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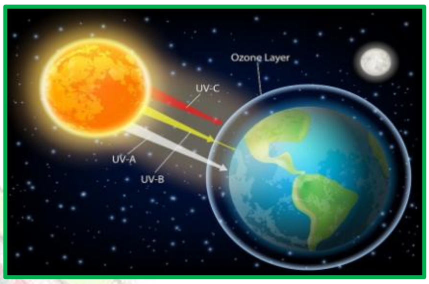
Role of UV-B Radiation in Production and Post-Harvest Management of Fruits

(*Vittal Kamble and Sangeetha Priya S.)
ICAR - Indian Institute of Horticultural Research, Bengaluru, Karnataka - 560 089
*Corresponding Author's email: vittalhort@gmail.com

UV-radiation which is considered as harmful for the cultivation of fruit crops exerts positive effects in improving the production and postharvest quality of fruit crops. It was reported to improve the plant growth, stomatal regulation, insect and disease control and climatic adaptation. It also enhances the post harvest life and quality of fruits by maintaining the firmness and enhancing the anti-oxidant activity.



Types of ultraviolet (UV) radiations

Introduction

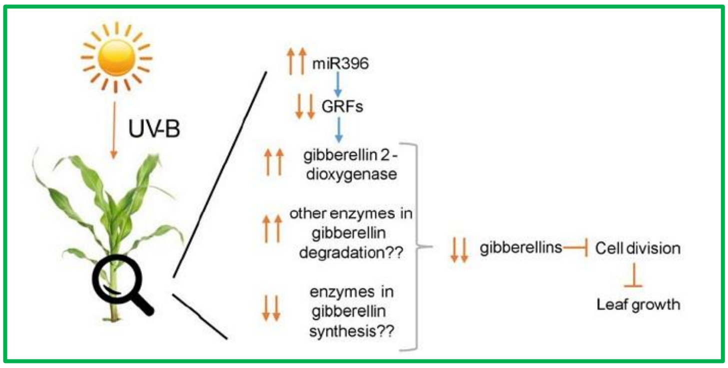
Ultraviolet (UV) radiation comprises a relatively minor fraction of the total solar radiation reaching the earth's surface and it is known to have both positive and negative effects on plants. Highly energetic shorter wavelengths of solar UV-B (290–315 nm) can potentially induce a number of deleterious effects on plants. Traditionally UV-B has been considered as stressor. However, recent studies have highlighted that the regulatory properties of low, ecologically relevant UV-B levels trigger distinct changes in the plants secondary metabolism resulting in an accumulation of these compounds.

Mechanisms through which UV-B induces changes in the plants and fruits

1. **Activation of secondary metabolism:** UV-B exposure activates the phenylpropanoid pathway, leading to the synthesis of phenolic compounds. These compounds, including flavonoids and anthocyanin, have antioxidant properties and contribute to the plants defence against UV-B radiation and other environmental stressors (Henry-Kirk, 2017).
2. **Stimulation of defence mechanisms:** UV-B exposure induces the expression of specific genes involved in stress responses. These genes play a role in the plants defence mechanisms, helping it cope with environmental challenges. UV-B radiation can also cause DNA damage in plant cells. In response, plants activate DNA repair mechanisms to mitigate the negative effects.
3. **Modulation of fruit morphology:** UV-B exposure to plants can influence the pigmentation of fruits by promoting the synthesis of pigments such as anthocyanin. This often results in changes in fruit colour. UV-B radiation may also affect the development of fruits which results in variation of fruit size and shape. The specific effects can depend on the plant species.
4. **Integration of signalling pathways:** UV-B responses are often integrated with other signalling pathways, including those involved in light perception and stress responses. This integration allows plants to coordinate their responses to multiple environmental factors.

5. **Regulation of hormonal pathways**: UV-B radiation can influence the levels and activities of plant hormones such as auxins, gibberellins and abscissic acid. These hormonal changes play important role in various aspects of plant growth, development and stress responses.
6. **Species-specific responses:** The effects of UV-B radiation can vary among different fruit species. Some fruits may show enhanced quality and resistance, while others may exhibit different responses or even susceptibility to UV-induced stress.

Effect of UV-B on plant system



Solar UV-B inhibits the growth of maize plant (Source: Peter Minorskey, 2017)

1. **Plant growth:** Plants respond to environmental changes by the adjustment in their morphology and growth patterns. It has been shown in several experiments that UV-B is negatively associated with biomass production in plants producing fruits. The leaf area is highly affected by UV-B and mainly decreases with higher levels by reduction of the leaf length. Affecting the leaf architecture by thicker epidermis and consequently denser leaves. A very obvious effect of UV-B on plants is the reduction of plant height. This is mainly due to reduced elongation of plant stems and internodes.
2. **Net photosynthesis:** Photosynthesis is one of the most sensitive metabolic processes and is directly linked to biomass production and yield. Reduction in biomass accumulation due to UV-B exposure was found in several plant species which ultimately reduce crop yield due to loss of rubisco enzyme activity, activity of sedoheptulose 1,7-biphosphatase and probably that of other Calvin cycle enzymes and with damage to PSII photochemistry. UV-B radiation causes changes in leaf colour and ultimately results in chlorosis, necrosis, desiccation of the leaves and decrease in leaf chlorophyll content. Damage to chloroplasts and photosynthetic pigments change results in reduction of photosynthesis (Sullivan and Rozema, 1997).
3. **Stomatal regulation:** Stomatal regulation is another important process limiting leaf photosynthesis. Reduction in stomatal conductance in response to UV-B radiation has been observed. High UV-B irradiances affect stomata directly by acting on the guard cell aperture and indirectly through changes in the mesophyll photosynthesis (Teramura, 2006). These effects could be due to damage to PSII in the guard cells, affecting photophosphorylation and hence ion transport.
4. **Protection, adaptation and repair:** Plants acquire diverse defence mechanisms which greatly modulate the sensitivity of the photosynthetic apparatus to UV-B radiation. These protective mechanisms include morphological changes such as increased length of epidermal cells, production of a waxy cuticle, accumulation of UV-B absorbing compounds and formation of various reactive oxygen species (ROS). Plants can reduce the impact of UV-B radiation on the photosynthetic system by developing a complex set of repair mechanisms including photoreactivation, excision and recombination repair. DNA is particularly sensitive to UV-B radiation because absorption of UV-B causes phototransformations, resulting in the production of cyclobutane pyrimidine dimers

(CPDs) and pyrimidine (6-4) pyrimidinone dimers (6-4 PPs). CPDs can be repaired by all of these repair mechanisms.

5. **Insects and pathogens:** In plant-environment interactions the plant has developed strategies to defend against enemies. Light and in particular UV-B radiation were shown to have high potential in the crops protection against insects and pathogens by the enhancement of phenolic compounds and the induction of defence genes. Chlorogenic acid induced by UV-B can participate in plants defences mechanism against insects. Furthermore, high rutin concentrations are associated with deterred the feeding of polyphagous insects.
6. **Plant responses**: low UV-B influence photomorphogenic responses in plants, characterized by the inhibition of hypocotyls growth, cotyledon expansion, biosynthesis of anthocyanins and flavonoids and stomatal opening (Favory, 2009). These responses are mediated by a recently characterized photoreceptor UV RESISTANCE LOCUS8 (UVR8) and are required for plants acclimation to UV-B stress. UVR8 is a UV-B photoreceptor which exists in the form of dimers in plants.

Irradiation in postharvest management of fruits

Irradiation is a process of controlled application of energy from ionizing and non-ionizing radiations to increase the safety and shelf-life of food. Irradiation kills microbes primarily by destroying DNA. Hence, prevents proliferation on of microorganisms such as bacteria, viruses, mould and yeast. The sensitivity of the organism increases with the complexity of the organism.

UV-B radiation for controlling postharvest diseases

Amongst physical methods, non-ionizing radiation has a potential for controlling postharvest diseases. Low dosage of short-wave UV-B (280-315 nm) can control storage rots of many fruits by targeting the DNA of microorganism. Hence it is used as a germicidal or mutagenic agent. In addition to this, UV-B irradiation can modulate induced defence in plants. At appropriate wavelength and dose, UV-B irradiation can stimulate accumulation of stresses induced phenylpropanoids and pathogenesis related proteins. The effect of UV radiation in reducing green mould in grapefruit is mediated through the host response, rather than being the only result of the germicidal action of the UV treatment.

Beneficial effects of UV-B in storage

- Maintain firmness in post-harvest storage of fruits
- It promotes the accumulation of total phenol and total flavonoids
- Enhanced antioxidant capacity during storage
- UV-B irradiation is beneficial for maintaining sensory qualities
- Increase in storage life of fruits
- Protect the fruits from chilling injury in cold storage

Conclusion

Enhanced UV-B exposure causes several primary effects on plant growth. These primary effects have subsequently led to a number of secondary and tertiary effects resulting in altered crop growth and development, which in turn affected light interception that lowered canopy photosynthesis, reduced fruit numbers and retention and finally biomass and yield reductions. However, lower levels of UV-B have more beneficial effects on plant growth and development. Furthermore, UV-B irradiation technology promises to offer an effective mean for minimizing postharvest loss and it also provides an effective and safer alternate to synthetic fungicides that are being phased out because of ecological or human health concerns. Radiation technology can complement and supplement existing technologies and can be efficiently used for insect disinfestations, maintenance of nutritional or functional components during storage.

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