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PRE-SOWING IRRADIANCE OF MAIZE CARYOPSES WITH UV-C AND ITS EFFECTS ON COMMON ROOT-INFECTING FUNGI

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ABSTRACT

In this study, caryopses of maize were exposed to UV-C radiation for 30, 60, 120 and 240 minutes before sowing to determine the effects on seed germination, plant growth, leaf area and colonization of common root-infecting fungi such as *Fusarium* species, *Rhizoctonia solani* Kühn. and *Macrophomina phaseolina* (Tassi) Goid. UV-C reduced seed germination, shoot length, shoot weight, root length and leaf area and improved root weights after various times of exposure. Colonization percentages of *Fusarium* species was reduced on 60 and 120 minutes of exposure of seeds. UV-C radiations completely eliminated R. *solani* and *M. phaseolina* in roots of maize on 30-minutes-exposure. However, longer exposure (240 minutes) increased their colonization percentages. It is concluded that seed treatment with UV-C radiations for 30 to 120 minutes effectively reduced incidence of commonly found root-infecting fungi.

KEYWORDS: UV-C radiations, *Fusarium* species, *Rhizoctonia solani* Kühn. and *Macrophomina phaseolina* (Tassi) Goid., Maize.

INTRODUCTION

UV-radiations are electromagnetic radiations emitted from the sun. According to wavelength UV-radiations are divided into three classes i.e. UV-A (320-400nm), UV-B (280-320nm) and UV-C (100-280nm). However, the most of the UV radiations are absorbed in the atmosphere by different kinds of gases. UV-C is completely absorbed by ozone layer in the earth atmosphere and unable to reach the earth surface. While, UV-B radiations partially stopped in the ozone layer. All kinds of UV radiations differentially affect the living organisms. Smaller wavelength UV-radiation affects growth and productivity of plants by reducing stability of genome (Kunz *et al*., 2006) by damaging plants molecular makeup and its physiology. However, some plant species apparently remain unaffected by UV-radiations (Becwar *et al.,* 1982).

The common pathogens causing losses in crops are fungi, bacteria, actinomycetes and nematodes. The soil-borne pathogens cause variety of diseases on plants including root-rot and root-knot diseases. Plant pathogenic fungi produce different types of resistant structures like resting spores, sclerotia and chlamydospores. Pathogens causing below ground infection on roots inhibit nutrient uptake by plants and resulting in mortality of plants. While losses resulting from such diseases are underestimated and mostly ignored (Baker and Cook, 1974). Common soil-borne root-infecting fungi are *Macrophomina phaseolina, Rhizoctonia solani, Fusarium solani* and *Fusarium oxysporum* the different cultivated areas of Pakistan causing root and stem rot and wilt disease on a wide range of crops (Booth, 1971; Ghaffar, 1992). *Macrophomina phaseolina* (Tassi) Goid. is reported to produce infection on more than 500 species of plants world wide (Dhingra and Sinclair, 1978; Sinclair, 1982; Shahzad *et al.,* 1988). *Rhizoctonia solani* Kühn causes infection on more than 2000 spp. (Parameter, 1970; Mirza and Qureshi, 1978).

Maize is among the most cultivated cereal crops around the world. In the present study Maize was used as test plant. The objective this study was to find out the effects of UV-C radiations on plant growth and infection severity of commonly found root infecting fungi in maize.

MATERIALS AND METHODS

Soil: Soil used for this experiment was sandy loam (Sand: Silt: clay, 70: 19: 11), pH ranged from 7.5-8.1 with moisture holding capacity of 40%. Soil naturally consisted inoculum of root-infecting fungi (3 sclerotia per g of *M. phaseolina*, 8% of *R. solani* on sorghum seeds used as baits and 3200 colony forming units in one g soil of *Fusarium spp*).The soil was screened through 2 mm sieve before use.

Caryopses treatment with UV-C radiations: Caryopses of maize (*Zea mays*) were washed with sterilized distilled water and air dried. Caryopses were then treated with ultraviolet (UV-C; < 280nm) light for 30, 60, 120 and 240 minutes from a source hanging above at a height of 36 cm. Untreated seeds served as control. Five caryopses were sown in each plastic pot (8cm diameter) with capacity of 300g soil. There were three replicates for each treatment. The pots were kept in accordance with completely randomized design on green house bench for 30 days and watered daily.

Plant growth and isolation of fungi from roots: Plants were uprooted after 30 days of seedling emergence. Growth data in terms of root length, root weight, shoot length, shoot weight, and leaf area was recorded. For estimation of area of the leaf, three leaves from each plant were selected randomly, and the area of leaf determined graphically. To determine the incidence of root infecting fungi, one cm long root pieces after washing in running tap water, were surface sterilized with 1% sodium hypochlorite and transferred on PDA plates supplemented with penicillin and streptomycin each at 200 $mg.L^{-1}$. Five pieces of root were placed on each petri plate. Petri dishes were incubated at room temperature and after one week, infection of roots by root infection fungi was recorded as follows:

$$\text{Colonization (\%)} = \frac{\text{Number of infected root pieces}}{\text{Total number of root pieces}} \times 100$$

Analysis of data: A randomized block design with three replicates of each treatment was used and data were subjected to analysis of variance (ANOVA) followed by the least significant difference test and Duncan's multiple range test to compare means at $p < 0.05$ (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The treatment of maize caryopses with UV-C radiation for different time intervals (0, 30, 60, 120 and 240 minutes) showed varying response of seedling growth. Insignificant increment in seed germination (80.00 %) was recorded at 120 minutes treatment with UV-C while germination reduced at 30, 60 and 240 minutes exposure to UV-C. Effect of UV radiations on seed germination has been studied on wide range of plant species (Tosserams *et al*., 1997; Peykarestan and Seify, 2012). Delayed germination was noticed in red bean seeds after various types of UV radiations from 220 to 400nm. However, the final germination percentage remained unaffected in a variety of red bean (Peykarestan and Seify, 2012). In contrast UV-irradiation speeded the germination of kale, cabbage, radish and agave seeds (Noble, 2002). Similarly, Shaukat *et al*., (2013) reported that UV-irradiation substantially increased the velocity of seed germination, however, the final germination percentage remained significantly suppressed by UV-irradiance. Shoot length of maize was not enhanced in any of UV-C treatment compared to control (36.22 cm) ($p<0.05$).

The caryopses of maize treated at 120 minutes showed maximum shoot length (30.99 cm) compared to all UV-C treatments. Shoot weight in UV irradiance plants significantly ($p<0.05$) declined in treatments compared to controls. However, maximum decrease was observed at 30-minutes-exposure. Significant ($p<0.05$) reduction in the root lengths of treated plants was observed compared to untreated controls. However, exposure for 120 minutes revealed insignificant reduction. Root weight was significantly increased ($p<0.05$) in 120 minutes treatment (0.54 g) followed by seed treatment at 240 minutes (0.39 g). UV radiations showed reduced plant lengths in wheat and pea plants after exposing for 2 h daily for a week (Alexieva *et al.*, 2001). Furthermore, reduced plant fresh and dry weights were also recorded in UV radiated seedlings of wheat and pea. Yao *et al*., (2005) demonstrated reduced growth and development of cucumber seedlings following combined treatments of UV and magnetic field. It was deduced due to the inhibition of secondary metabolism. It was also suggested that dicotyledonous species are more sensitive to shorter UV wavelength than monocotyledonous species (Yao *et al*., 2006). However, root weights remains unaffected by UV-C irradiance for different times of exposure compared to control. Sarghein *et al*., (2011) found that exposure of UV-C radiation to pepper plants did not affected the root growth.

The area of the mean leaf of maize seedling was also reduced after the treatments with UV-C radiations in all treatment compared to the control (Table 1). Increased UV radiation affects the development of leaves by altering cell division and number of cells in leaves. This phenomenon results in reduction of leaf area (Nogués *et al*., 1998). Cen and Bornman (1990) studied that UV radiating plants showed substantial decreased in leaf area and leaf dry weight and change in the leaf structure. Reduced leaf area under UV radiation is considered to be photo-morphogenic response which can limit the damage to the leaf tissue due to UV radiation (Sarghein *et al.*, 2011). Harmful effects of UV radiation on plants at cellular levels include change in chemical composition of proteins, nucleic acids and lipids (Hollosy, 2002). These changes ultimately affect various physiological and biochemical processes of plants.

Table 1. Effects of seed treatment with UV-C on germination and seedling growth of maize*.

Treatments (minutes)	Germination (%)	Shoot length (cm)	Shoot weight (g)	Root length (cm)	Root weight (g)	Mean leaf area (cm^2)
0	73.33 ±13.3 a	36.22 ± 0.8 a	1.128 ± 0.12 a	23.22 ± 0.4 a	0.309 ± 0.01 b	34.93 ± 0.8 a
30	66.67 ± 6.7 a	27.11 ± 3.3 ab	0.573 ± 0.14 b	13.78 ± 0.8 b	0.218 ± 0.02 b	22.47 ± 3.3 b
60	66.67 ± 13.3 a	25.55 ± 2.4 b	0.750 ± 0.09 b	16.89 ± 2.6 b	0.302 ± 0.02 b	22.55 ± 3.3 b
120	80.00 ± 0.0 a	30.99 ± 2.2 ab	0.904 ± 0.12 ab	22.33 ± 2.1 a	0.541 ± 0.08 a	27.55 ± 2.5 ab
240	66.67 ± 6.7 a	22.22 ± 4.0 b	0.625 ± 0.10 b	18.06 ± 1.2 ab	0.398 ± 0.08 ab	21.75 ± 3.8 b
$LSD_{0.05}$	29.7	8.75	0.357	5.107	0.169	9.174

*, Data comprising mean of three replicates ± standard error. Figures sharing similar alphabet are not statistically significant at $p<0.05$ according to Duncan Multiple Range Test

The effects of UV radiation on plants have generally been studied by irradiation of their seedlings. In the present studies, maize caryopses, prior to their sowing, were irradiated with UV-C for various time periods. The seedlings resulting from these seeds exhibited reduction in growth which is in agreement with Tevini *et al*., (1991) who reported decline in sunflower and corn seedlings exposed to UV radiation. UV effects on growth are generally considered to be mediated by phytohormones (IAA) via photo-destruction or inhibition of some enzymatic reactions. The damages do occur to the chloroplasts, peroxisomes and mitochondria (Brandle *et al.,* 1977; Terumara *et al.,* 1991). It is certain that effects of UV radiation vary from species to species and cultivar to cultivar of a species (Sarghein *et al*., 2011). The results of our studies suggest that the exposure of maize caryopses to UV-C brings cytological, physiological or biochemical changes in the seeds which are translated in inhibition of growth of seedlings emerging from the irradiated seeds.

The root-infecting fungi, on the other hand, showed significant reduction in root colonization when maize caryopses were treated with UV-C radiation for different time intervals. *Fusarium* spp. was reduced at 60 and 120 minutes treatment while *R, solani* was completely suppressed when caryopses were treated for 30 minutes with UV-C. However, *M. phaseolina* at 30 and 120 minutes showed no colonization. UV-C irradiance for 30 and 120 minutes showed suppression of root infecting fungi. UV-C irradiance for 240 minutes enhanced colonization of root-infecting fungi (Fig. 1). Siddiqui *et al*., (2011) recorded reduced infection of root-rot fungi in mungbean and groundnut after treating seeds with UV radiations for various exposure times. Similarly, de Staaij *et al*., (2001) studied the effect of enhanced level of UV radiations on arbuscular mycorrhizal fungi (AMF) in roots of grassland plant species and found reduced infection percentages of AMF in roots of tested plant species. Frequency of phylloplane fungi are directly affected by UV radiation (Newsham *et al*., 1997). Growth, pigmentation and spore production of *Alternaria solani,* a leaf spot pathogen, were also affected by UV radiation (Fourtouni *et al*., 1998). It seems that UV-C irradiance altering some biochemical pathways of caryopses when exposed for different time intervals. UV-C exposure till 120 minutes was beneficial for plants against the colonization of root-infecting fungi but at 240 minutes of exposure this benefit shifted towards root-infecting fungi. There may be a critical time period for UV-C exposure between 120 to 240 minutes in the plant-fungi-interactions. Increased UV exposure alters the plant disease susceptibility and balance of competition (Teramura *et al.,* 1991). Further studies are required to elucidate this phenomenon.

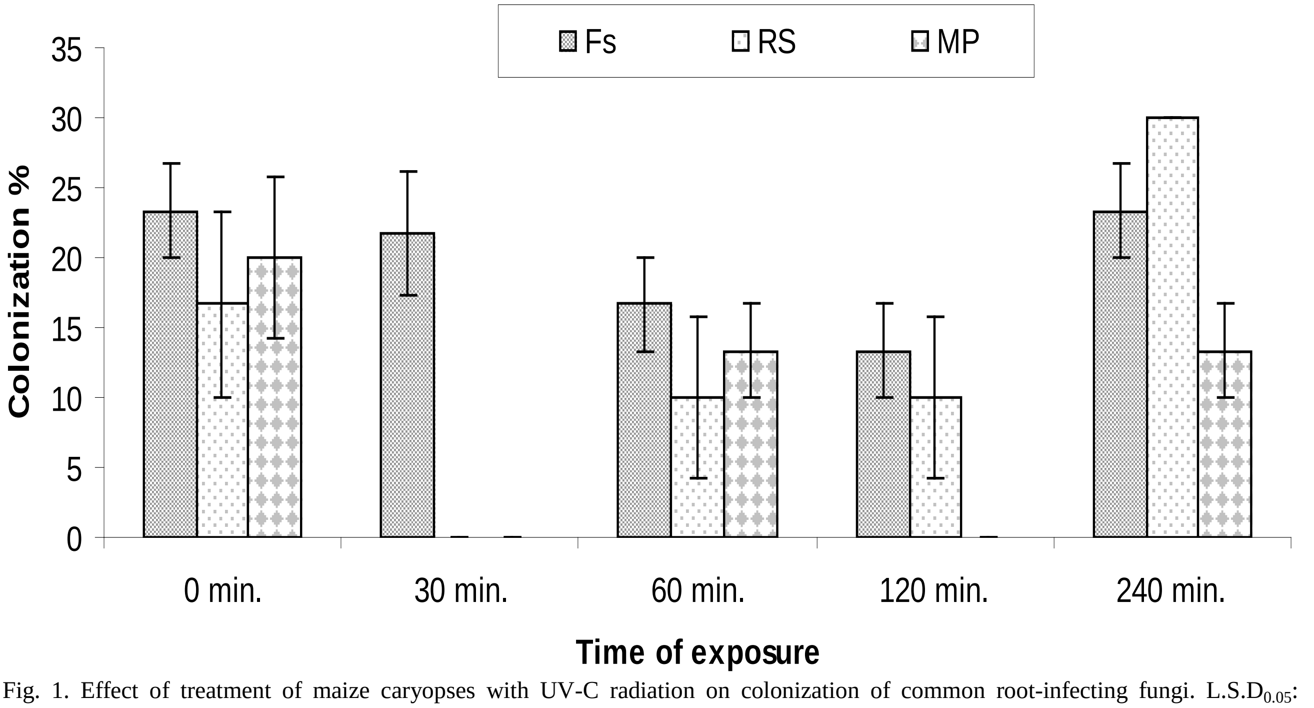

Fig. 1. Effect of treatment of maize caryopses with UV-C radiation on colonization of common root-infecting fungi. $L.S.D_{0.05}$: *Fusarium* species (FS), 11.26; *Rhizoctonia solani* (RS), 14.85 and *Macrophomina phaseolina* (MP), 10.50.

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