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Efficacy of Wild Plant Parts in Combination with UV Irradiation in the Control of Root Rot Fungi

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Abstract

The present study was carried out to investigate the efficacy of *Prosopis juliflora* and *Aerva javanica* in combination with UV radiation. Soil was amended with *P. juliflora* and *A. javanica* stem, leaves, and flower powder at 1 % w/w, and the seeds of cowpea (*Vigna unguiculata* L.) and mung bean (*Vigna radiata* L.) was treated with ultraviolet (UV-C) radiation for 15 and 30 min to promote growth and for the control of root infecting fungi like *Macrophomina phaseolina* (Tassi) Goid, *Fusarium* spp. and *Rhizoctonia solani* Kühn. Colonization percentages of root rot fungi were completely suppressed when seeds were treated with ultra violet (UV-C) radiation for 30 min and the soil was amended with *P. juliflora* and *A. javanica* leaf powder at 1 % w/w. There was significant enhancement in the growth parameters of both crop plants when seeds were treated with UV rays for 30 min and the soil was amended with *P. juliflora* and *A. javanica* leaves powder.

Keywords: UV rays, *P. juliflora*, *A. javanica*, root rot fungi

Introduction

Ultraviolet (UV) irradiation is one of the presently available non-fungicidal strategies used to control fungal diseases [1,2]. UV radiations are electromagnetic in nature and range between 10 - 400 nm with 3 to 124 eV energies. UV rays are divided into 3 different wavelength bands: long wave UV-A (400 - 315 nm), medium UV-B (315 - 280 nm), and short UV-C (< 280 nm) [3]. UV rays have their place in our ecosystem. UV rays are necessary for our body to produce vitamin D, a substance that helps strengthen bones and safeguards against different diseases. UV has positive applications in the fields of disinfection and sterilisation. UV can effectively kill microorganisms such as viruses and bacteria [4]. UV radiations play a considerable role in the pasteurization of juices, post lethality treatment for meats, and the treatment of food contact surfaces.

Prosopis juliflora belongs to family Leguminosae, subfamily Mimosoidae, and mostly grows as a weed in Australia and the United States. It serves as a source of food, wood, and even medicine [5]. *P. juliflora* is commonly used to treat eye conditions, digestive problems, open wounds, and dermatological disorders. It has soothing, astringent, and antiseptic properties [6]. *P. juliflora* has antibiotic activity, and its aqueous extracts are antibacterial. Tannin found in bark, root, and wood has antibacterial, antidiarrheal and antiviral activity. Quercetin found in the plant has analgesic, antiallergenic, antibacterial, antidiabetic, anti-inflammatory, and antiviral activity [7]. Soil amendment with *P. juliflora* stem and leaf powder at 0.1 and 1 % w/w showed significant enhancement in growth parameters and reduction in colonization percentage of root rot fungi [8].

Aerva javanica parts, such as flowers and roots, possess medicinal properties against kidney problems and rheumatism. The leaves of *A. javanica* are used externally to heal wounds and the inflammation of joints, and are also used for fodder for goats. A decoction of the plant is used as a gargle for toothache [9] and to remove swelling. *A. javanica* shows anti-hyperglycaemic [10], cytogenetical [11],

cytotoxic [12], and anti-plasmodial activities. Carbohydrates, steroids, triterpenoids, and flavonoids have been reported in *A. javanica* previously [13]. *A. javanica* is most effective against many bacteria and other microorganisms [14]. *A. javanica* shows anti-microbial, anti-hyperglycaemic, cytogenetical, cytotoxic, anti-plasmodial, and anti-diarrhoeal activities [15]. Ikram and Dawar [16] observed that soil amendment with *A. javanica* leaves at 1 % w/w showed significant enhancement in growth parameters and significant reduction in colonization percentage of root rot fungi. Root rot fungi, such as *M. phaseolina*, *R. solani*, and *F. solani*, are known to produce root and stem rot diseases in different crop plants throughout the world [17,18]. Root rot of crop plants may involve attack of more than one pathogen [19,20]. An interaction among the soil borne plant pathogenic fungi can influence the disease intensity and severity on many crop plants [21].

The main purpose of controlling plant diseases is to improve the growth quality and yield of crops. Therefore, the present study was carried out to study the efficacy of ultraviolet (UV-C < 280 nm) radiations on the growth parameters and in the control of root infecting fungi of mung bean and cowpea plants.

Materials and methods

Seed treatment with UV-C radiation

The seeds of cowpea (*Vigna unguculata* L.) and mung bean (*Vigna radiata* L.) were irradiated with UV-C (< 280 nm) for 15 and 30 min.

Soil amendment with plant parts

The stem, leaves, and flowers of *Prosopis juliflora* (Swartz) DC. and *Aerva javanica* (Burm. f.) Juss. ex Schult were collected from the University of Karachi campus. All plant parts were washed with distilled water to remove dust particles and dried under shade. The plant part materials were grinded by using an electric grinder and stored in sealed bottle for further studies at room temperature. The soil was amended with *P. juliflora* and *A. javanica* stem, leaves, and flower powder at 1 % w/w. The UV irradiated seeds were sown in 8 cm diameter plastic pots, each pot containing 300 g soil, and watered regularly to maintain sufficient moisture required for the growth of plants.

Isolation of fungi from roots

The roots of treated and non-treated plants were washed in running tap water (to remove adhering soil) and were dried with blotter paper. From the roots of each treatment, 5 small segments (1 cm long) were randomly cut and surface sterilized with calcium hypochlorite (1 %) for 3 min. The root fragments from each plant were placed onto petri plates containing Potato Dextrose Agar (PDA) plus antibiotics (Penicillin and Streptomycin). Plates were incubated at 30 ± 1 °C and, after one week, emerging fungi from each root segment were identified and their colonization was determined by using the following formula.

$$\text{Colonization \%} = \frac{\text{Number of root pieces colonized by a fungus}}{\text{Total no. of root pieces}} \times 100 \quad (1)$$

Data analysis

Data were subjected to analysis of variance (ANOVA) followed by the least significant difference (LSD) test at P = 0.05 [22].

Results

Germination of cowpea seeds were significantly increased when soil amended with *P. juliflora* leaves, stem powder and seed treated with UV radiation for 15 min as compared to *P. juliflora* flower powder. Maximum shoot length was recorded when soil amended with *P. juliflora* leaves powder and seed treated with UV radiation for 15 and 30 min as compared to stem and flower powder. Shoot weight and root length significantly ($P < 0.001$) enhanced when seed treated with 15 and 30 min and soil amended with *P. juliflora* leaves and stem powder as compared flower powder. Root weight was enhanced when soil amended with *P. juliflora* leaves powder and seed treated with UV radiation for 30 min. In case of mungbean, soil amendment with all parts of *P. juliflora* gave 100 % germination and seed treated with UV radiation for 15 min as compared to control. Shoot length of mungbean plants were significantly ($P < 0.001$) enhanced when seed treated with UV radiation for 15 min and soil amended with *P. juliflora* leaves and stem powder while shoot weight, root weight and root length enhanced when seed treated with UV radiation for 30 min and soil amended with *P. juliflora* leaves (**Figure 1**).

Leaf area and number of nodules of cowpea and mung bean plants significantly ($P < 0.001$) enhanced when seed treated with UV radiation for 15 and 30 min and soil amended with *P. juliflora* leaves. In cowpea and mungbean colonization of root rot fungi viz., *M. phaseolina*, *Fusarium* spp., and *R. solani* were completely suppressed when seed treated with UV radiation for 15 and 30 min and soil amended with *P. juliflora* parts powder (**Figure 2**).

In cowpea germination percentage of seeds significantly ($P < 0.001$) increased when seeds treated with UV radiation for 15 and 30 min and soil amended with *A. javanica* stem and leaves powder as compared to flower powder. Length and fresh weight of shoot significantly ($P < 0.001$) enhanced when seeds irradiated with UV radiation for 15 min and soil amended with *A. javanica* leaves as compared to stem powder. Soil amended with *A. javanica* leaves powder and seeds irradiated with UV radiation for 30 min showed enhancement in root length while root weight was significantly ($P < 0.001$) increased when soil amended with *A. javanica* leaves and seeds irradiated with UV radiation for 15 and 30 min. In case of mungbean, germination percentage of seeds was maximum when soil amended with *A. javanica* parts powder and seed treated with UV radiation for 15 min as compared to control. Seeds treated with UV radiation for 15 min and soil amended with *A. javanica* leaves powder showed enhancement in length and fresh weight of shoot. Length and fresh weight of root significantly ($P < 0.001$) enhanced when seeds irradiated with UV radiation for 15 min and soil amended with *A. javanica* leaves as compared to other treatments (**Figure 3**).

Leaf area and number of nodules in cowpea were significantly ($P < 0.001$) increased when seeds treated with UV radiation for 15 min and soil amended with *A. javanica* leaves powder as compared to stem powder. In mungbean leaf area enhanced when seeds treated with UV radiation for 30 min and soil amended with *A. javanica* leaves powder as compared to stem and flower powder. Number of nodules significantly ($P < 0.001$) increased when seeds treated with UV radiation for 15 min and soil amended with *A. javanica* leaves powder. In both crop plants, colonization of root rot fungi viz., *M. phaseolina*, *Fusarium* spp., and *R. solani* was completely suppressed when *A. javanica* part powder was used at 1 % w/w and seeds irradiated with UV radiation (**Figure 4**).

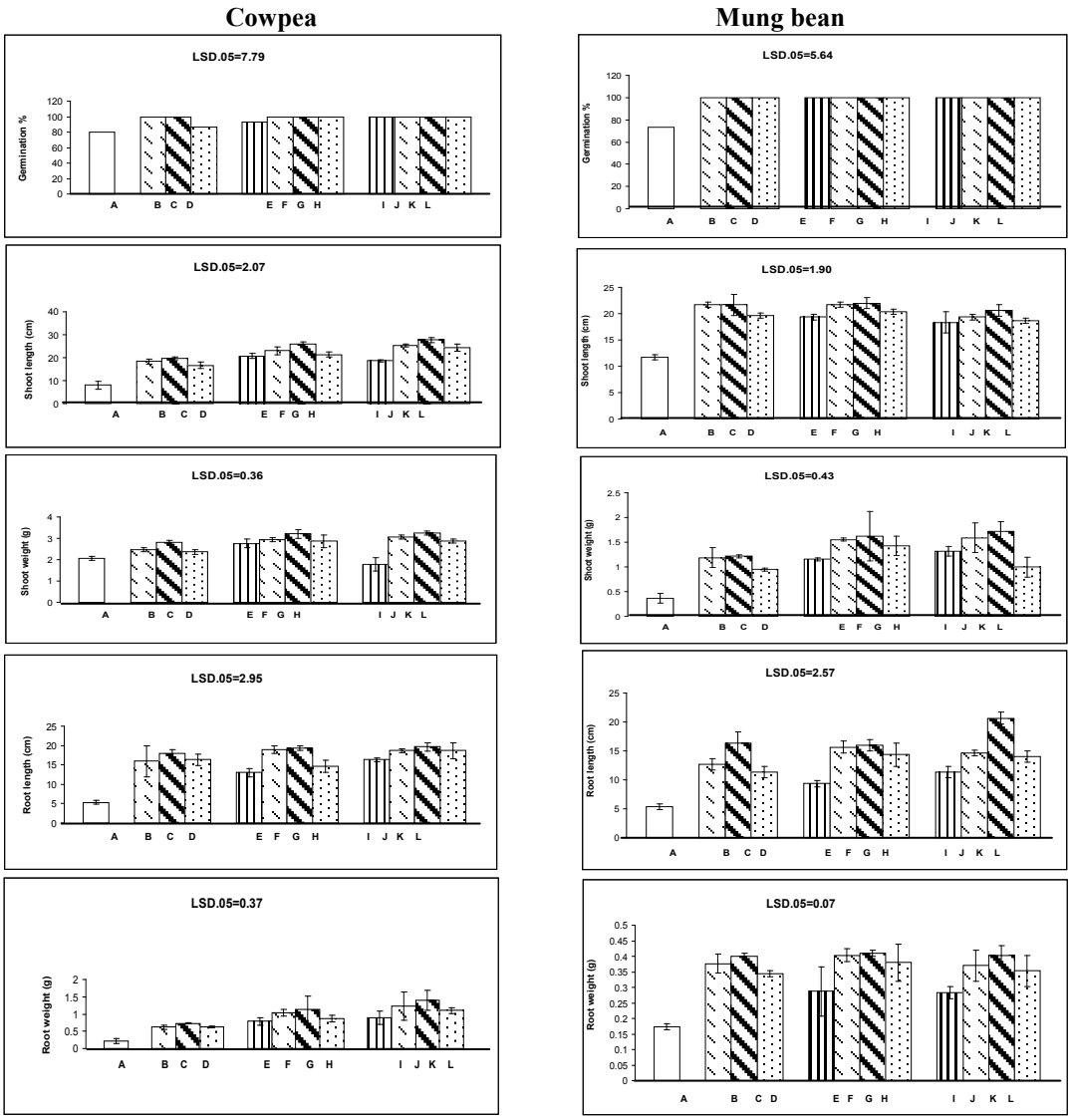

Figure 1 Effect of UV radiation with *P. juliflora* on the growth parameters of cowpea and mung bean. A = Control, B = *P. juliflora* stem at 1 %, C = *P. juliflora* leaves at 1 %, D = *P. juliflora* flower at 1 %, E = Seeds treated with UV radiation for 15 min, F = *P. juliflora* stem at 1 % + seeds treated with UV radiation for 15 min, G = *P. juliflora* leaves at 1 % + seeds treated with UV radiation for 15 min, H = *P. juliflora* flower at 1 % + seeds treated with UV radiation for 15 min, I = Seeds treated with UV radiation for 30 min, J = *P. juliflora* stem at 1 % + seeds treated with UV radiation for 30 min, K = *P. juliflora* leaves at 1 % + seeds treated with UV radiation for 30 min, L = *P. juliflora* flower at 1 % + seeds treated with UV radiation for 30 min.

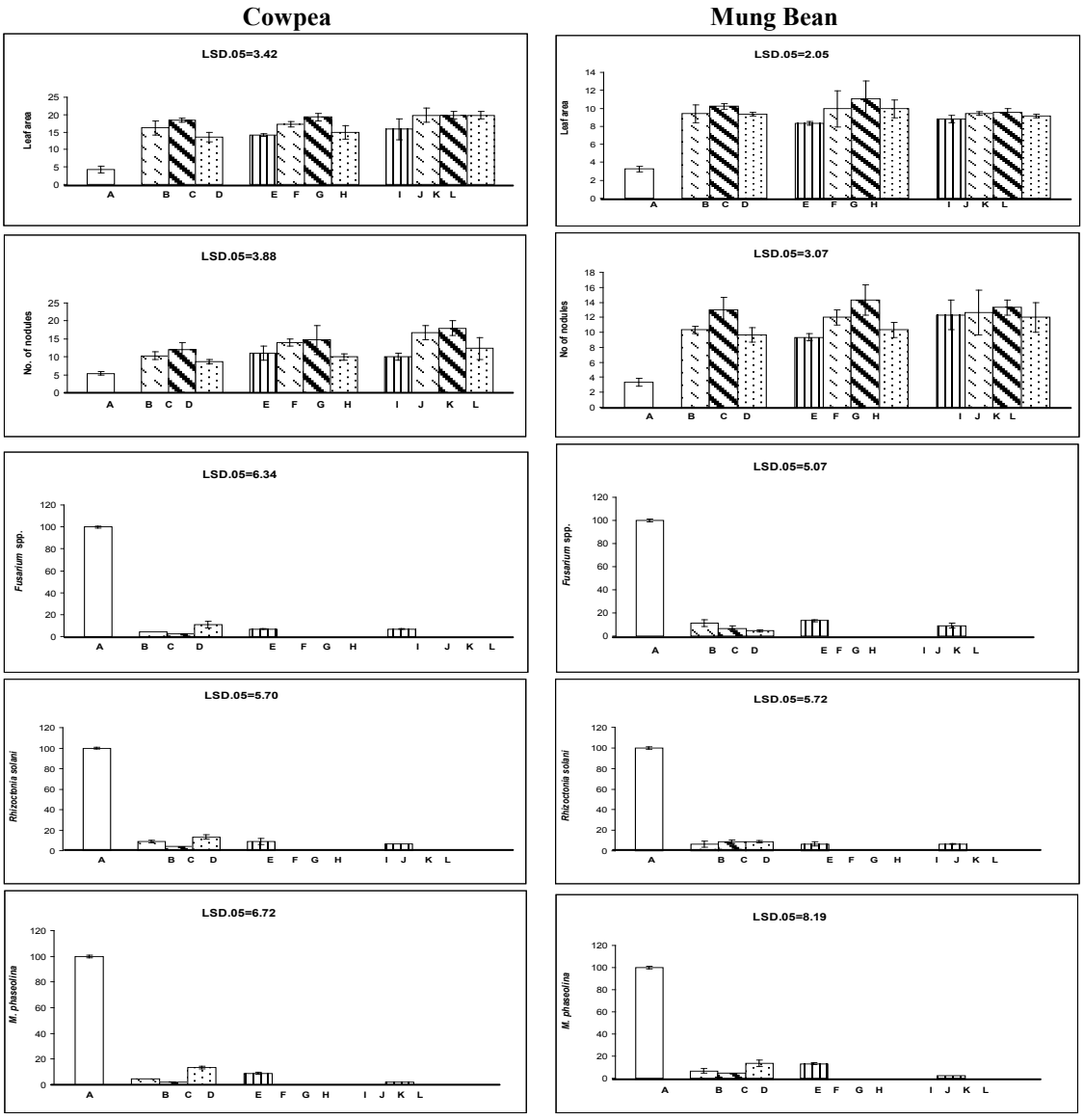

Figure 2 Effect of UV radiation with *P. juliflora* on growth and in the control of root rot fungi of cowpea and mung bean. A = Control, B = *P. juliflora* stem at 1 %, C = *P. juliflora* leaves at 1 %, D = *P. juliflora* flower at 1 %, E = Seeds treated with UV radiation for 15 min, F = *P. juliflora* stem at 1 % + seeds treated with UV radiation for 15 min, G = *P. juliflora* leaves at 1 % + seeds treated with UV radiation for 15 min, H = *P. juliflora* flower at 1 % + seeds treated with UV radiation for 15 min, I = Seeds treated with UV radiation for 30 min, J = *P. juliflora* stem at 1 % + seeds treated with UV radiation for 30 min, K = *P. juliflora* leaves at 1 % + seeds treated with UV radiation for 30 min L = *P. juliflora* flower at 1 % + seeds treated with UV radiation for 30 min.

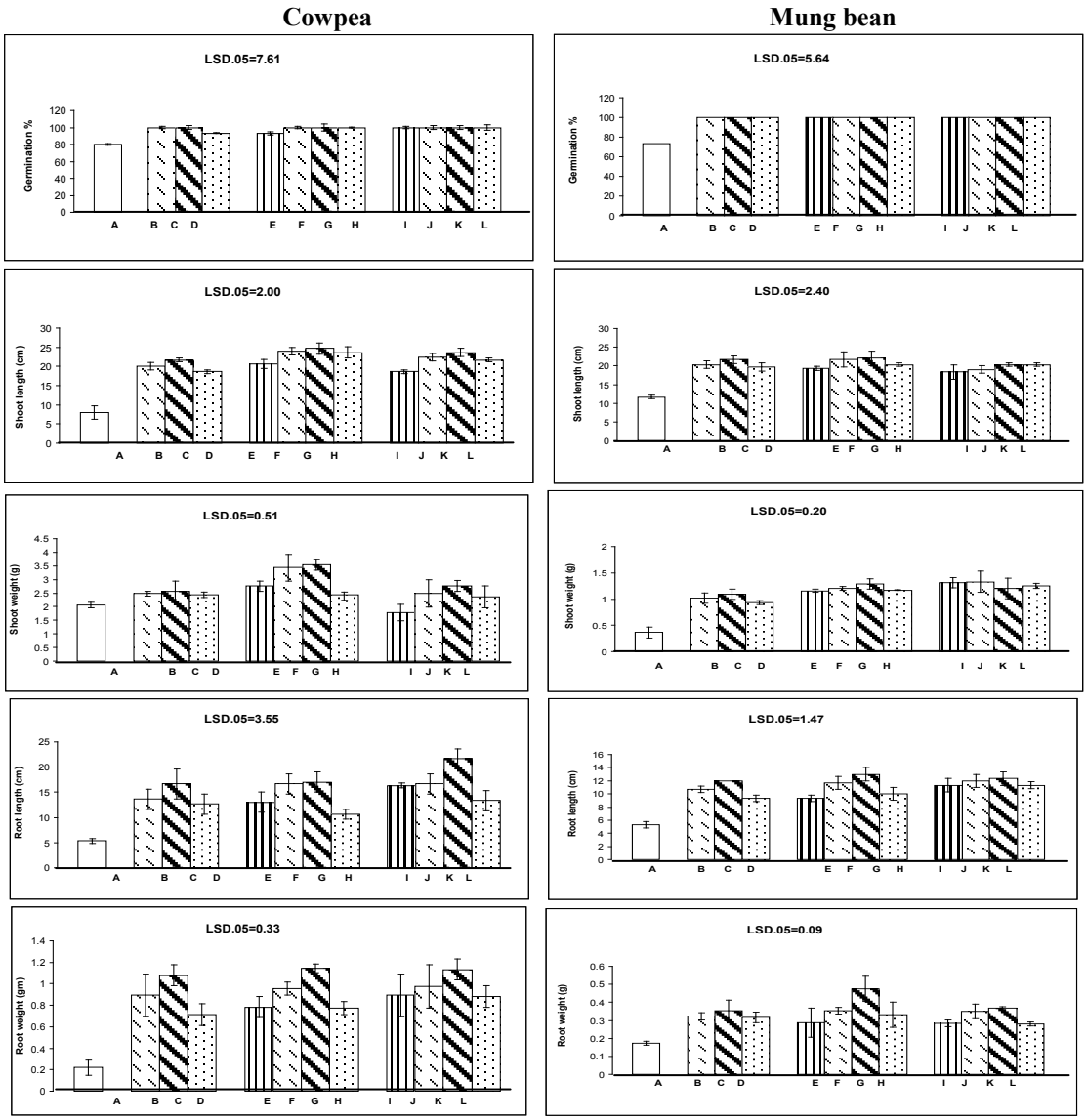

Figure 3 Effect of UV radiation with *A. javanica* parts powder on the growth parameters of cowpea and mung bean. A = Control, B = *A. javanica* stem at 1 %, C = *A. javanica* leaves at 1 %, D = *A. javanica* flower at 1 %, E = Seeds treated with UV radiation for 15 min, F = *A. javanica* stem at 1 % + seeds treated with UV radiation for 15 min, G = *A. javanica* leaves at 1 % + seeds treated with UV radiation for 15 min, H = *A. javanica* flower at 1 % + seeds treated with UV radiation for 15 min, I = seeds treated with UV radiation for 30 min, J = *A. javanica* stem at 1 % + seeds treated with UV radiation for 30 min, K = *A. javanica* leaves at 1 % + seeds treated with UV radiation for 30 min, L= *A. javanica* flower at 1 % + seeds treated with UV radiation for 30 min.

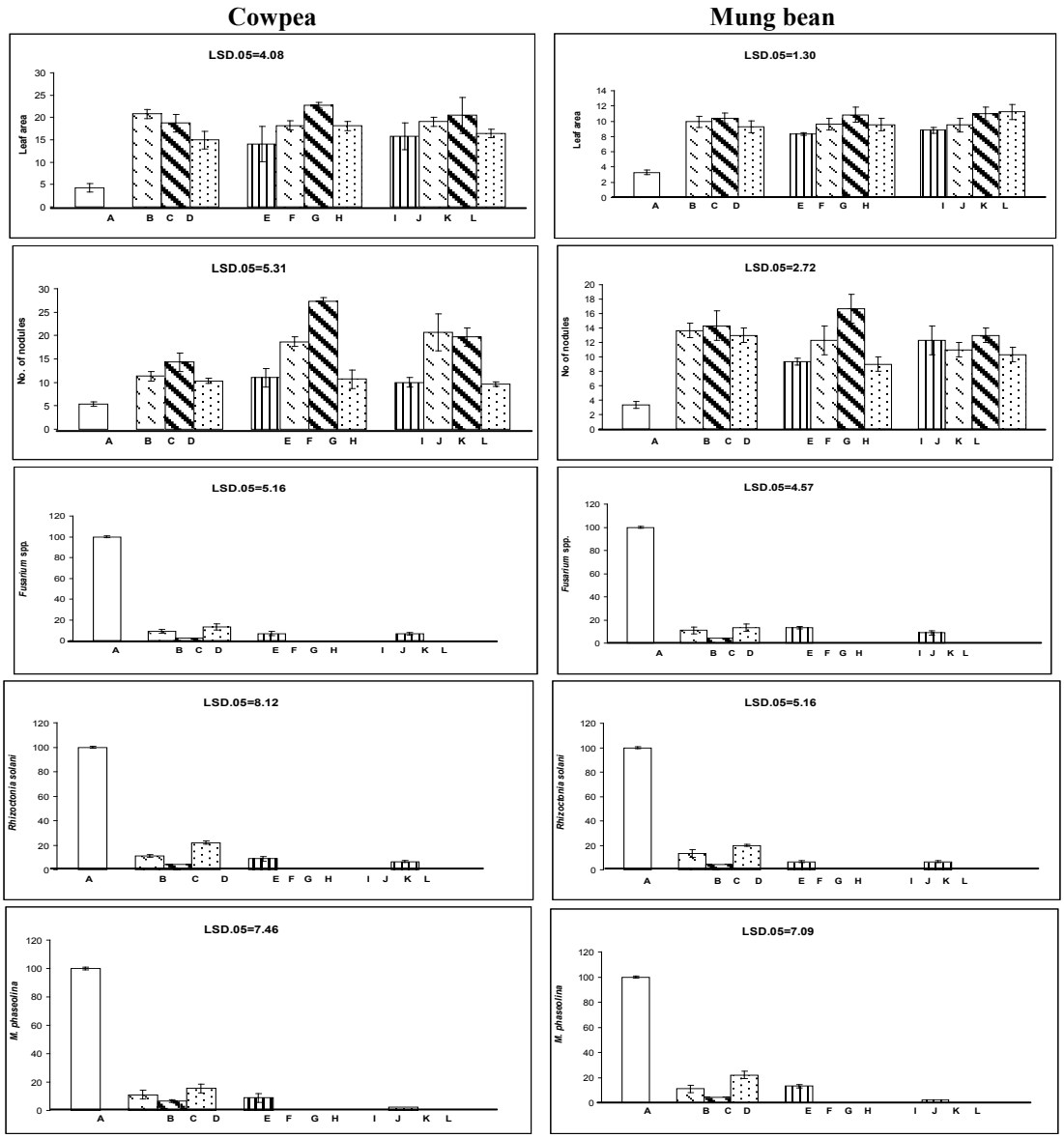

Figure 4 Effect of UV radiation with *A. javanica* on the growth and in the control of root rots fungi of cowpea and mung bean. A = Control, B = *A. javanica* stem at 1 %, C = *A. javanica* leaves at 1 %, D = *A. javanica* flower at 1 %, E = Seeds treated with UV radiation for 15 min, F = *A. javanica* stem at 1 % + seeds treated with UV radiation for 15 min, G = *A. javanica* leaves at 1 % + seeds treated with UV radiation for 15 min, H = *A. javanica* flower at 1 % + seeds treated with UV radiation for 15 min, I = Seeds treated with UV radiation for 30 min, J = *A. javanica* stem at 1 % + seeds treated with UV radiation for 30 min, K = *A. javanica* leaves at 1 % + seeds treated with UV radiation for 30 min, L = *A. javanica* flower at 1 % + seeds treated with UV radiation for 30 min.

Discussion

Seed treatment with UV rays showed complete suppression of colonization percentage of root rot fungi, similar to results observed by Menzies and Belanger [23], where UV irradiation was used to minimize the dispersal of root pathogens. UV irradiation reduces the infection of *Fusarium* spp. at 99.9 %, and tomato mosaic virus at 90 %, and reduced the population of the target and non-target pathogens [24]. UV-treated nutrient-rich solution has the ability to reduce bacterial density [25]. UV light is effective in reducing various bacterial populations on egg shell surfaces [26]. Infections of *Escherichia coli* and *Salmonella* were reduced when pork skin and muscle was irradiated with UV irradiation [27], as was *Listeria monocytogenes* on chicken meat [28] and *Salmonella typhimurium* on poultry carcasses [29].

Seed irradiated with UV rays for 15 min showed significant enhancement in the growth parameters of crop plants, similar to results mentioned by Siddiqui *et al*. [30], where UV-C exposure for 60 min showed enhancement in growth parameters and physiological parameters, as well as reduction in root infecting fungi. Shiozaki *et al*. [31] recorded that shoot length and the fresh weights of pea plants were enhanced by treatment with UV radiation. Many researchers observed that seed treatment with UV rays increased the productivity of crop plants [32]. Different doses of UV-C radiations were lethal to bacteria, viruses, mold spores, yeast, and algae, and inactivate the microbial spores at varying levels [33]. Warriner *et al*. [34] reported that UV light was effectively used for the sterilization of packaging carton surfaces. A few studies recently reported that UV-light treatment inactivate the spores of *Aspergillus niger* in corn meal [35]. Takeshita *et al*. [36] observed that UV light inactivated the growth of *Saccharomyces cerevisiae,* and controlled the microbial growth on fresh processed lettuce. Allende and Artes [37] reported that UV light was effective for reducing the levels of psychotropic and coli form bacteria, as well as yeast, without affecting the quality of lettuce. Sharma and Demirci [38] demonstrated that UV light has the potential to reduce bacterial contamination on food surfaces and eliminate pathogens, such as *Escherichia* coli, from alfalfa seeds. The present work suggested that seed treatment with UV radiation for 15 min and soil amendment with *P. juliflora* and *A. javanica* leaf powder enhanced the productivity of crop plants and suppressed the colonization percentage of root infecting fungi. More work should be carried out under field conditions in order to obtain good crop quality.

Conclusions

Seed treatment with UV radiation and soil amendment with wild plant parts showed an environmentally friendly strategy for controlling root rot pathogens as a substitute for chemical fungicides. We can apply it to fields for the control of root rot fungal diseases of crop plants. Agrochemicals, such as insecticides and herbicides, increase the risk of environmental pollution; there is a need to provide a healthy and pollution free environment, and there is also a need to increase community awareness to protect the environment with environmentally friendly methods.

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