Effect of ultraviolet radiation on the health and secondary metabolism of *Coriandrum sativum*

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Abstract:

Ultraviolet radiation is a component of sunlight that can have various effects on plants, including coriander. When it comes to coriander, UV radiation can have both advantageous and disadvantageous effects on its root and shoot development. UV radiation can stimulate root growth in coriander by increasing the production of certain hormones that promote root development. On the other hand, excessive exposure to UV radiation can be detrimental to coriander's overall growth and development. Excessive UV radiation can damage the DNA molecules in coriander plants, leading to physiological and biochemical changes that impede the absorption of nutrients and water by the roots and hinder photosynthesis in the shoots. Moreover, UV radiation can also induce oxidative stress in coriander plants, resulting in the generation of reactive oxygen that can harm the cellular structures of both the roots and shoots. The negative impact of UV light on coriander can result in decreased seedling biomass, inhibition of hypocotyl or root formation, and growth anomalies, and lower overall productivity of the coriander plants. Furthermore, UV light affects coriander differently based on intensity and time of exposure along with the precise phase of development of the coriander plant. Therefore, Coriander should not be exposed to UV rays without caution and provide optimal growing conditions to ensure healthy root and shoot development. Although there have been studies on the impact of UV-B upon root development and carbon allocation in woody species, minimal research has been done on the impact of UV-B rays on root development and carbon allocation in coriander and other herbaceous species like cucumber.

In conclusion, UV radiation can have both advantageous and disadvantageous impacts on the root and shoot growth of coriander. Further research is needed to fully understand the specific mechanisms and optimal UV exposure levels for coriander growth, to maximize its potential as a crop and mitigate any negative effects of UV radiation on its root and shoot development. In

conclusion, UV light can have both good and detrimental impacts on the root and shoot growth of coriander. Further research is needed to fully understand the specific mechanisms and optimal UV exposure levels for coriander growth, to maximize its potential as a crop and ensure its sustainable cultivation in environments with varying levels of UV radiation. In summary, UV radiation can negatively impact the absorption of nutrients and water by coriander roots, hinder photosynthesis in the shoots, induce oxidative stress, and damage cellular structures in both the roots and shoots of coriander plants.

Keywords: UV-radiation, DNA damage, plant health, oxidative stress.

1. Introduction:

Understanding the effects of ultraviolet (UV) radiation on plant health entails investigating a variety of factors, including the measurement of primary and secondary metabolites. UV treatment can have a variety of impacts on plants, and its impact on primary metabolites such as chlorophyll and protein levels can provide useful information. Moderate exposure to UV radiation frequently boosts chlorophyll synthesis in plants. Chlorophyll is an essential pigment for photosynthesis, assisting in the conversion of light energy into chemical energy. This stimulation has the potential to increase photosynthetic activity and, as a result, overall plant development. However, the relationship between UV exposure and chlorophyll content is complex, as high or persistent radiation can cause damage and a subsequent decrease in chlorophyll levels. Thus, regulating UV exposure is crucial for maximizing the beneficial effects on chlorophyll content. Similarly, UV treatment may affect plant protein levels. Proteins are required for a variety of physiological functions, and moderate UV exposure can cause stress reactions, which lead to an increase in specific protective proteins. On the contrary, prolonged or strong UV exposure may cause harm, thereby lowering total protein levels. The careful balance of boosting defensive proteins while avoiding damage emphasizes the need for controlled UV exposure in plant health. Examining secondary metabolites, such as polyphenols, in response to UV exposure provides further information about a plant's adaptation mechanisms.

Polyphenols act as antioxidants, helping plants defend against environmental stresses. Moderate UV exposure frequently promotes polyphenol production, which improves the plant's ability to withstand oxidative stress. Polyphenol content can be used to assess a plant's response to UV-induced stress and

resilience. UV radiation can alter other secondary metabolites, such as flavonoids, in addition to polyphenols. Flavonoids help to defend against UV rays and act as antioxidants. Monitoring these substances provides a thorough insight into how plants use their biochemical resources to combat the impacts of UV exposure [1].

Moving from metabolites to the genomic level, UV radiation has the potential to alter plant DNA. UV light is principally responsible for the production of thymine dimers and other DNA damage. While some DNA damage is a normal reaction to environmental stress, excessive or extended UV exposure can overwhelm the plant's repair processes, resulting in mutations and changes to the DNA structure. The degree of these DNA modifications is determined by parameters such as UV intensity, exposure time, and the plant's ability to cope with and repair damage. To assess the influence of UV radiation on plant health, a holistic approach is required, taking into account both primary and secondary metabolites, as well as genetic responses. UV-induced stress causes plants to engage in defence mechanisms, resulting in a balance of positive stimulation and potential injury. Plants contain UV-absorbing chemicals such as flavonoids and anthocyanins, which operate as natural sunscreens by absorbing and diffusing ultraviolet energy. Antioxidant defences are also activated to neutralize reactive oxygen species produced by UV exposure. DNA repair processes, including enzymes like photolyases and nucleotide excision repair systems, are essential for maintaining genetic integrity. Plants also adapt their stomatal behaviour to manage water loss and gas exchange, which aids in water balance and lowers the chance of UV damage. Furthermore, in response to UV stress, certain plants change the composition of their cell walls, strengthening cell structure and increasing resistance to physical damage caused by UV radiation [2].

In response to UV exposure, complex signal transduction pathways are launched, resulting in the activation of certain genes. This enables coordinated cellular responses, which help plants adapt to changing environmental conditions. Understanding these adaptive systems reveals how plants reduce the detrimental impacts of UV exposure, increasing resilience and general health. UV radiation has an impact on many elements of plant physiology, ranging from primary metabolites like chlorophyll and proteins to secondary metabolites like polyphenols and flavonoids, ultimately leading to genetic reactions at the DNA level. Plants' adaptive mechanisms demonstrate their exceptional ability to cope with

environmental obstacles, providing vital lessons for improving plant health in varied habitats.

2. Materials and methods:

For this study, *Coriandrum sativum* was taken as the model plant, one was treated under UV for 19 hours and other was untreated.

2.1. Estimation of total pigment in the sample:

The amount of total pigment in the sample was measured using different wavelength of light (Lichtenthaler *et al*.1987) [3]. Chlorophyll A was measured at 662nm, Chlorophyll B was measured at 645nm, and Carotenoids was measured at 470nm and calculated the amount from the respective absorbance from the specific wavelength.

2.2. Estimation of Polyphenol:

The polyphenol content was estimated according to Brolis *et al.*, (1998), with some minor adjustments. [4] A Gallic acid calibration curve (Singleton *et al*., 1999. [5] with minor modifications done by Talukder *et al.* 2016 [6]) was needed for estimating the polyphenol content.

2.3. Estimation of Protein:

Protein estimation was conducted following the method outlined by Okutucu B. *et al.* (2017) [7]. BSA (Bovine Serum Albumin) served as the standard for quantifying the total protein content in the tissues. To establish the BSA calibration curve, a series of standard BSA concentrations ranging from 0 to 1.0 mg/ml were prepared in advance. Each standard BSA solution underwent a reaction with alkaline copper sulphate solution and Folin's reagent following the previously described procedure, with an absorbance reading recorded at 660 nm.

2.4. Extraction of Plant DNA for Gel electrophoresis:

Plant DNA was extraction was done according to Edward *et al.* 1991 [8]

Materials required: Plant tissue, DNA extraction buffer, phenol-chloroform, Ammonium acetate, ethyl alcohol was needed for extraction of plant DNA. After extracting the plant DNA, Agarose gel electrophoresis was done.

3. Results and discussion

3.1. Plant Pigment Content:

It was observed that in the control sample, the amount of chlorophyll A, chlorophyll B, and carotenoid is slightly decreased in the UV-treated sample from the control sample. From the result, it can be concluded that the UV rays have a noticeable effect on plant

pigment. The UV stress may prevent the production or degradation of the plant pigments so that the significant change was observed.

Sample (mg/ml)	Chlorophyll A	Chlorophyll B	Carotenoids
Control sample	5.15	7.6	5.6
The sample treated with UV	3.22	3.7	2.5

Table 1: Amount of plant pigments

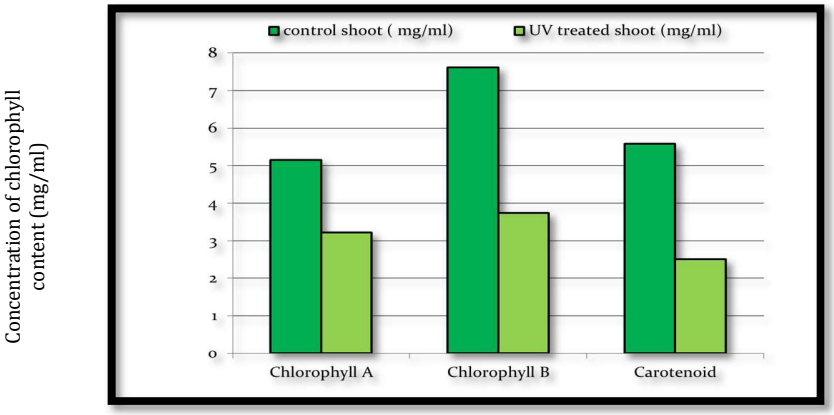

Fig 1: Graphical representation of plant pigment under different treatments

3.2. Protein Content

It is observed that in the control sample the amount of protein (0.34 mg/ml), it is decreased significantly in UV-treated plants (0.25 mg/ml). Therefore it can be concluded that the applied stress on the sample degenerated the protein structures.

Sample	Concentration of protein (mg/ml)
Control sample (50% dilution)	0.34
The sample treated with UV	0.25

Table 2: Amount of protein

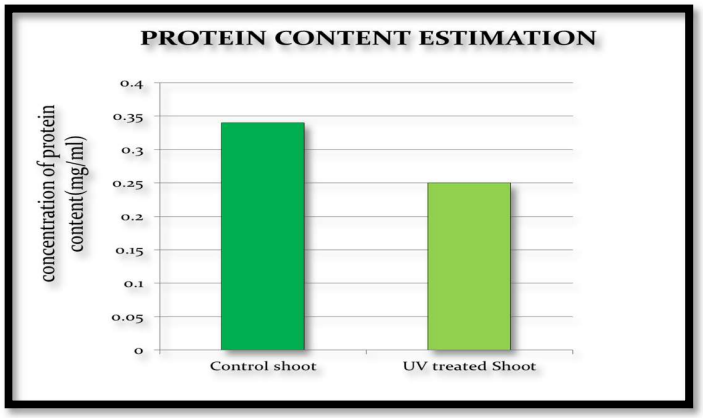

Fig 2: Graphical representation of Protein content

3.3. Polyphenol Content:

It was observed that in the control sample the amount of polyphenol (0.50 mg/ml), a significant increase was recorded in polyphenol content in UV treated sample (0.56 mg/ml). Hence it can be concluded that the plant tried to increase the defence against the applied stress to survive.

Sample	Concentration of polyphenol(mg/ml)
Control sample	0.50
The sample treated with UV	0.56

Table 3: Amount of Polyphenol

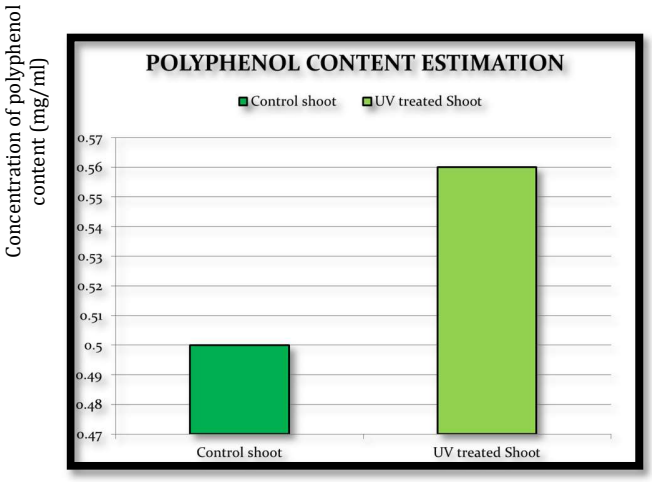

Fig 3: Graphical representation of Polyphenol content

3.4. Quality test of DNA by Gel electrophoresis

Lane 1: control root
Lane 2: treated root
Lane 4:control shoot
Lane 5: treated shoot

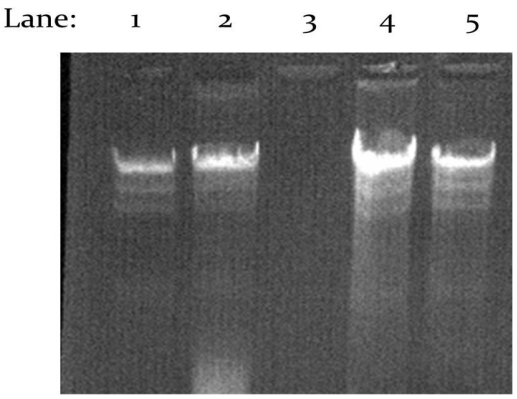

Fig 4: Gel electrophoresis of DNA sample

L1- DNA of the root tissue of the control sample.

It can be observed that the DNA in lane 1 suggests it is undamaged.

L2-DNA of the root tissue of the sample treated with UV.

In lane 2 it can be observed that the DNA is showing a little bit more intensity compared to the control sample. Hence it can be concluded that the treated sample was not damaged.

L4- DNA of the shoot tissue of the sample of the control sample.

In lane 4 as well it is also indicating no damage at all.

L5-DNA of the shoot tissue of the sample treated with UV.

In lane 5 it is observed that it is more damaged due to UV stress.

Conclusion:

The outcome of this present study reveals that, under UV treatment not only effect on plant pigment content but also it affects primary metabolites (proteins), and secondary metabolites (polyphenols). Accumulation gets altered significantly. Apart from the alteration in its metabolic profile, the integrity and quality of DNA is also altered. It portrays the fact that UV irradiation affects plant health while plants evolve a mechanism to cope with it. This preliminary study's impact of UV on plants would broaden our understanding of plants' unique capability to cope with altered environmental conditions and thus enable us to understand the unique mechanism of plant metabolism under high UV or under a UV-rich environment.

Acknowledgment

The authors acknowledge the support of the University of Engineering and Management, Kolkata.

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