Effects of salicylic acid on photosynthetic pigment content in *Ocimum basilicum* L. under UV-C radiation stress

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Abstract

Basil plants (*Ocimum basilicum* L.) were sprayed with salicylic acid (1mM) and exposed to Ultraviolet-C (UV-C) radiation (40 Wm^{-2}) after emergence of six developed leaves. Plants were grown for 18 days and exposed to UV-C for 5 $mind^{-1}$ alternatively. Chlorophyll a, chlorophyll b and carotenoide were considered for analysis of photosynthetic pigments. The results showed that the photosynthetic pigments were decreased under UV-C radiation. Decreasing of photosynthetic pigments under UV-C radiation was significantly alleviated by salicylic acid treatment.

Key words: basil, UV radiation, salicylic acid, photosynthetic pigments

Introduction

The role of salicylic acid (SA) as a defense signal in plants has been well established in tobacco and *Arabidopsis* (Delaney et al., 1994). As an important endogenous signal molecule, SA has been proven to be a major component in signal transduction systems, which can induce particular enzymes catalyzing biosynthetic reactions and is essential for the development of systemic acquired resistance (Van Loon and Antoniw, 1982). In addition to its role in plant pathogenesis (Shulaev et al., 1997), SA is also believed to play role in plant responses to abiotic stresses such as ozone and ultraviolet (UV) light (Yalpani et al., 1994; Sharma et al., 1996; Rao and Davis, 1999), heat (Dat et al., 1998; Senaratna et al., 2000**;** Larkindale and Knight, 2002), chilling, drought stresses (Senaratna et al., 2000), salt and osmotic (Borsani et al., 2001). These studies suggest that while moderate doses of SA enhance the antioxidant status and induce stress resistance, higher concentrations activate a hypersensitive cell death pathway and increase stress sensitivity. Besides, parallel increases in SA and pathogenesis-related proteins have been reported in plants exposed to UV-C light and ozone, which suggests a common signal transduction pathway in plant responses to biotic and abiotic stresses (Yalpani et al., 1994).

Plants use sunlight for photosynthesis and, as a consequence, are exposed to the ultraviolet radiation that is present in sunlight. UV radiation is generally divided into three classes: UV-C, UV-B, and UV-A. The UV-C region of the UV spectrum includes wavelengths below 280 nm; these highly energetic wavelengths are effectively absorbed by ozone in the strato- sphere and, thus, are not present in sunlight at the earth surface. UV-C wavelengths will be removed from the light reaching the earth's surface so long as there is any ozone presents (Caldwell et al 1989).

The aim of this work is to determine the effect of SA treatment on basil plants under UV stress. The present study was aimed at evaluating a putative relationship between mechanisms of photo- and antioxidative protection and SA accumulation in UV stress.

Material and methods

***Plant material*:** Seeds of sweet basil (*Ocimum basilicum* L.) were grown in pots filled with sandy loam soil in the greenhouse at 22/20˚C (day/night), and 16/8 h light/dark photoperiod for 56 days. These pots were irrigated daily by Hoagland solution. The plants were divided into four groups: 1. control plants; 2. plants treated with SA; 3. plants treated with UV-C; 4. plants treated with SA and UV-C. Salicylic acid (1 mM) was sprayed on the leaves to the six leaves stage for 4 successive days. Basil plants were exposed to UV-C radiation after emergence of six developed leaves. UV-C was produced by a UV lamp (250 nm) that providing irradiation dose of approximately 40 Wm^{-2} from 50

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cm distance. Plants were grown for 18 days and exposed to UV-C radiation for 5 $mind^{-1}$, alternatively.

Assay of photosynthetic pigments: Photosynthetic pigments were extracted from leaves in 80 % aqueous acetone and content of chlorophyll a, b, carotenoide were estimated spectrophotomertrically in 662, 645 and 470 nm as described by Lichtenthaler (Lichtenthaler and Wellburn, 1985).

Results

Figure 1 shows the effect of UV-C and SA on photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoide) of leaves in basil. Results indicated that the chlorophyll a and chlorophyll b content were decreased under UV-C stress. Foliar spray of SA in concentration of 1mM alleviated the reduction in chlorophyll a and b content in both UV treated and control plants. Carotenoid content of plants were exposed to UV-C decreased but this decrease was not significant. SA treatment moderated carotenoide reduction.

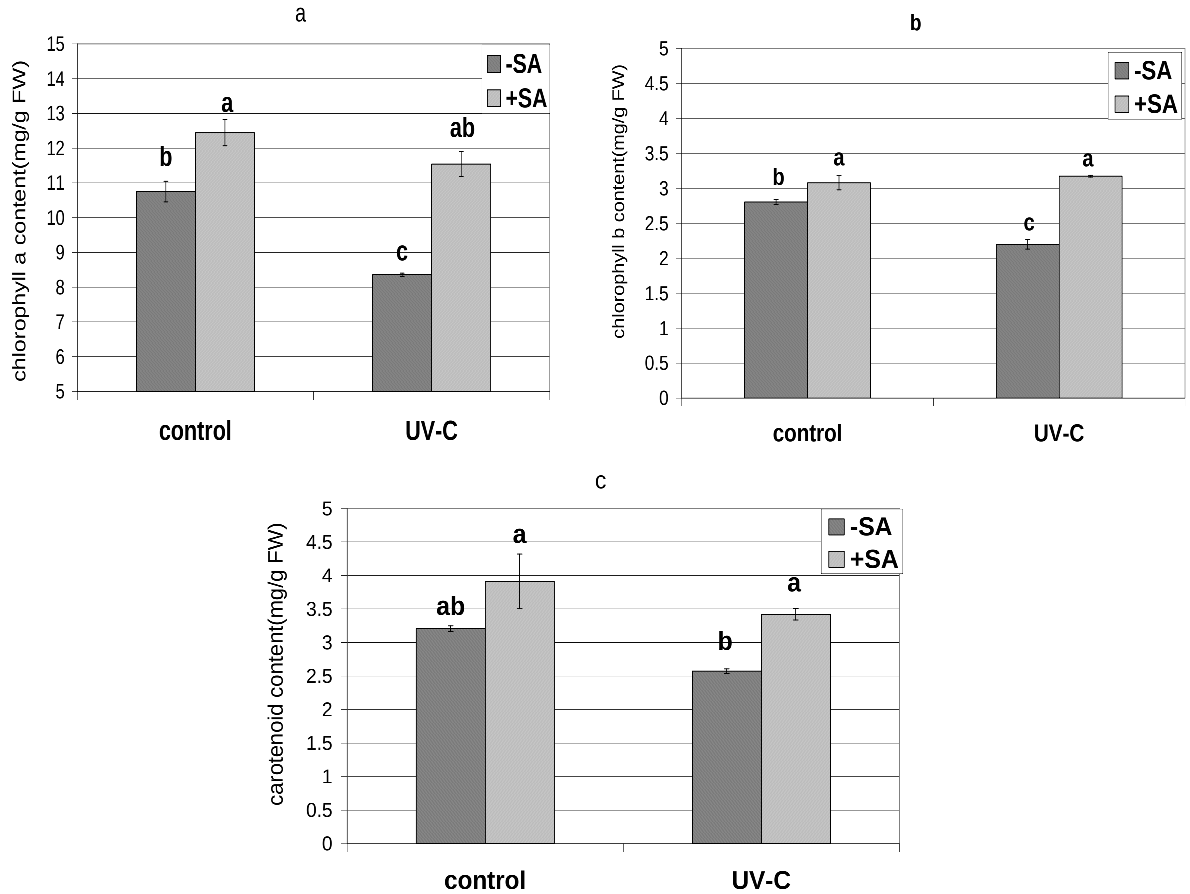

Figure 1: Effects of salicylic acid on the photosynthetic pigments (chlorophyll a (a), chlorophyll b (b) and carotenoide (c)) of basil plants under UV-C radiation. Different superscripts on bars (each duration) showed significant ($P < 0.05$) difference between the means according to Duncan test.

Discussion

Decrease in contents of photosynthetic pigments under UV-C stress is in agreement with findings of Mahdavian *et al.* (2008) in pepper (Mahdavian et al., 2008) and Takeuchi et al. (2002) in rice (Takeuchi et al., 2002). UV light causes multiple effects on the photosynthesis machinery, including loss of plastoquinone, Rubisco and chlorophylls, and degradation of phycobiliproteins in cyanobacteria. Electron transport through PSII is highly sensitive to UV light and the inhibition of electron transport through PSII under UV light is accompanied by lowering of variabled fluorescence chlorophyll *a* and lowering of the intensities of the thermoluminescence Q and B bands (Esa, 2008). UV damages chloroplasts that led to decrease of chlorophyll content (Teramura and Briggs, 1996)

Caldwell et al. (1995) concluded that in sensitive plants, UV-B and UV-C significantly decreased chlorophyll contents, primarily because UV destroyed the structure of chloroplast, inhibited synthesis of chlorophyll and increased the rate of chlorophyll degradation (Caldwell et al. 1995). Rahmatzade and Khara showed that UV-C radiation reduced chlorophyll a, b and carotenoides in wheat plants (Rahmatzadeh and Khara, 2007). Du and Jin (2000) showed that the carotenoids and chlorophyll decreased with treatment of UV-C irradiation (Du and Jin, 2000).

Foliar spray of SA in concentration of 1 mM increased photosynthetic pigments in both UV treated and control plants (Figure 1). It is consistent with the result of Mahdavian et al., 2008 (Takeuchi et al., 2002). Sinha et al. (2003) concluded SA-treated maize plants contained more chlorophyll and carotenoide than the control plants (Sinha et al., 1993). Zhao et al. (1995) reported that photosynthetic pigment contents increased in soybean plants treated with SA (Zhao et al., 1995). According to the results of Ervin et al. (2004) and Janda et al. (1999), foliar application of SA may alleviate the decline in photochemical efficiency and turf quality (Ervin et al., 2004; Janda et al. 1999).

There are not good experimental evidences for the roles played by SA in stability of chlorophylls in plant tissues. However, there is two ways for increasing the level of a certain compound in tissues: promotion of *de novo* synthesis and suppression of degenerative processes. It seems that SA inhibits the synthesis of ROS and also can inactivate them. Removal of ROS can protect chloroplast membranes and may stabilize chlorophylls subsequently. Increasing of photosynthetic pigments in UV- stressed plants in response to SA may be related to the induction of antioxidant responses that protect the plant from damage. Cheng *et al.* (1996) suggested a hypothesis for the *in vivo* antioxidant activity of salicylic acid (Cheng et al., 1996). Moreover SA might serve as a regulator of biogenesis of chloroplasts (Uzunova and Popova, 2000).

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