±11.5	36.6±5.7	20±0.00	46.6±5.7
T. h spore suspension & A. cake (.1%)	5.0±0.05	0.5±0.00	12.0±0.05	0.9±0.00	80±0.00	23.3±5.7	13.3±5.7	56.6±5.7
T. h spore suspension & A. cake(1%)	5.2±0.3	0.5±0.05	12.1±0.3	0.9±0.00	86.6±11.5	40±0.00	26.6±5.7	43.3±5.7
T. h spore suspension & BS cake (.1%)	5±0.00	0.5±0.00	11.8±0.2	0.9±0.00	80±0.00	26.6±5.7	16.6±5.7	50±0.00
T. h spore suspension & BS cake (1%)	5.3±0.3	0.5±0.05	12.1±0.2	0.9±0.00	80±0.00	33.3±11.5	30±10	50±10
R. m cell suspension & M.cake (.1%)	5.5±0.4	0.5±0.05	12.4±0.4	0.9±0.00	86.6±11.5	30±10	23.3±5.7	53.3±11.5
R. m cell suspension & M.cake (1%)	5.7±0.1	0.5±0.05	12.8±0.1	0.9±0.00	93.3±11.5	36.6±5.7	16.6±11.5	50±0.00
R. m cell suspension & C. cake (.1%)	5.1±0.1	0.5±0.00	11.9±0.1	0.9±0.00	80±0.00	30±0.00	13.3±5.7	43.3±5.7
R. m cell suspension & C. cake (1%)	5.1±0.2	0.5±0.00	11.9±0.1	0.9±0.00	80±0.00	36.6±15.2	13.3±5.7	46.6±5.7
R. m cell suspension & A .cake (.1%)	4.9±0.05	0.5±0.00	11.4±0.4	0.9±0.00	80±0.00	33.3±11.5	20±0.00	40±0.00
R. m cell suspension & A .cake (1%)	5.0±0.00	0.5±0.00	12.1±0.2	0.9±0.00	80±0.00	36.6±5.7	13.3±5.7	53.3±5.7
R. m cell suspension & BS cake (.1%)	5.0±0.1	0.5±0.00	12±0.2.00	0.9±0.00	80±0.00	33.3±5.7	16.6±5.7	46.6±5.7
R. m cell suspension & BS cake (1%)	5.31±0.2	0.5±0.00	11.9±0.05	0.9±0.00	86.6±11.5	40±0.00	16.6±5.7	43.3±5.7
$LSD_{0.05}$	0.39	1.25	0.48	0.03	14.6	11.5	10.9	11.39

A.n = Acacia nilotica; *S.m = Sapindus mukorossi; T.h = Trichoderma harzianum; R.m = Rhizobium meliloti;* M. cake = mustard; C. cake = cotton; A cake = almond; BS. = black seed

Table 4. Effect of soil amendment with oil cakes and priming of seeds on growth parameters of sunflower and control of root rot fungi.

Treatments	Growth parameters					Colonization %		
	Root length (cm)	Root weight (g)	Shoot length (cm)	Shoot weight (g)	Germination %	*M. phaseolina*	*R. solani*	*Fusarium* spp.
Control (non treated seeds & soil)	8.0±0.05	0.4±0.00	20.4±0.6	0.8±0.00	100±0.00	23.3±5.7	26.6±5.7	43.3±5.7
Amendment with mustard cake (.1%)	8.2±0.1	0.4±0.00	21.7±0.4	0.8±0.00	100±0.00	26.6±5.7	16.6±5.7	43.3±5.7
Amendment with mustard cake (1%)	8.5±0.4	0.4±0.05	23.2±0.2	0.9±0.00	100±0.00	26.6±11.5	23.3±5.7	43.3±5.7
Amendment with cotton cake (.1%)	8.1±0.1	0.4±0.00	22.2±0.2	0.8±0.00	100±0.00	30±0.00	26.6±5.7	40±0.00
Amendment with cotton cake (1%)	8.2±0.4	0.4±0.00	22.5±0.5	0.8±0.05	100±0.00	26.6±11.5	16.6±5.7	46.6±5.7
Amendment with almond cake (.1%)	8.0±0.05	0.4±0.00	22.4±0.2	0.8±0.00	93.3±11.5	36.6±5.7	10±0.00	46.6±5.7
Amendment with almond cake (1%)	8.2±0.05	0.4±0.00	22.3±0.3	0.8±0.00	100±0.00	33.3±11.5	20±0.00	43.3±5.7
Amendment with Black seed cake (.1%)	8±0.00	0.4±0.00	22.3±0.3	0.8±0.00	93.3±11.5	30±0.00	13.3±5.7	40±0.00
Amendment with Black seed cake (1%)	8.3±0.1	0.4±0.00	22±0.00	0.8±0.00	93.3±11.5	30±10	13.3±5.7	50±10
priming with *A. n* leaves extract	8.6±0.2	0.4±0.05	23.3±0.2	0.9±0.00	100±0.00	40±0.00	26.6±5.7	50±0.00
priming with *S. m* leaves extract	8.4±0.2	0.4±0.00	22.4±0.4	0.8±0.00	100±0.00	23.3±11.5	13.3±5.7	46.6±5.7
priming with *T. h* spore suspension	8.3±0.4	0.4±0.05	22.8±0.1	0.8±0.05	100±0.00	26.6±5.7	13.3±5.7	53.3±5.7
priming with *R. m* cell suspension	8.1±0.2	0.4±0.00	22.2±0.3	0.8±0.00	100±0.00	16.6±5.7	13.3±5.7	56.6±5.7
A. n leaves extract & M. cake (.1%)	8.5±0.1	0.4±0.00	23.6±0.4	0.9±0.00	100±0.00	33.3±11.5	20±17.3	46.6±5.7
A. n leaves extract & M. cake (1%)	8.7±0.1	0.4±0.05	24.1±0.1	0.9±0.00	100±0.00	36.6±5.7	26.6±5.7	50±0.00
A. n leaves extract & C. cake (.1%)	8.2±0.2	0.4±0.00	22.3±-0.3	0.8±0.00	100±0.00	36.6±5.7	16.6±5.7	43.3±5.7
A. n leaves extract & C. cake (1%)	8.6±0.2	0.4±0.00	22.6±0.4	0.8±0.05	100±0.00	40±0.00	23.3±5.7	46.6±5.7
A. n leaves extract & A. cake (.1%)	8±0.00	0.4±0.00	22.0±0.05	0.8±0.00	100±0.00	30±10	20±0.00	40±0.00
A. n leaves extract & A. cake (1%)	8.6±0.2	0.4±0.05	22.6±0.3	0.8±0.05	100±0.00	36.6±15.2	23.3±5.7	46.6±11.5
A. n leaves extract & BS. cake (.1%)	8.1±0.2	0.4±0.00	23.2±0.3	0.8±0.05	100±0.00	33.3±5.7	33.3±11.5	53.3±5.7
A. n leaves extract & BS. cake (1%)	8.2±0.2	0.4±0.00	22.4±0.4	0.8±0.00	100±0.00	33.3±11.5	16.6±5.7	50±10
S. m leaves extract & M. cake (.1%)	8.6±0.3	0.4±0.05	23±0.00	0.8±0.05	100±0.00	36.6±15.2	30±0.00	43.3±5.7
S. m leaves extract & M. cake (1%)	8.7±0.1	0.4±0.05	23.2±0.3	0.8±0.05	100±0.00	33.3±11.5	23.3±5.7	43.3±5.7
S. m leaves extract & C. cake (.1%)	8.0±0.1	0.3±0.05	22.0±0.05	0.8±0.00	100±0.00	33.3±5.7	23.3±5.7	46.6±11.5
S. m leaves extract & C. cake (1%)	8.3±0.2	0.4±0.05	22.1±0.2	0.8±0.00	100±0.00	30±0.00	13.3±5.7	53.3±5.7
S. m leaves extract & A. cake (.1%)	8±0.00	0.4±0.00	22.0±0.05	0.8±0.00	100±0.00	36.6±5.7	20±0.00	43.3±5.7
S. m leaves extract & A. cake (1%)	8.4±0.2	0.4±0.05	22±0.00	0.8±0.00	100±0.00	36.6±5.7	26.6±11.5	40±0.00
S. m leaves extract & BS cake (.1%)	8.1±0.1	0.4±0.05	22.1±0.2	0.8±0.00	100±0.00	33.3±5.7	16.6±5.7	53.3±5.7
S.m leaves extract & BS cake (1%)	8.4±0.4	0.5±0.00	22.4±0.5	0.8±0.05	100±0.00	30±0.00	13.3±5.7	43.3±5.7
T. h spore suspension & M. cake (.1%)	8.6±0.2	0.5±0.00	23.4±0.1	0.9±0.00	100±0.00	40±0.00	16.6±5.7	40±0.00
T. h spore suspension & M. cake (1%)	8.8±0.1	0.5±0.00	23.8±0.2	0.9±0.00	100±0.00	36.6±5.7	13.3±5.7	50±0.00
T. h spore suspension & C. cake (.1%)	8.1±0.2	0.4±0.00	22.3±0.3	0.8±0.00	100±0.00	40±0.00	23.3±5.7	50±10
T. h spore suspension & C. cake (1%)	8.5±0.3	0.4±0.00	23.2±0.3	0.9±0.00	100±0.00	33.3±11.5	16.6±5.7	50±0.00
T. h spore suspension & A. cake (.1%)	8±0.00	0.4±0.00	22.0±0.05	0.8±0.00	100±0.00	36.6±5.7	13.3±5.7	53.3±11.5
T. h spore suspension & A. cake(1%)	8.3±0.2	0.4±0.05	22.7±0.2	0.8±0.05	100±0.00	30±0.00	10±0.00	40±0.00
T. h spore suspension & BS cake (.1%)	8.0±0.05	0.4±0.00	22±0.00	0.8±0.00	100±0.00	36.6±5.7	20±0.00	43.3±5.7
T. h spore suspension & BS cake (1%)	8.1±0.2	0.4±0.00	22.4±0.5	0.8±0.05	100±0.00	43.3±5.7	16.6±5.7	46.6±5.7
R. m cell suspension & M.cake (.1%)	8.4±0.1	0.4±0.05	23±0.00	0.9±0.00	100±0.00	40±0.00	16.6±5.7	43.3±5.7
R. m cell suspension & M.cake (1%)	8.6±0.2	0.4±0.00	23.7±0.3	0.9±0.00	100±0.00	36.6±5.7	13.3±5.7	53.3±5.7
R. m cell suspension & C. cake (.1%)	8±0	0.4±0.00	22.1±0.2	0.8±0.00	100±0.00	33.3±11.5	26.6±5.7	50±0.00
R. m cell suspension & C. cake (1%)	8.0±0.05	0.4±0.00	22.5±0.1	0.8±0.00	100±0.00	33.3±5.7	13.3±5.7	40±0.00
R. m cell suspension & A .cake (.1%)	8.1±0.1	0.4±0.00	22.0±0.1	0.8±0.00	100±0.00	40±0.00	23.3±5.7	46.6±5.7
R. m cell suspension & A .cake (1%)	8.1±0.1	0.4±0.00	22.9±0.1	0.8±0.05	100±0.00	26.6±5.7	16.6±5.7	50±0.00
R. m cell suspension & BS cake (.1%)	8.1±0.05	0.4±0.00	22.4±0.4	0.8±0.00	100±0.00	36.6±5.7	20±0.00	46.6±5.7
R. m cell suspension & BS cake (1%)	8.1±0.1	0.4±0.00	22.8±0.4	0.8±0.05	100±0.00	33.3±11.5	10±0.00	56.6±5.7
$LSD_{0.05}$	0.33	0.05	0.49	0.04	4.83	12.3	9.77	9.47

A.n = Acacia nilotica; *S.m = Sapindus mukorossi; T.h = Trichoderma harzianum; R.m = Rhizobium meliloti;* M. cake = mustard; C. cake = cotton; A cake = almond; BS. = black seed

Soil used: Soil used was obtained from experimental plot of Department of Botany, University of Karachi. The sandy loam soil containing (sand, silt, clay, 70, 11 and 10%), pH ranged from 7.1-9.65 with moisture holding capacity (MHC) of 49% (Keen & Raczkowski, 1922), total nitrogen 0.077-0.099% (Mackenzie & Wallace, 1954), 3-7 sclerotia/g of *M. phaseolina* g^{-1} as found by wet sieving technique (Sheikh & Ghaffar, 1975), 5-20% of *R. solani* on sorghum seeds used as baits (Wilhelm, 1955) and *Fusarium* spp., 2000 cfu g^{-1} as assessed by soil dilution technique (Nash & Synder, 1962).

Soil amendment: Mustard, cotton, almond and black seed cakes were amended seprately in the soil @ 0.1 and 1 % w/w and let them to decompose for about one week by maintaining moisture content under green house conditions.

Seed priming: Peanut (*Arachis hypogaea* L.), chickpea (*Cicer arietenum* L.), sunflower (*Helianthus annus* L.) and okra (*Abelmoschus esculentus* L.) seeds were primed with leaves extracts of *A. nilotica* and *S. mukorossi* for 10 minutes and non-primed seeds were used as control. Five seeds were sown in 8 cm diam., plastic pot and each containing 300g soil and watered regularly to maintained sufficient moisture required for the growth of plants. The pots were kept under screen house in randomized complete block design with three replicates per treatment. Pots containing un-treated seeds were also kept under screen house which served as control. Germination and growth parameters like shoot length, root length, shoot weight and root weight were observed. Number of nodules and colonization percentage were recorded after 30 days of seed germination.

Determination of root infecting fungi: To determine the incidence of root rot fungi, one cm long root pieces of leguminous and non-leguminous plants after washing in running tap water were surface sterilized with 1% $Ca(OCl)_2$ and transferred on PDA (Potato dextrose agar) containing plates supplemented with Penicillin @ 200 mg and streptomycin @ 200 mg/litre (5 root pieces per plate). Petri dishes were incubated at room temperature for 5 to 7 days and colonization of roots by root infecting fungi was recorded after incubation period.

Statistical analysis: Data were subjected to analysis of variance (ANOVA) followed by the least significant difference (LSD) test at P = 0.05 and Duncan's multiple range test to compare treatment means, using statistica software according to Sokal & Rohlf (1995).

Results

Significant increment in growth parameters of peanut, chickpea, okra and sunflower was recorded when soil was amended with mustard, cotton, almond and black seed cakes @ 0.1 and 1% w/w and seeds were primed with *A. nilotica* and *S. mukorossi* plant parts extracts and *Trichoderma harzianum* (173 x 10^5 conidia/mL) and *Rhizobium meliloti* (144 x 10^7 cells/mL). Also, root infecting fungi like *Macrophomina phaseolina*, *Rhizoctonia solani* and *Fusarium* spp were significantly controlled. In peanut and chickpea significant increase ($p<0.001$) in root length, root weight, shoot length and number of nodules were observed when soil was amended with mustard cake @ 1% (Tables 1 & 2). Shoot weight of peanut was significantly increased ($p<0.01$) when soil was amended with mustard cake @ 1% (Table 1). Priming of seeds with *T. harzianum* spore suspension significantly enhanced ($p<0.001$) the growth parameters of peanut like root length and shoot length whereas combined effect of priming with *T. harzianum* spore suspension and soil amendment with mustard cake @ 1% showed significant increase ($p<0.001$) in growth parameters of peanut and significant reduction ($p<0.001$) in root infecting fungi like *M. phaseolina* and *R. solani* ($p<0.01$) (Table 1). In chickpea, root infecting fungi like *Fusarium* spp. ($p<0.01$), *R. solani* ($p<0.5$) and *M. phaseolina* ($p<0.5$) significantly reduced when seeds were primied with *T. harzianum* spore suspension. Combined effect of primed seeds with *A. nilotica, S. mukorossi* leaves extract and *T. harzianum* spore suspension and amendment of soil with mustard cake and cotton cake @ 1% showed significant increase ($p<0.001$) in growth parameters of okra like root length, shoot length and shoot weight and highest reduction ($p<0.001$) in root rot fungi like *M. phaseolina*, *R. solani* and *Fusarium* spp was also observed (Table 3). In sunflower, combined effect of seed priming with *T. harzianum* spore suspension and soil amendment with mustard cake @ 1 % was found to be most significant for growth parameters like root length, root weight, shoot length and shoot weight and root infecting fungi like *M. phaseolina* and *R. solani* were also significantly ($p<0.001$) reduced (Table 4). Of the all experimental results, it was found that combined effect of priming of seeds with *T. harzianum* spore suspension and amendment of soil with mustard cake @ 1% was found to be most effective for growth and control of root rot fungi on leguminous and non-leguminous crops (peanut, chickpea, okra and sunflower) followed by *R. meliloti* primed seeds in combination with cotton, almond and black seed cakes amendment respectively as compared to control treatment (non treated seeds and soil).

Discussion

In the present study, significant enhancement in growth parameters and significant reduction of root infecting fungi on leguminous and non-leguminous crops was recorded when soil was amended with different oil cakes and seeds were primed with plant parts extracts and microbial antagonists. Sultana & Ghaffar (2010) found that amendment of soil with oil cakes had significant effect on seed germination, seedling mortality and plant size of bottle gourd, bitter gourd and cucumber. Maximum seed germination (94-96%) and minimum seedling mortality (4.3-6%) of cucumber and maximum germination (93%), plant size (26.6 cms) and minimum

seedling mortality (2.3%) in bitter gourd were recorded when soil was amended with mustard cake. Ikram & Dawar (2014) suggested that *Pseudomonas aeruginosa* and *Trichoderma harzianum* in combination with soil amendment with *Prosopis juliflora* plant parts at 1% w/w were the most effective for the control of root-rot fungi of leguminous plants. Ehteshamul-Haque *et al*. (1995) observed that amendment of soils with oil cakes like cotton cake and neem cake showed significant results in the control of root infecting fungi viz., *F. solani*, *M. phaseolina* and *R. solani*. Similarly Ehteshamul-Haque *et al*. (1998) used neem cake, cotton cake and seaweeds *Stoechospermum marginatum* which showed promising results in the control of root infecting fungi on sunflower. Tariq *et al*. (2006); Tariq & Dawar, 2015 used plant parts powder of mangroves as soil amendment in the control of root pathogens of okra, mungbean and mash bean and observed that germination of seeds, shoot length, root length, shoot weight and root weight were significantly increased. According to Ramarao & Raja (1983) oil cakes have been found to be most effective against the growth of *Sclerotium rolfsii*. El-Mougy and Abdel-Kader (2008) reported that priming of faba bean seeds showed a highly significant effect causing complete suppression of root rot incidence at both pre and post-emergence stages of plant growth compared with the control treatment. Similarly, Harris *et al*. (2008), stated that priming of wheat seeds with 0.3% Zn significantly enhanced the mean shoot dry mass. The present observation clearly suggested that combined effect of primed seeds and amendment of soil with mustard cake @ 1% found to be most effective for the suppression of root infecting fungi and better growth and highest yield of leguminous and non leguminous crops.

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