



Evaluating the Impact of UVC Exposure on Forage Maize Seeds under Hydroponic Condition

Jose Alfredo Palacio¹, Bayardo Emilio Cadavid¹, Edwin García Quintero²

10.18805/IJAr.AF-816

ABSTRACT

Background: UV radiation, with shorter wavelengths than visible light, plays a pivotal role in stimulating growth processes and boosting the synthesis of beneficial compounds in plants. Moreover, it triggers morphological changes and genetic responses, shaping plants' physical traits and adaptability. Nevertheless, a nuanced understanding is necessary as excessive UV exposure can also cause harm, underscoring the complexity of the relationship between UV radiation and plants. The study aimed to evaluate the effect of ultraviolet C (UVC) light exposure on the germination and growth of forage maize seeds under controlled conditions in an indoor crop. One sample of seeds was exposed to UVC light, while the other was not.

Methods: The experiment was carried out for 14 days, with the plants subjected to mixed blue-red light, fertigation and kept at a maximum external temperature of 30°C and maximum internal temperature of 25.1°C. UVC light is applied for 10 minutes to the seeds before germination.

Result: The results showed that the plants exposed to UVC light had an average growth increase of 3cm compared to those that did not receive the treatment. However, the protein content of both sets of seedlings was similar. The study suggests that further research is necessary to determine the optimal duration and distance for UVC exposure to minimize any potential negative effects on the plants. It also highlights the need to investigate the effect of UVC radiation on the nutritional content of hydroponic crops to ensure that the increased growth does not come at the expense of nutritional quality. The experiment was carried out in Medellín, Colombia, with a maximum solar radiation of 1000 W/m² and an altitude of 1500 meters. Overall, the study provides evidence that UVC radiation can enhance the growth of hydroponic maize seedlings, but more research is needed to fully understand its effects. At the end, there is an improvement in the growth of forage corn in seeds that have been subjected to UVC light compared to those that have not. It is worth highlighting the need for more research on changes in nutritional components in general.

Key words: Growth, Hydroponic maize, Indoor farming, Nutritional content, UVC radiation.

INTRODUCTION

Green and dry forage yields decrease with increasing sowing density (Kumar *et al.*, 2016) and methods are required to improve performance. In general, forage crops are a good way to take advantage of precipitation when it occurs and accommodate drought conditions, while high value or quality driven crops are not good choices for limited irrigation (Reddy *et al.*, 2018) and particularly, although it has been indicated that the Hydroponic Green Fodder (HGF) should be used as a supplement and not as a total substitute for conventional forages, it can become an ideal forage to increase the nutritional condition of livestock, especially in arid and semi-arid areas where food scarcity for livestock is common. In addition, the incorporation of some components, such as marine yeasts to decrease the proliferation of pathogenic fungi or marine algae as a substrate to decrease seed maize production using HGF for three types of planting densities and the percentage of crude protein (CP) obtained can be appreciated (Table 1) (López-Aguilar *et al.*, 2009). It can be observed that the researchers achieved a considerable yield considering the planting density, but the CP seems not to have been modified according to the levels of measurement error deviation.

In the future, the goal is to standardize the methods, additives and results of hydroponic forage production technology for small farmers. To ensure consumer

¹Department of Electronics, Institución Universitaria Pascual Bravo Pascual, Medellín, Colombia.

²Department of Electric, Universidad de Antioquia, Medellín, Colombia.

Corresponding Author: Jose Alfredo Palacio, Department of Electronics, Institución Universitaria Pascual Bravo Pascual, Medellín, Colombia. Email: josealpa@pascualbravo.edu.co

How to cite this article: Palacio, J.A., Cadavid, B.E. and Quintero, E.G. (2024). Evaluating the Impact of UVC Exposure on Forage Maize Seeds under Hydroponic Condition. Indian Journal of Agricultural Research. 58 (Special Issue): 1048-1052. doi: 10.18805/IJAr.AF-816.

Submitted: 18-08-2024 **Accepted:** 30-04-2024 **Online:** 03-09-2024

confidence, hydroponic food must be as safe and healthy as conventional alternatives (Ghorbel, 2022). Hydroponic forage, for example, is nutritious, palatable and digestible and can be grown in low-cost devices with locally available materials and home-grown grains. Against the obstacle of climate change, hydroponic forage production is an effective alternative technology for sustainable livestock production (Indira *et al.*, 2020; Afzalnia *et al.*, 2020). Regardless of the type of plant, crops require different types of treatment, including fertilization, irrigation and lighting.

LED light irradiation can improve the nutritional levels of vegetables and the phytochemical contents of plant species. Additionally, irradiation with combinations of LEDs

Table 1: Yield of production and obtained CP (crude protein).

Planting density (kg/m ²)	Performance (kg FVH/m ²)	% PC
1.5	12.95±0.75	14.5±0.5
2	18.75±1.05	15.2±0.6
2.5	21.20±0.95	15.8±0.9

in different proportions and the combination of LEDs with normal light sources (FL) can improve the phytochemical content, biomass and nutritional quality of vegetables and medicinal plants (Jung *et al.*, 2021).

A lot of research has been conducted on the effects of ultraviolet radiation on plants and plant tissues. UV light has been found to be effective on plant growth, product quality and photomorphogenesis (María *et al.*, 2014).

In terms of UV light, it has generally been documented that UV-B radiation reduces the content of chlorophylls because photons of this type of light are more energetic than those of visible light, so they are capable of breaking chemical bonds of proteins. However, the increase in chlorophylls found may be due to the increase in the production of secondary metabolites that allow the penetration of UV-B radiation to decrease and protect proteins associated with the photosynthetic apparatus, avoiding degradation of their pigments and even increasing their synthesis (María *et al.*, 2014). When examining the percentage change observed between the values of the variables in a standard germination test and an accelerated aging test that induced stress conditions with high temperature and humidity, which increased the physiological deterioration of the seed, a positive effect of UV-C radiation was found on the vigor and germination variables for sunflower and soybean seeds (Loconsole and Santamaria, 2021).

Research analyzed by Peñaranda *et al.* (2020) shows that UVA promotes biomass formation, leaf generation and elongation, increased leaf area and tissue growth but does not increase flavonoid concentration. On the other hand, low concentrations of UVB promote flavonoid concentration, chlorophyll concentration and tissue growth but reduce vegetative growth. Other advantages found by Mditshwali (2017) using UV-C radiation include its

beneficial impact on physicochemical quality. UV treatment reduces the loss of firmness and color development in tomatoes during storage and handling, which is highly desirable. UV radiation also reduces vitamin loss. Short-term exposure to UV-B radiation induced intra-specific defense responses in common buckwheat seedlings, manifested by various changes in flavone and flavonol concentrations (Debski *et al.*, 2016).

In general, the exposure time and power of UV light vary depending on the type of UV light, plant species and exposure objective. Prolonged and/or intense exposure to UV light can be harmful to plant growth and health, while brief and/or moderate exposure can be beneficial.

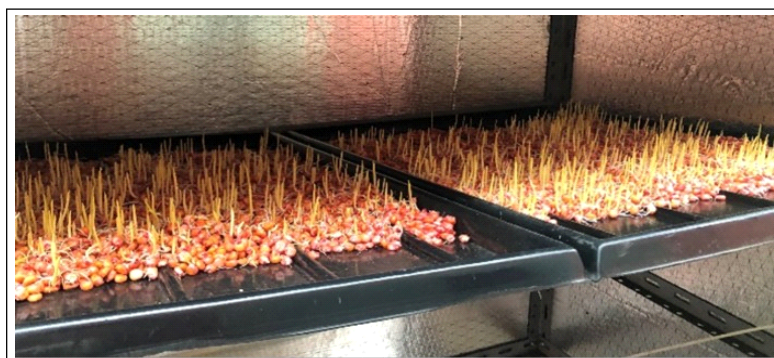
In terms of nutrition, exposing mushrooms to ultraviolet light during growth leads to measurable increases in vitamin D2 content and as a result, mushrooms can provide appreciable amounts of vitamin D2 in the diet. Irradiating mushrooms with UV-A and UV-C light during growth leads to an increase in vitamin D2 concentration, with UV-C registering a higher concentration than UV-A Edward (2015). It is a necessity for the future to explore and develop the possibility of improving the technology of producing more nutritious forage (Kokani *et al.*, 2023).

A method for producing hydroponic green forage is proposed that allows for studying the behavior of forage maize germination subjected to short periods of UV-C radiation near 254 nm and analyzing the behavior of the sprouts and the amount of protein achieved compared to forage produced from seeds not treated with UV-C light.

MATERIALS AND METHODS

A sample of forage maize seeds was exposed to ultraviolet C (UVC) light using a 254 nm central frequency lamp of 10W at a distance of 30 cm for 5 minutes, while another sample was left without UVC exposure. A sowing was carried out in a 40×60 cm tray equivalent to 1 kilogram of maize seeds, as shown in Fig 1.

The system was illuminated for 14 days with a mixed blue-red light commonly used in indoor crops. Irrigation and/or fertigation were carried out by nebulization, as shown in Fig 2, with a concentration of 1400 parts per million and a pH of approximately 6.1.

**Fig 1:** Growth chamber.

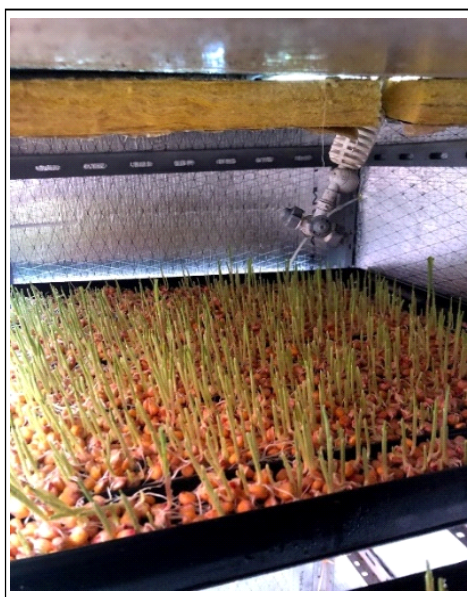


Fig 2: Irrigation by nebulization.

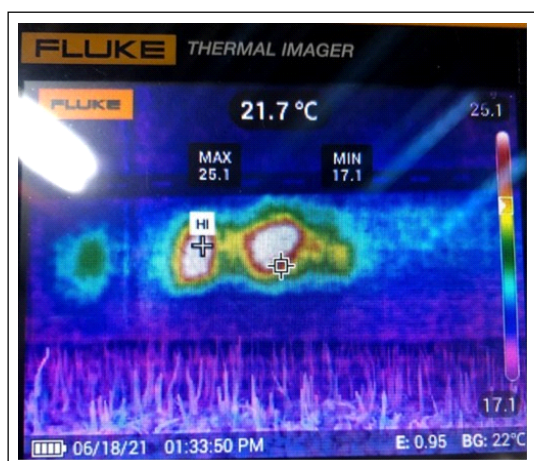


Fig 3: Internal temperatures reached with maximum external solar radiation.

Irrigation was done in 20-second intervals every 2 hours. The crop was protected and kept at a maximum external temperature of 30 degrees Celsius and with a maximum internal temperature of 25.1 degrees Celsius, as shown in Fig 3.

A 500-liter tank was used for irrigation supply, with a 1/2 HP pump, an inverter of 1000 watts and a charge regulator for an approximately 180-watt panel (Fig 4). The system was implemented in an area with a maximum solar radiation of 1000 W/m² and an altitude of 1500 meters in the city of Medellin, Colombia.

The objective of this study was to evaluate the effect of exposure to UVC light on the germination of forage maize seeds and their subsequent growth under controlled conditions in an indoor crop.

To carry out the experiment, a sample of forage maize seeds was divided into two groups: One exposed to UVC light and the other without exposure to such light. UVC exposure was carried out with a 254 nm central frequency lamp of 10 W at a distance of 30 cm from the seeds for 5 minutes. Fig 5a shows the sowing procedure in a 2400 cm² tray equivalent to 1 kilogram of maize seeds with and without UVC.

RESULTS AND DISCUSSION

Each experiment was run with the two types of grain after subjecting them to UVC light, they were kept close under the same type of artificial RGB light and the same average value of fertigation by nebulization, at 6 days for one of the experiments it can be appreciate the difference in growth of both treatments (Fig 5b), compared to the first day (Fig 5a).

In this experiment, hydroponic maize seedlings were exposed to UVC light from a 10-watt lamp positioned 50 cm away for a duration of 10 minutes. The results showed that the plants subjected to UVC light exhibited an average growth increase of 3 cm compared to those that did not receive the treatment. The experiment was carried out for 14 days and at the end of the period, the plants that received



Fig 4: Control chart and location of the fodder production system.



Fig 5: Experiment one on day one (a) and day six (b).

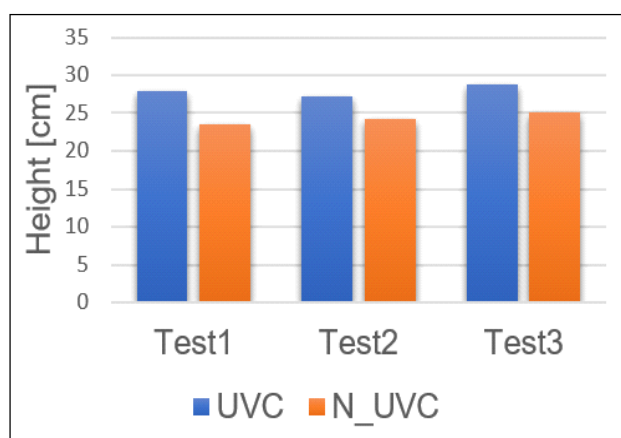


Fig 6: Comparison of each treatment with UVC ultraviolet light and without N_UVC ultraviolet light.

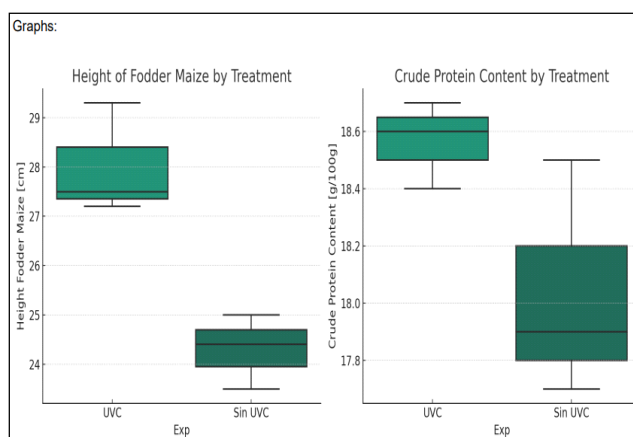


Fig 7: Statistical values of height and crude protein for both tests.

the UVC treatment had an average height of 28 cm, while those that did not have the treatment had an average height of 25 cm. This experiment was replicated three times and in all cases, the plants were subjected to mixed blue and red light and irrigated with fertigation of a concentration of 1400 ppm and pH levels between 5.9 and 6.4. The growth trend is illustrated in Fig 6. Each test corresponds to a run of experiment with the same type of grain.

Despite the significant growth differences observed between the plants that received the UVC treatment and those that did not, the results of the experiment revealed that the protein content of both sets of seedlings was similar. Both groups of plants had on average crude protein levels of 18.6 [g/100 g] and 18 [g/100 g] with UVC and without UVC respectively (Fig 7 right). as well as 27.5 [cm] and 24.3 [cm] for the t fodder maize height (Fig 7 left). The values of the hypothesis analysis obtained for both height and protein content for forage maize are defined below:

Results of the t-Test: Height of Fodder Maize: t-Value: 4.699 and p-Value: 0.0093

Protein content: t-Value: 2.083 p-Value: 0.1057

For height, a p-value<0.05 indicates a significant difference. For protein content, a p-value>0.05 indicates no significant difference.

It is worth noting that UVC radiation is known to be harmful to living organisms due to its ability to break down the DNA of cells, which can result in cell death or mutations. However, in this experiment, the exposure time was relatively short and the distance between the lamp and the seedlings was significant, which may explain why the plants were able to tolerate the UVC radiation without experiencing any negative effects on their protein content.

Although the use of UVC light in the germination of hydroponic green fodder can inhibit germination, because UVC light can damage DNA and other cellular structures in seeds, in this study in which the seed was subjected to UVC light for a short time, it germinated in the same proportion as the seeds that were not subjected to UVC light. It is important to carry out other investigations that lead to analyzing whether the plant in forage presents a reduction in other types of nutrients not analyzed in this research.

CONCLUSION

In conclusion, this experiment provides evidence that UVC radiation can enhance the growth of hydroponic maize seedlings. However, further research is necessary to determine the optimal duration and distance for UVC exposure to minimize any potential negative effects on the plants. Additionally, the effect of UVC radiation on the

nutritional content of hydroponic crops should be more investigated to ensure that the increased growth does not come at the expense of nutritional quality.

Although the plants subjected to UVC light had lower growth, it can be found that on average the crude protein content is similar.

ACKNOWLEDGEMENT

The resources of this project have been financed by the Institución Universitaria Pascual Bravo.

Conflict of interest

All authors declare that they have no conflict of interest.

REFERENCES

- Afzalnia, S. and Karimi, A. (2020). Barley cultivars and seed rates effects on energy and water productivity of green fodder production under hydroponic condition. *Indian Journal of Agricultural Research*. 54(6): 792-796. doi: 10.18805/IJARE.A-554.
- Debski, H., Szwed, M., Wiczowski, W., Szawara-Nowak, D., Baczek, N. and Horbowicz, M. (2016). UV-B radiation increases anthocyanin levels in cotyledons and inhibits the growth of common buckwheat seedlings. *Acta Biologica Hungarica*. 67(4): 403-411. <https://doi.org/10.1556/018.67.2016.4.6>.
- Edward, T. (2015). Effect of ultraviolet-a and ultraviolet-c light on the concentration of vitamin d2 and mechanical properties of oyster mushrooms during growth. Egerton University.
- Ghorbel, R., Chakchak, J., Kosum, N. and Cetin, N.S. (2022). Hydroponic Technology for Green Fodder Production: Concept, Advantages and Limits. 6th International Students Science Congress Proceedings, (October). <https://doi.org/10.52460/issc.2022.010>.
- Indira, D., Aruna, P., Swetha Kanthi, S. and Kumar, K. (2020). Hydroponics as an alternative fodder for sustainable livestock production. *World Journal of Advanced Research and Reviews*. 5(2): 87-92. 10.30574/wjarr.2020. 5.2.0030.
- Jung, W.S., Chung, I.M., Hwang, M.H., Kim, S.H., Yu, C.Y. and Ghimire, B.K. (2021). Application of light-emitting diodes for improving the nutritional quality and bioactive compound levels of some crops and medicinal plants. *Molecules*. 26(5). 1477. <https://doi.org/10.3390/molecules26051477>.
- Kokani, D., Desai, B.G., Bhagat, D.J., Dandekar, V.S. and Dhekale, J.S. (2023). Effect of feeding hydroponic horse gram sprouts on nutrient intake, utilization and growth in konkan kanyal goat kids. *Indian Journal of Small Ruminants*. 29(1): 158-162. <https://doi.org/10.5958/0973-9718.2023.00023.5>.
- Kumar, R., Singh, M., Tomar, S.K., Meena, B.S. and Rathore, D.K. (2016). Productivity and nutritive parameters of fodder maize under varying plant density and fertility levels for improved animal productivity. *Indian Journal of Animal Research*. 50(2): 199-202. doi: 10.18805/ijar.9423.
- Loconsole, D. and Santamaria, P. (2021). UV lighting in horticulture: A sustainable tool for improving production quality and food safety. *Horticulturae*. 7(1): 1-13. <https://doi.org/10.3390/horticulturae7010009>.
- López-Aguilar, R., Murillo-Amador, B. and Rodríguez-Quezada, G. (2019). El forraje verde hidropónico (fvh): Una alternativa de producción de alimento para el ganado en zonas áridas. *Interciencia*. 34(2): 121-126.
- María, L., La, E.D.E., Sobre, R.U., Compuestos, L.O.S.P.Y., En, F., Vera, C., L, T.M. (2014). Efecto De La Radiación Uv-B Sobre Los Pigmentos Y Compuestos Funcionales En Dos Cultivares De Acelga Tipo Baby. *Revista Iberoamericana de Tecnología Postcosecha*. 15(2): 193-200.
- Mditshwa, A., Magwaza, L.S., Tesfay, S.Z. and Mbili, N.C. (2017). Effect of ultraviolet irradiation on postharvest quality and composition of tomatoes: A review. *Journal of Food Science and Technology*. 54(10): 3025-3035. <https://doi.org/10.1007/s13197-017-2802-6>.
- Peñaranda, J.C., Rodrigo, G.C., Ticona-Bustillos, A.R., Valenzuela C.E., Ramos, S., San Martin, A., Almanza, G.R. (2020). Variación en la concentración de flavonoides y clorofila, y cambios en la morfología y anatomía foliar, debidos a radiación visible (PAR) o ultravioleta (UVA, UVB) en *Baccharis Latifolia*. *Revista Boliviana de Química*. 37(5): 210-222. <https://doi.org/10.34098/2078-3949.37.5.1>.
- Reddy, S.R. and Nayak, P. (2018). Crop production with limited irrigation: A review. *Agricultural Reviews*. 38(01): 12-21. <https://doi.org/10.18805/ag.r-1680>.