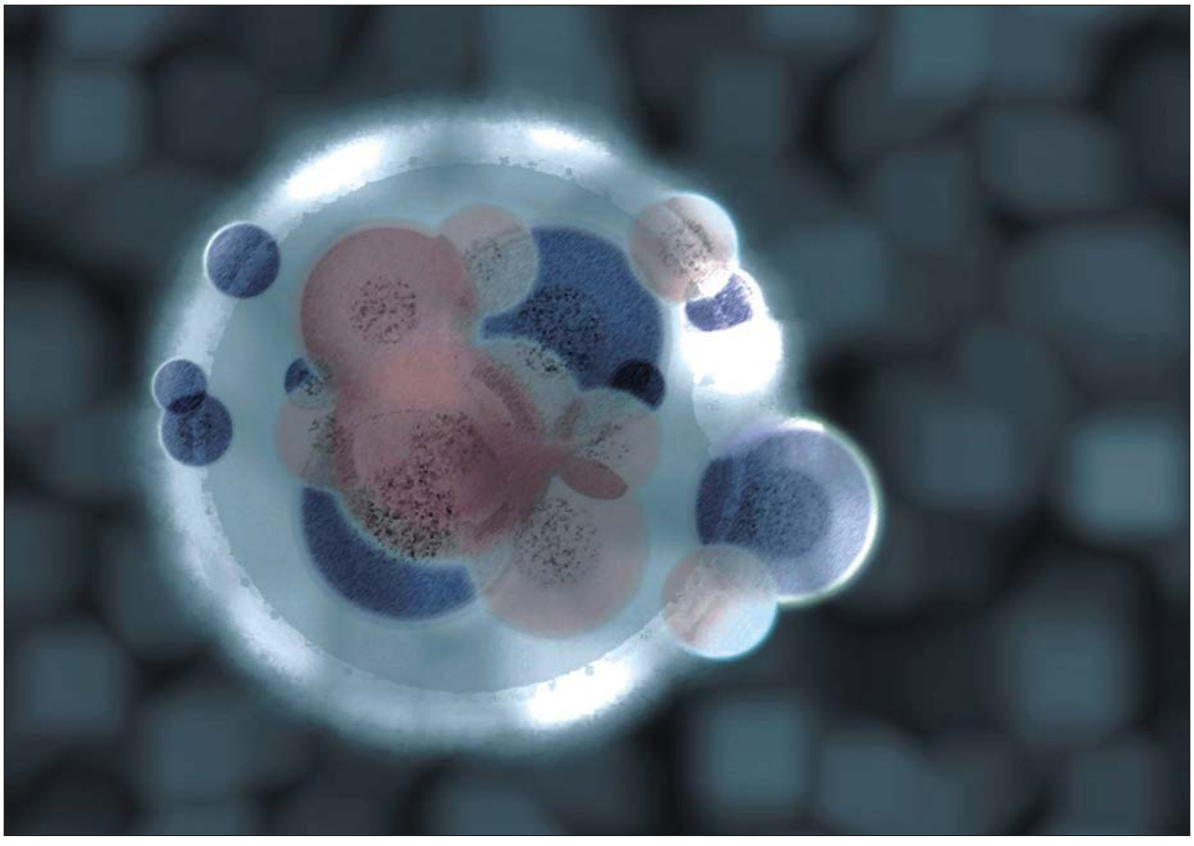

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Anatomical and Morphological Changes Caused by Interaction Between UV-C Radiation and Colonized Wheat by Some Species of Arbuscular Mycorrhizas

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Abstract: Among the harmful components of sunlight is ultraviolet radiation of wavelengths 220-380 nm. UV-C (220-280 nm) is one of the three UV spectra that is filtering out in the atmosphere, but it can cause oxidative and morphological changes in the some conditions. Vesicular arbuscular mycorrhiza can resist many plants against stress conditions. Wheat (*Triticum aestivum* L. cv. Azar2) plants colonized by three species of mycorrhizae namely *Glomus etunicatum, Glomus intraradices* and *Glomus veruciforme* were used in this study. They have been exposed to UV-C (245 nm) light for 7 h. We measured dry and fresh weight of shoot and root systems and length of the longest roots and leaves. Also, we measured percentage of root length colonization. Furthermore, number of mesophyll cells in each treatment is determined by staining the leaf cross sections. Mycorrhizal treated plants showed increased root length colonization in comparition to non-mycorrhizal treatment. However, no significant difference was observed in the leaves length all of the treatments. Also, fresh and dry weight was increased in UV treated mycorrhizal plants in comparition to non-inoculated ones. Infection percentages and number of mesophyll cells had not significant difference between mycorrhizal and non-mycorrhizal plants.

Key words: UV-C, *Triticum aestivum*, morphological changes, mycorrhiza

INTRODUCTION

Plants protect themselves from the effect of ultraviolet radiation by a range of acclimation responses. Short wavelengths of UV (λ<280 nm) interact with nucleic acids, proteins and a multitude of other molecules (Casati and Andreo, 2001). Typically, UV-acclimated plants possess an elevated capacity for DNA repair (Britt, 1999), contain high levels of enzymatic and non-enzymatic scavengers of Reactive oxygen specious (ROS), accumulate high levels of UV-screening phenolic metabolites and are altered in plant and leaf architecture (Jansen, 2002).

UV-C induces a range of morphological and anatomical effects on plants. These effects include thickening in the surface tissue, leaf thickening, inhibition of stem leaf longation and necrosis of leaves (Ries *et al*., 2000), shifts in the root-shoot ratio (Jansen, 2002). UV affects on reproductive morphology include increased flower diameter (Petropoulou *et al*., 2001). Auxins in particular, are implicated in developmental processes like elongation growth, photo-and gravitropism, apical dominance and lateral root initiation (Normanly, 1997). UV-radiation can impact on auxin metabolism (Jansen, 2001). The UV catalyzed photodestruction of auxin has been observed under *in vitro* conditions (Ros and Tevini, 1995). So, this photooxidation of IAA induces morphologic responses in plants (Ballare *et al*., 1995).

Vesicular arbuscular mycorrhizae form mutualistic associations with the roots of about 80% of all terrestrial plant species and are abundant in the soil of most ecosystems (Van de Staaij *et al*., 2001). These fungi are important in tolerance of plants against stress conditions. In a greenhouse experiment, mycorrhizal association of *Acer saccharum* (sugar maple) showed reduced number of arbuscules, when the host plants were grown under increased UV-B fluxes (Klironomos and Allen, 1995). The other work in the field conditions on *Calamagrostis epigeios* and *Carex arenaria* also obtained such results (Van de Staaij, 2001).

MATERIALS AND METHODS

Inoculum production: Pot cultures of the Arbuscular Mycorrhizal (AM) fungi *Glomus etunicatum, Glomus intraradices* and *Glomus veruciforme* were initiated on corn (*Zea mays* L.) in a greenhouse during the April to July 2006. Soil used for production of mycorrhizal inoculum was collected from the field and mixed with sand (1:5 w/w) and 100 g fungal inoculum. Soil and sand was autoclaved before mixing at 121°C for 4 h. Plants were grown at 32°C under 18 h light and 8 h dark periods and were illuminated by white fluorescent light and sodium lamp with total irradiance of about 75 $\mu E\ m^{-2}\ s^{-1}$. Rorison's solution was used as nutrient medium.

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Finally, roots were removed from the soil, cut and then mixed with the soil. This culture included soil/sand mixture, hyphae, spores and colonized roots.

Plant treatment: Wheat (*Triticum aestivum* L. cv.Azar2) seeds were sterilized with 10% sodium hypochlorite solution for 10 min and washed thoroughly with distilled water. Then, seeds were planted in autoclaved soil/sand mixture (1:3 w/w) and 50 g of fungal inoculum in AM treatments. Each treatment was replicated 3 times. Plants were grown at 27°C under 14 h photoperiods and were illuminated by 75 μE m^{-2} s^{-1}. They were exposed to UV-C lamp after 28th day. UV-C radiation was produced by a germicidal lamp (254 nm) that providing an irradiation dose of approximately 40 W m^{-2}. Plants were grown for 50 days and exposed to UV-C lamp for 7 h. The distance between lamps and samples was 50 cm. Plants watered with half strength of Hoagland's nutrient solution. The root system of each plant was separated from the shoot and fresh and dry weight and the length of roots were measured. Root length colonization by arbuscular mycorrhizal fungi were determined using gridline intersect method (Phillips and Hayman, 1970). Leaf sections were stained by free hand sectioning method.

RESULTS

Irradiation of UV-C caused a decrease in root length of UV treated samples (Fig. 1). However, this reduction was higher in non-mycorrhizal than mycorrhizal plants (Fig. 2). Noting the effects of UV irradiation on fresh weight of roots (Fig. 3), a decrease in fresh weight was observed, but non-mycorrhizal plants have a lower fresh weight than that of mycorrhizal samples. Also, similar results were observed about the effect of UV-C radiation on fresh weight of shoot system (Fig. 4).

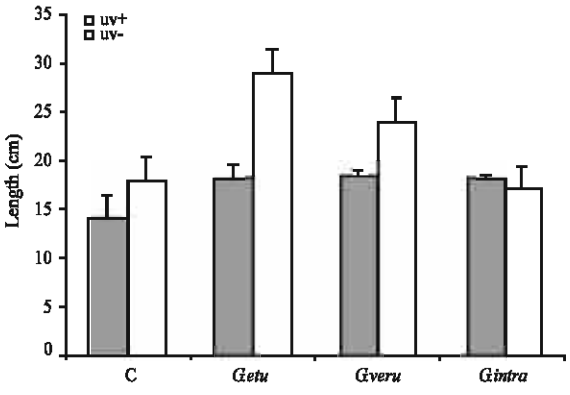

Fig. 1: Effect of UV-C on root growth of mycorrhizal and non-mycorrhizal wheat plants

Figure 5 shows that UV-C radiation has caused significant decrease in dry weight of the roots and this reduction was generally higher in non-fungal plants. Such result has been observed for dry weight of the shoots (Fig. 6). Non-irradiated plants had more root length colonization than irradiated ones, but these differences were not significant (Fig. 7). Finally, staining and observation leaf sections showed that the number of mesophyll cells was the same in the all treatments, but a slight increase was observed in the sections of the non-mycorrhizal UV-C treated plants (Fig. 8).

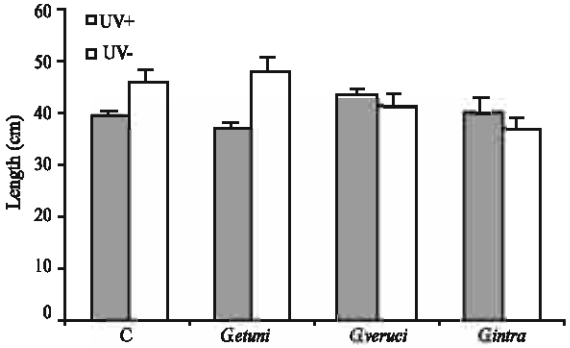

Fig. 2: Effect of UV-C on the longest leaves growth in mycorrhizal and non-mycorrhizal wheat plants

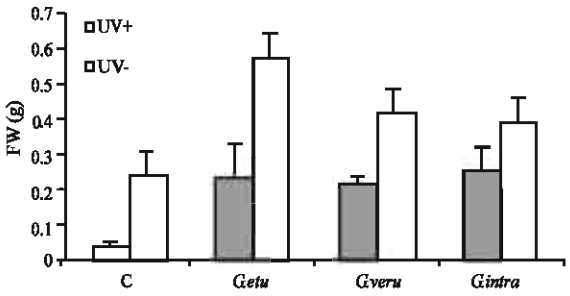

Fig. 3: Effect of UV-C on fresh weight of roots in mycorrhizal and non-mycorrhizal wheat plants

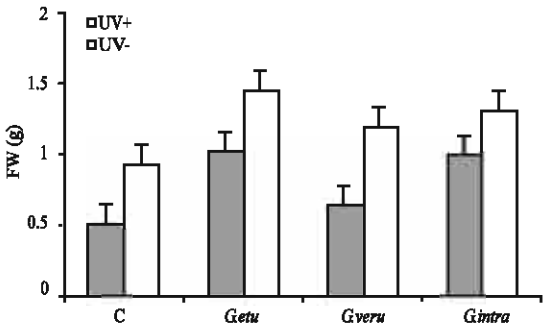

Fig. 4: Effect of UV-C on fresh weight of shoots in mycorrhizal and non-mycorrhizal wheat plants

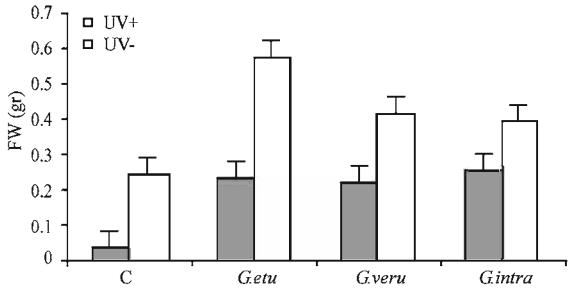

Fig. 5: Effect of UV-C on dry weight of roots in mycorrhizal and non-mycorrhizal plants.

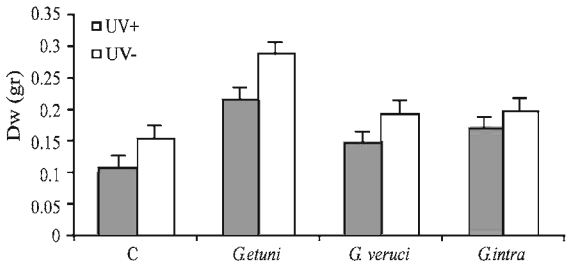

Fig. 6: Effect of UV-C on dry weight of shoots in mycorrhizal and non-mycorrhizal wheat plants.

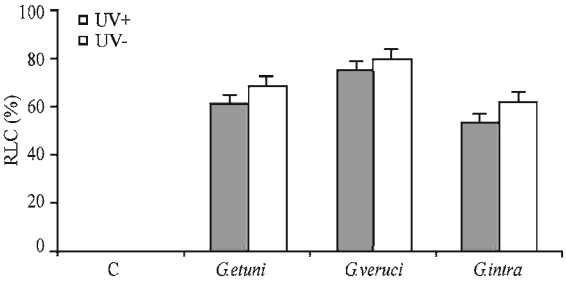

Fig. 7: Effect of UV-C on root length colonization in mycorrhizal and non-mycorrhizal wheat plants.

DISCUSSION

UV-C radiation has been used as a mutagenic agent in plants and has several negative effects on morphology and anatomy of plants (Stapleton, 1992). Also, in mycorrhizal plants, UV-C may affect on arbuscular mycorrhizal infection percentages (Van de Staaij, 2001). Several studies have suggested that UV-C radiation could be involved in morphological changes and plant growth. UV radiation could affect on root-shoot ratio (Ballare, 1990) and stem and leaf elongation (Jansen, 2002). Also, UV radiation may reduce infection by arbuscular mycorrhizal fungi (AMF) (Van de Staaij, 2001).

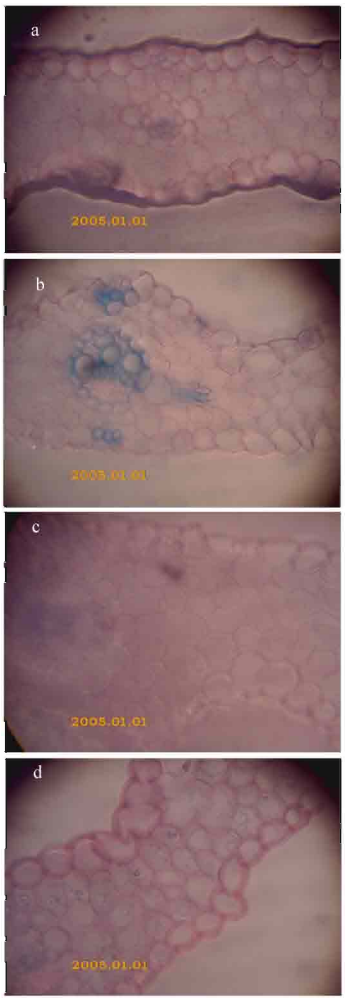

Fig. 8: No. of mesophyll cells. a: The image of leaf section from wheat plant that colonized by mycorrhiza in absence of UV radiation (X100), b: The image of leaf section from wheat plant that colonized by mycorrhizain presence of UV radiation (X100), c: The image of leaf section from non- mycorrhizal wheats in presence of UV radiation (X100), d: The image of leaf section from non- mycorrhizal wheats in absence of UV radiation (X100)

It has been observed that UV radiation has no effect on hyphal infection and number of vesicles, because UV can not penetrate in the soil and its effects result via above ground part of the plants. The main effect of UV on AMF is a reduction in the number of arbuscules. Therefore, decrease in root length colonization by AM may be a result of reduction in the number of

arbuscules. Since arbuscules are the structures in which exchange of nutrients between the partners takes place, a reduction in their number reduces the yields of this association.

Causing the reduction of growth in UV treated plants, two mechanisms can be involved. The first mechanism is decrease in arbuscule number. Since, the uptake of nitrogen, phosphorus and water from the soil takes place in arbuscules (Koide and Mosse, 2004), decrease in these structures may decrease plant growth. The second mechanism involves changes in IAA metabolism during UV-C treatment. IAA absorbs strongly in the UV part of spectrum and the levels of this hormone reduce during photooxidation (Ros and Tevini, 1995). Since IAA regulates the plant growth, any decrease in the level of this phytohormone can lead to reduction of plant growth in compare with non-irradiated samples. In the other hand, IAA can enhance development of mycorrhizal symbiosis. In one study on maize, it has been suggested that IAA can increase development of AMF symbiosis (Fitze *et al*., 2005).

In this study, we observed necrosis in the leaves of wheat plants that have been exposed to UV-C radiation. UV radiation causes damage of photosynthetic apparatus (Stapleton, 1992). It may be due to necrosis and loss of chlorophyll in leaves of plants.

In this study fungal treatment increased growth of mycoorrhizal plants in compare with non-mycorrhizal plants, that indicates the effect of this association in the resistance of plants against UV oxidative stress.

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