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Research Article

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The Influence of Ultraviolet-C Radiation on Seedling Growth of Cowpea (*Vigna unguiculata* (L) Walp.)

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Abstract This research was conducted to investigate the effects of ultraviolet-C (UV-C) radiation on seedling emergence and seedling growth parameters of cowpea seeds. The UV-C radiation treatments at different exposure times (0, 30, 60, 180 and 300 minutes) on the seeds were applied by using a ST 51 G/W 51UV tube with a wavelength of about 254nm. The control and UV-C treated seeds were sown in plastic boxes filled with experimental soil and incubated at optimum conditions. The seedling emergence rates (%), seedling height (cm), root length (cm), fresh and dry weights of seedlings (g) were determined. The maximum seed emergence rate was 86.6% for the seeds treated with UV-C for 60 minutes while the lowest was 83.3% for the control and 180 minutes UV-C treatment. The parameters ranged from 10.5±1.09–12.2±0.90 cm for seedling heights, 10.96±2.56–15.45±1.78 cm for root lengths, 1.015±0.07–1.106±0.11 g for fresh seedling weights and 0.064±0.004–0.080±0.012 g for dry seedling weights. Significant differences ($p<0.05$) were found for the values of seedling heights and root lengths. The seeds treated with 300 minutes resulted in the highest seedling heights and root lengths. As a result, future field experiments should be done to fully understand the effects of UV-C radiation on cowpea seeds.

Keywords root length, seedling emergence rate, seedling height, UV-C irradiation

1. Introduction

The cowpea (*Vigna unguiculata* (L.) Walp) is an annual plant, belonging to the family *Fabaceae*. It is an important legume crop and mainly grown in Africa [1]. The seeds of cowpea provide a valuable protein, and the leaves and immature seed pods are also used in human diets [2]. The cowpea seeds contain about 23-25% protein and 60.3% carbohydrates [3]. There are some environmental factors that limit agricultural production all over the world. To overcome this problem, the sustainable agricultural productions based on new technologies are required to develop new and alternative high yielding plants, adapting to various environmental conditions [4]. The most important quantitative traits, such as yield and quality, depend on genetic variation, along with environmental interactions in the plant breeding. Plant breeders have used various methods to create new varieties and one of these methods is alternative biophysical methods. These biophysical methods include ionizing radiation (gamma and X-rays), laser, magnetic and electromagnetic fields, microwave and UV radiation [5, 6].

UV light with wavelengths range from 100 to 400 nm. It is generated from either the sun or the light sources. They are invisible by human eyes, having both harmful and/or beneficial effects. Scientists categorized UV light into 4 main groups because of their different effects and features on the livings: UV-A (315 - 400 nm), UV-B

(280 - 315 nm), UV-C (200 -280 nm) and the vacuum UV (100 - 200 nm) [7]. The UV-C in non-ionizing region of the electromagnetic spectrum is from 200 to 280 nm. UV radiation is an electromagnetic radiation that can cause various physiological and morphological changes in plants [8, 9]. Roles of UV radiation are different not only among the plant species [10, 11] but also within the species [12]. Cellular components including nucleic acid, protein, lipid, enzyme, amino acid, chlorophyll content and fresh weight of plant have been influenced by UV radiation [13]. When UV-C radiation interacts with plant tissues, it may cause a decrease in protein synthesis and modifications on cellular structures by ionization and dimerization of pyrimidine bases in DNA structure. They can also reduce the metabolic processes in photosynthesis, effecting the plant growth. UV light may result in changes of some important characteristics of plants such as plant color, plant shape and maturity. In addition, they can be used to control the plant diseases and pests [14]. Low UV-C treatments may cause beneficial stress (plant hormesis) reactions in plants [15].

Several previous reports indicated that UV-C promotes seed germination in peanuts [16], in wheats [17] and in maize and sugar beets [18]. UV-C treatments increased flowering and plant growth in freesia [19] and in the number and average weight of tomatoes [20]. And also, they prevented occurrence of diseases in strawberries [21]. Although many works on UV-C have been conducted on various plants, there is a lack of information related to cowpea. The complex mechanisms and the alterations of UV-C irradiation on plants and cells are not obviously clear yet. Therefore, this work aimed to determine potential changes on seedling parameters of cowpea seeds treated with UV-C, and to reveal optimum exposure time for cowpea using this technique.

Materials and Methods

Plant material

A commercial cowpea (*Vigna unguiculata* (L) Walp.) variety (Poyraz) was used as plant material in this experiment.

Treatment of UV-C irradiation

The cowpea seeds were treated with UV-C radiation at the Biology Laboratory of the Faculty of Education, University of Çanakkale Onsekiz Mart by using the system (ST 51 G/W 51UV tube) consisted of an arrangement of one lamp (2cm diameter, 30 cm long, 300 Watt output and 254 nm wavelength) accommodated on the top of a cylindrical aluminum container (15x15x30 cm). During UV-C irradiation treatment, the seeds in the petriplates were placed in the UV-C system at 27±1 ^{o}C temperature. UV-C radiation doses were applied at a distance of 15 cm for 30, 60, 180, and 300 minutes. The treated seeds, including control (0) were sown in rectangular plastic boxes filled with experimental soil. The seeds were placed under controlled conditions for 21 days. The pots were irrigated to maintain sufficient moisture as needed. Three replications of 100 seeds for every treatment were arranged in a completely randomized block design. Seedling emergence was daily recorded until stabilized at the 7th day [22]. The seedlings were uprooted at the 21st day after planting to determine the seedling height (cm), root length (cm) and fresh and dry weights of the seedlings (g).

Statistical analyses

The seedling emergence and growth parameters data were analysed by using SAS statistical software [23]. Least significant differences (LSD) among the mean values of parameters were evaluated at the level of 5 %.

Results and Discussion

Seedling emergence rate (%), seedling height (cm), root length (cm), and fresh and dry weights of seedlings (g) were measured and evaluated in the experiment. The seedling emergence rates of the seeds are given in Table 1. The UV-C treatment of 60 min had the highest seedling emergence rate (86.6%) while the control and 30 min treatment had the lowest values (83.3%). Seedling emergence rates for 30 and 300min treatments were found out to be 84.3 % and 85.5%, respectively. The differences among the treatments were not significant in respect of seedling emergence rates. Mahmood and Ibrahim [24] reported significant germination percentage on wheat seeds treated with UV-C. And also, some researchers showed that pre-sowing treatments with UV radiation increased seed germination percentages on various plant species [25, 26].

Table 1: Seedling emergence rates (%) of cowpea seeds treated with UV-C radiation.

Treatments (Minutes)	Seedling emergence rate (%)
Control	83.3
30	84.3
60	86.6
180	83.3
300	85.5
Mean	84.6
$LSD_{0.05}$	10.1

The effects of seed treatments with UV-C radiation on seedling growth parameters are shown in Table 2. The differences among the treatments were found to be significant ($p<0.05$) for seedling heights and root lengths of cowpea seeds (Table 2). The values range from 10.5 ± 1.09 to 12.2 ± 0.90 cm for seedling heights and from 10.96 ± 2.56 to 15.45 ± 1.78 cm for root lengths. With respect to seedling heights, 300 min (12.2 ± 0.90 cm) and 180 min (12.0 ± 0.73 cm) treatments gave the highest values. For the root lengths of the treatments between 15.45 ± 1.78 cm (300 min) to 10.96 ± 2.56 cm (30 min) were ascertained. The differences among the treatments were significant. As far as the fresh and dry seedling weights of the treatments were considered, no statistical differences were detected. The values were between 1.106 ± 0.11 - 1.015 ± 0.07 g for fresh seedling weights and 0.080 ± 0.012 - 0.064 ± 0.004 g for dry seedling weights.

Table 2: Seedling growth parameters of cowpea seeds treated with UV-C radiation

Treatments (Minutes)	Seedling height (cm)±SE*	Root length (cm)±SE*	Fresh seedling weight (g)±SE*	Dry seedling weight (g)±SE*
Control	10.9 ± 1.05^{b}	11.35 ± 1.06^{c}	1.015±0.07	0.066±0.007
30	10.5 ± 1.09^{b}	10.96 ± 2.56^{c}	1.020±0.12	0.073±0.006
60	10.7 ± 0.48^{b}	14.31 ± 0.59^{ab}	1.016±0.04	0.080±0.012
180	12.0 ± 0.73^{a}	12.17 ± 3.31^{bc}	1.106±0.11	0.075±0.003
300	$12.2 \pm 0.90_{a}$	15.45 ± 1.78^{a}	1.106±0.11	0.064±0.004
Mean	11.3	12.8	1.02	0.073
$LSD_{0.05}$	0.81	2.40	0.11	0.013

[*] There were significant differences between values which shown by different letters ($p < 0.05$).

SE: Standard Error

Siddique *et al* [27] reported significant increases in growth parameters for mung bean and groundnut seeds treated with UV-C. In their findings for groundnut, they found maximum shoot lengths and weights for treatment of UV-C (60 min) and maximum root lengths and weights for treatment of UV-C (30 min). Sadeghianfar *et al* [18] found some changes on seed germination treated with UV-C in maize and sugar beet. They pointed that the positive effects of UV-C radiation on seed germination were possibly explained by due to two factors as follows; (a) broking down of seed coat causing higher oxygen and water imbibition; (b) higher temperature accelerating seed germination, seed respiration and mitochondrial activities. Previous studies have showed some alterations and changes on some characteristics of various plants which are similar to our findings on seedling parameters [16, 17, 19, 20].

Although there were many studies carried out on the subject, little is known about the mechanism by which UV-C affects the plants. This is mainly because of the detrimental and/or beneficial effects on plants are complex and thus, need to be explained in detail. These effects range from changes in seed germination, growth and development to primary metabolic functions, photosynthetic activity, and enzyme activities. Most notably, the plants are mainly influenced by various factors such as UV-C dosage, exposure time, plant species used, environmental conditions (temperature, pH, etc.) and the plant materials used (seed, tuber, rhizome, etc.).

Conclusion

The present investigation showed cowpea seeds treated with 300 min UV-C resulted in an increase in the seedling height and root weight compared to other treatments. The seeds treated with UV-C for 60 min gave rise to highest emergence rate with a value of 86.6%. It is clearly shown that the seedling height and root weight affected by the UV-C radiation. UV-C exposure leads primarily to several biochemical and physiological events occur in plant cells. Since the effects of UV-C rays on plants cannot be fully explained and thus, the complex mechanisms between plants are to be investigated in more detail especially in molecular cell level. Future work will, therefore, be more addressed to field condition experiments to understand clearly the harmful and/or beneficial effects of UV-C treatments. In addition, the UV-C radiation exposure durations vary from a few minutes to several hours. Therefore, it is suggested that appropriate UV-C irradiation doses and durations for every plant species should be determined for enhancing growth parameters in the further confirmations.

Authors' Contributions

ŞT: designed the study, supervised the experiments and wrote the manuscript, and SY: contributed in laboratory experiments and made statistical analyses. All authors read and approved the final manuscript.

Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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