REVIEW ARTICLE

Ascorbic Acid As A Protective Agent For Plants Against Ultraviolet Radiation

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ABSTRACT

Out of all the rays of sun light, the ones that have affected our plants in a dangerous way are ultraviolet radiations. The penetration of UV-B radiation through the atmosphere due to ozone depletion is having cataclysmic effects. In recent years, due to its antioxidant properties, Ascorbic acid is being increasingly investigated for its possible role in protecting plants against ultraviolet radiation. This paper gives a brief review of the research which has been carried out establishing vitamin C as a protective agent for plants, as a defense against ultraviolet radiation.

1. INTRODUCTION

1.1. ULTRA VIOLET RADIATION

The sun is a primary source of light and energy on Earth. The rays of sunlight reach us in the form of electromagnetic radiations which are x-rays, gamma rays, infrared rays, visible rays, microwaves, radio waves and ultraviolet radiations (UV rays). Out of all these rays the ones with the most devastating adverse effects on plants are UV rays. They have a wavelength of 200 to 400 nm.

UV RADIATIONS CAN BE CATEGORISED INTO THREE CATEGORIES:

1. UV-A (315-400 nm.)
2. UV-B (290-315 nm.)
3. UV-C (100-290 nm.)

1.2. THE NEGATIVE EFFECTS OF UV RAYS ON PLANTS:

UV-C radiation is absorbed by the super atmospheric ozone layer; whereas UV-B radiation is absorbed by the Earth's ozone layer. The depletion of the ozone layer allows the penetration of UV-B radiation through the atmosphere culminating in catastrophic changes. Several European studies have reported the dangerous implications of UV-B radiation on plants. Some of these effects are

1. UV radiations inhibit the growth processes of almost all the green plants.
2. The reduction in total dry weight, with reduction in growth of plants in the Pea and Cabbage family [1].
3. Reduction in plant size, leaf area, fresh and dry weight, lipid content and photosynthetic activity.
4. Decrease in crop yield, seed production etc.
5. There are good evidences of potential yield loss from increased UV-B intensity in Soybean and Pea.
6. Several scientists investigated UV-B effects on flowering. [2-4].
7. UV-B radiations absorbing pigments and diffusing conductance of water vapor through stomata also have been reported by [5].

1.3. ASCORBIC ACID

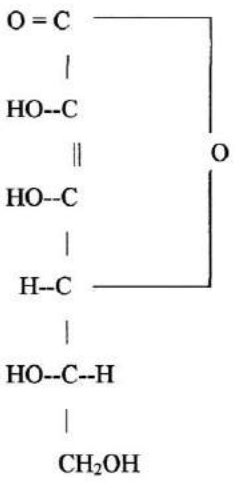
Ascorbic acid is also referred to as vitamin C, Cevitamic acid and Antiscorbutic acid.
Vitamin C is the most prolific source of antioxidants in plants. As a consequence, it is being increasingly investigated if ascorbic acid can confer some protection to plants against air polluting gases.

OCCURRENCE & PROPERTIES:

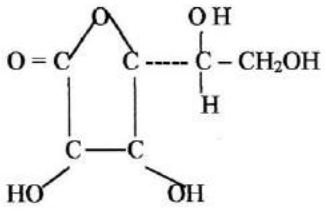
1. Vitamin C occurs abundantly in fruits such as citrus fruits, lemons, limes & grapes.
2. The leafy green vegetables such as spinach, cabbage, tomatoes etc. contain plenty of vitamin C.
3. It is a colorless, odorless, crystalline substance, slightly sour in taste and optically active.
4. Melting point - 190-192° C.
5. It is soluble in water & insoluble in ether, alcohol and sterols.
6. Molar mass- 176.1256 g/mol.
7. Density-1.7 g/ml.
8. Alkalies destroy its activity but it is stable in weak acid solutions.
9. It spares vitamin A, E, & some B complex from oxidation.

1.4. STRUCTURE OF ASCORBIC ACID

Walter Haworth was awarded the Nobel Prize in 1973 for determining the structure of ascorbic acid ($C_6H_8O_6$). It is a derivative of hexose called L–glucose.



(L- ASCORBIC ACID)



(HAWORTH'S RING)

2. ASCORBIC ACID AS AN ANTIOXIDANT

- Oxidation is a chemical reaction that transfers electrons or hydrogen from a substance to an oxidizing agent.

- Oxidation reactions can produce free radicals. In turn, these radicals can start chain reactions. When the chain reaction occurs in a cell, it can cause damage or death to the cell.

- An antioxidant is a molecule that inhibits the oxidation of other molecules. The antioxidant Ascorbate terminates the chain reactions by removing the free radical intermediates, by donating electrons and hydrogen ions and reacting with Reactive Oxygen Species of the free radical.

- Free radical oxidizes ascorbate first to monohydroascorbate and then dehydroascorbate. The free radical reduces to water, while the oxidized form of ascorbate is stable and does not cause cellular damage.

3. REVIEW OF LITERATURE

3.1. IMPACT OF UV-RADIATIONS ON PLANTS:

[6-15] have written reviews of UV-B effects in terrestrial plants which have been published during the last decade. Terrestrial plants exposed to UV-B radiations have been shown to have many biological and physiological changes and effects but much is yet un deciphered. Crop plants growing in temperate regions have been studied at length but plants growing in tropical regions and non crop plants have been less studied. More than 300 plant species and cultivars have been studied and about 50% of these plants have proved to be UV-sensitive in relation to negative biochemical, physiological, or morphological changes brought about by UV-B.

In many sensitive plant species like, Wheat, Rice, Sunflower, Cucumber, Maize, Rye and Soybean, reduced leaf area and stem growth have been found [16-20]. Plant height and leaf area which are growth parameters, were found to be significantly reduced by higher UV-B radiation [21]. An influence response relationship was demonstrated for leaf area and hypocotyls length of Cucumber and Sunflower seedlings, which were grown under artificial UV-B radiation in growth chambers [22].

Several scientific investigations have proved that by excluding UV-B radiation by plastic films or glass, flowering is stimulated in *Melilotus*, *Trifoliumdasyphyllum and Tagetes*[23-25]. Compared to plants merely irradiated with white light, UV-B influence resulted in the inhibition of photoperiodic flower induction. For example, the long day-plant *Hyoscyamusniger* [26].showed a 20% decrease of flowering resulting from irradiation with, 100 mwm^{-2} UV-B, a 50% reduction from 300 mwm^{-2} UV-B.

Enhanced UV-B radiation has negative growth impact on trees like conifers, especially the seedlings [27].Ozone filter technique was used to intensively study the biochemical composition of sunflower and corn seedlings and their growth physiological function[28]. Growth parameters like plant height and leaf area were significantly reduced for both type of seedlings under the higher UV-B radiation. Results obtained in previous studies on other plant species with artificial UV-B application in green house and in the fields or in growth chambers confirm these observation.[29-30] Multiple sites of UV-B inhibition have been demonstrated throughout the years with the most sensitive site around photosystem II [31-34]. Much more resistance to UV-B radiation is obseved in Photosystem I [35-38].In contrast, ribulose 1, 5-biphosphate carboxylase (Rubisco), the key enzyme of the Kelvin cycle, has recently been shown in pea leaves, to be very UV-sensitive [39].

3.2. IMPACT OF ASCORBIC ACID ON PLANTS:

The participation of ascorbate in the scavenging of hydrogen-peroxide was demonstrated at the end of 1970's which highlighted a major function of ascorbate in plant cells [40-41].

Tanaka *et al.* (1985) suggested a possible relationship between ascorbic acid content and tolerance to O_3 after observing different Spinach varieties. 6)suggested that in the leaves of soybean Ascorbic acid in the leaves of soybean, because of its free radical scavenging property, may protect the leaf cells from injury by ozone or other oxyradical products.

Ascorbate, in its role as an antioxidant, is a component of the regulatory system that serves to coordinate supply and demand in photosynthesis [42]. The ascorbate system is involved not only as an antioxidant protecting against H_20_2 and other oxygen radicals, but it is also intimately associated with the process of photosynthetic control and energy dissipation [43]. Ascorbic acid is highly concentrated in the chloroplast in green plant tissues [44]. It has been estimated that 35-40 % of the cells total ascorbic acid may be present in its chloroplast [45].

4. FUTURE DIRECTIONS

The fact that UV-B radiations are imparting a large number of effects on plants is evident from the Review of literature. Being in a tropical country, the Indian plants are subjected to comparatively warmer conditions than the temperate plants of European and American countries on which majority of the studies have been carried out.

Considering the native conditions of the country, the plants are much more susceptible to UV-B radiation. These effects of UV B radiations are countered by plants which have developed their own mechanisms of synthesizing ascorbic acid. It must be kept in mind that this chemical might be generated in these plants at optimal or sub optimal levels.

The purpose of future studies should be to establish vitamin C (provided externally) as a protective agent for these tropical plants. Provided a positive correlation comes out between these tropical and subtropical genera and the ascorbate concentration in this tropical climate is found out to be sub-optimal, the concentration within the plant can be enhanced by various plant breeding methods.

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