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UV-C (< 280 nm) RADIATION MODULATING SOIL-BORNE ROOT INFECTING FUNGI COLONIZATION AND PLANT GROWTH

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ABSTRACT

Soil borne fungal pathogens like *Macrophomina phaseolina* (Tassi) Goid, *Rhizoctonia solani* Kühn and *Fusarium* spp. cause root rot diseases on crop plants and ultimately lead to their death. Chick pea, Sunflower and Mash bean are susceptible to *M. phaseolina* (Tassi) Goid, *R. solani* Kühn and *Fusarium* spp. Seeds of chick pea (*Cicer arietinum* L.), sunflower (*Helianthus annuus* L.) and mash bean (*Vigna mungo* L.) were exposed to ultra violet (UV-C) radiation for 10, 20, 30 and 40 minutes to study their effect on seeds germination, plant growth parameters as well as its effect on root rot fungi, *M. phaseolina* (Tassi) Goid, *R. solani* Kühn and *Fusarium* spp. We found a substantial increase in shoot weight, shoot length, root length and root weight of both chick pea and sunflower plants when their seeds were treated with UV- C for 40 minutes. This treatment regime also showed inhibitory effects on root rot colonization by *M. phaseolina*, *R. solani* and *Fusarium* spp. However, 20 minutes of UV exposure to mash bean seeds showed similar increase in plant shoot weight, shoot length, root length and root weight. Thus exposure of chick pea *(Cicer arietinum* L.) and sunflower (*Helianthus annuus* L.) seeds to UV-C for 40 minutes are ideal condition for both the management of root rot fungi and improved crop growth parameters.

Key-words: radiation, soilborne fungal pathogens, seed exposure, plant growth.

INTRODUCTION

Plant pathogens are major threat to sustainable food production (Cook, 1994; Fravel, 2005). Soil borne pathogens viz., *Macrophomina phaseolina* (Tassi) Goid, *Rhizoctonia solani* Kühn and *Fusarium* spp., attack roots, limit nutrition uptake and produce root rot disease complex resulting in the death of plants (Nelson *et al*., 1983; French and Kennedy, 1963; Sinclair and Gray, 1972). For long, use of chemical fungicides have been the method of choice to control fungal infestation. However, these chemicals are bringing harm to both the environment, and the many organisms those live in that environment (Korsten, 2006), the development of fungicide- resistant strains of phytopathogens (Okada and Furukawa, 2008) and the high cost of synthetic fungicides (De Costa and Gunawardhana, 2012). Thus, there has been a need to find alternative methods to control plant pathogens. Electromagnetic radiation of long wavelengths including ultraviolet, ultrasonic, microwave, radio frequency and optical radiations are the non-ionizing radiations, causes excitation of atoms an alteration of electrons within their orbits but does not possesses enough energy to eject electrons to produce ions (Shleien, 1992). The germicidal effects of radiant energy from the sunlight was first reported by Downes and Blunt (1878) and then later the morphological and physiological effects of radiation was described by James and Nasim (1987) Depending on the period of exposure, radiations may influence morphology, anatomy, physiology and the biochemistry of plants (Kim *et al*., 2004, Wi *et al.,* 2005) Currently, UV irradiation is one of the best available strategies to manipulate pathogenic fungi (Canale *et al*., 2011; Darras *et al*., 2012). UV radiations between 10 – 400 nm with 3 to 124 eV energies can show both positive and negative effects. UV-C radiation has been shown to inhibit the growth of root rot fungi (Bokhari *et al*., 2013) as well as increase plant growth and plant yields (Kunz *et al.,* 2006). However, some plant species have been found to be unaffected by UV irradiation (Becwar *et al*., 1982). UV rays can be divided into three different wavelength bands; UV-A or long wave (400-315 nm), UV-B or medium wave (315-280 nm), and UV-C or short wave (< 280 nm).

In the present study, we explored the effects of UV-C radiations (UV-C <280 nm) on plant growth. We also investigate the effects of radiation on the growth and the infection ability of root infecting fungi on leguminous and non-leguminous crops.

MATERIALS AND METHODS

Exposure of seeds to radiation

Seeds of mash bean (*Vigna mungo* L.), chick pea (*Cicer arietinum* L.) and sunflower (*Helianthus annuus* L.) were surface sterilized with 1% $Ca(OCl)_2$ for 3 minutes and dried under laminar flow hood. Seeds were then exposed to ultraviolet radiation (UV-C <280 nm) for10, 20, 30 and 40 minutes.

Greenhouse Experiment

The experiment was conducted in 8cm diameter plastic pots and the soil (300 g/pot) for seed planting was obtained from an experimental plot that was maintained at the Department of Botany, University of Karachi. Soil sample was tested for pH (8.0), 40 % moisture holding capacity (Keen and Raczkowski, 1922), 0.079% total nitrogen (Mackenzie and Wallace, 1954), 4 sclerotia/g soil of *M. phaseolina* (Sheikh and Ghaffar, 1975), 7% of *R. solani* (Wilhelm, 1955) and 4000 cfu/g soil of *Fusarium* spp., (Nash and Synder, 1962). Then test seeds were irradiated as described above and then planted plastic pots (5seeds/pot). Similarly, the seeds that did not go through UV radition were planted in plastic pots served as control. All treatments were kept on screen house bench in a completely randomized manner. Each treatment was replicated three times. Plants were uprooted after 30 days of germination.

Assessment of colonization by root rot fungi

Roots of each treatment were washed in running tap water and then surface sterilized with 1% calcium hypochlorite for 3 minutes. Roots were cut into 1 cm pieces were transferred onto Potato Dextrose Agar containing penicillin and streptomycin (@ 200 mg/L) Petri plates (5 root pieces per plate). Petri plates were incubated at room temperature (28 - 33˚C). After a week the colonization on roots by root infecting fungi was recorded.

Data analysis

Data were analyzed statistically and the least significant difference (LSD) test and Duncan’s multiple range test were performed to compare the treatment means (Gomez and Gomez, 1984).

RESULTS

We found a significant increase in the shoot weight ($p< 0.05$) and shoot lengths ($p<0.001$) of both chickpea and sunflower plants when their seeds were treated with UV- C for 40 minutes (Fig. 1). We also noted a major increase in mash bean plant shoot length ($p< 0.05$) and root weight after 20 minutes exposure of mash bean seeds to UV-C (Fig. 2). There was a significant reduction in root rot colonization by *M. phaseolina*, *R. solani* and *Fusarium* spp. on chick pea, sunflower and mash bean when their seeds were irradiated with UV- C radiations for 10, 20, 30 and 40 minutes. However, we found a complete inhibition of *R. solani* and *Fusarium* spp. ($p< 0.01$) and *M. phaseolina* colonization when sunflower seeds were irradiated for 40 minutes before planting (Fig. 1). We also noticed that mash bean seeds exposed to UV-C for 40 minutes were completely protected from *M. phaseolina* and *R. solani* colonization (Fig. 2).

DISCUSSION

Exposure of seeds to UV- C radiation for 40 minutes showed significant reduction in root rot fungi and colony formation in both leguminous and non-leguminous plants. UV- C light has been shown to have a germicidal effect on various microorganisms that are present in different habitats (Sharp, 1939). In the present study, we found that both chickpea and sunflower seeds exposed to the UV-C rays for 40 minutes inhibited root rot colonization and improved plant height and weight. However, root rot colonization on mash bean seeds significantly reduced after 30 minutes exposure Our study supports data from a previous study by Nasim *et al*. (2013), who also found that UV-C exposure to corn seeds for 30 and 120 minutes not only eliminated *R. solani* and *M. phaseolina* colonization on corn plants but also improved plants root weight. It has been observed a gradual decrease in fungal biomass and colony diameter with increased exposure time in the two bioassays (Bokhari *et al*., 2013). Sensitivity to UV radition have also been reported for other fungal species, such as *Beauveria bassiana, Engyodontium albus, Simplicillium lanosoniveum* and *Lecanicillium aphanocladii* (Braga *et al*., 2002; Fernandes *et al.*, 2007). Darras *et al*., (2012) have shown that UV-C radiation resulted a 55% reduction in lesion diameters caused by *Botrytiscinerea* on florets of gerberas .Storage rots of vegetables and fruits can be reduced by UV-C irradiation (Wilson *et al.*, 1997). Siddiqui *et al.*, (2011) noted an improved growth of groundnut and mungbean that were exposed to UV-C. DeStaaij *et al*., (2001) observed that when roots of grass land plant species were irradiated with high level of UV radiations, there were reduction in infection percentages of Arbuscular Mycorrhizal Fungus (AMF) in roots of tested plant species.

Present results suggested that seed treatment with UV- C radiation at 40 minutes was found to be the most effective in improving the plant growth as well as reduced the colonization of root infecting fungi. It is strongly suggested that it can be applied on large scale for better yield. Seeds treated with radiation are non-chemical strategy to control the pathogens which is found as a best alternating way in substitute of chemical control, which is hazardous for the ecosystem.

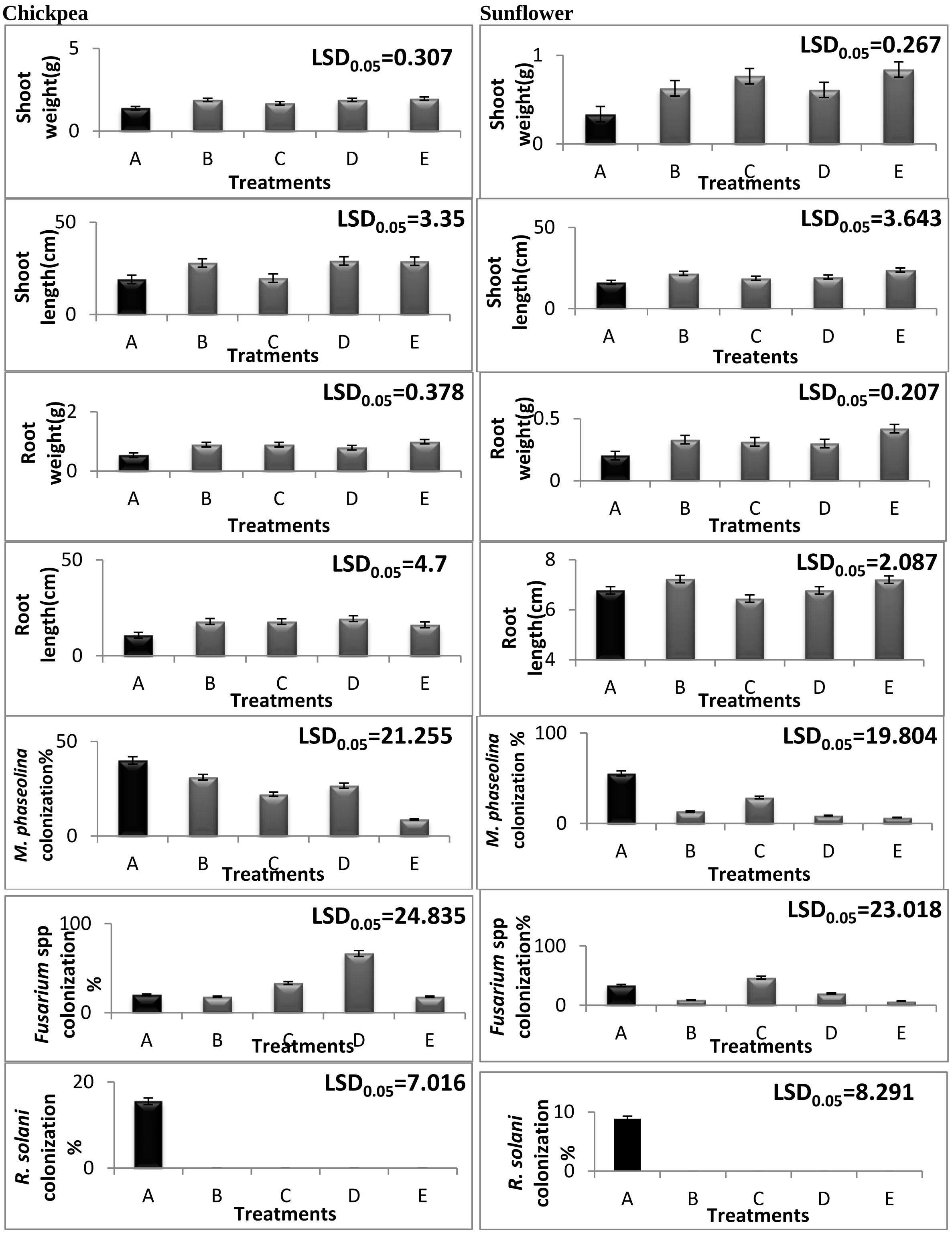

Fig.1. Effect of UV radiation on growth parameters and colonization of root rot fungi of chickpea and sunflower. A=Control, B= 10 minutes UV-C radiation, C= 20 minutes UV-C radiation, D= 30 minutes UV-C radiation, E= 40 minutes UV-C radiation.

Mash bean

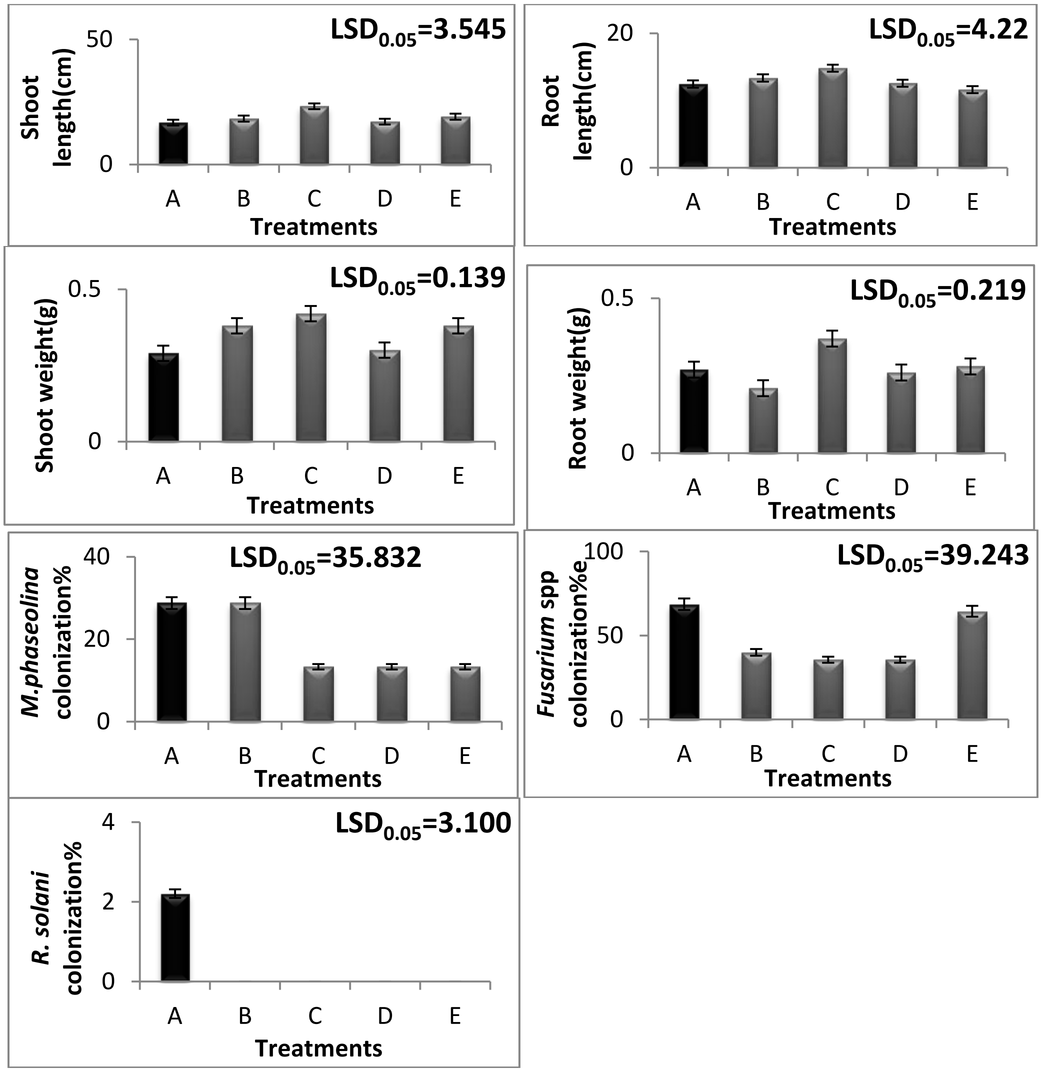

Fig. 2. Effect of UV radiation on growth parameters and colonization by root rot fungi of mash bean.
A=Control, B= 10 minutes UV-C radiation, C= 20 minutes UV-C radiation, D= 30 minutes UV-C radiation, E= 40 minutes UV-C radiation.

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