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Different UV-C irradiation levels impact on seed germination and Seedling Growth of *Calligonum polygonoides* Linn. in the Thar Desert.

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ABSTRACT

,The shrub *Calligonum polygonoides* L. is a key perennial species in the Thar Desert and is distributed across the arid and semi-arid regions of western Rajasthan. It typically grows as a psammophyte on dunes. Germinating *C. polygonoides* seeds under laboratory conditions is challenging. The seeds are covered with reddish-brown hair-like bristles that aid in dispersal. To prepare the seeds for study, the bristles were removed by scraping with coarse sandpaper, and medium-sized seeds were selected. After this uniform selection, the seed surfaces were sterilised with 0.1% $HgCl_2$ and repeatedly washed with distilled water. Following sterilisation, the seeds were subjected to UV-C treatments.

Irradiation was conducted at a distance of 30 cm from the source, using a Philips ultraviolet tube light (TUV 30 W) with a wavelength of 253.7 nm (2537 Å) for durations of 5, 10, 15, 20, 25, and 30 minutes. After irradiation, the *Petri*-plates containing the seeds were kept in the dark for 24 hours to prevent any photoreactivation. The UV-C irradiations resulted in irregular seed germination percentages, with the highest seedling growth observed at the 15-minute duration. In contrast, durations of 25 and 30 minutes led to complete inhibition of seed germination. Statistical analysis indicated that the results were not significant for all parameters except for the comparison between control and treatment for seed germination and between durations for radicle length.

This study demonstrates that 15 minutes of UV-C exposure enhances seed germination percentage and promotes hypocotyl and radicle length, while longer exposure to UV-C has a toxic effect on seed germination and seedling growth.

Keywords- *C. Polygonides L.*, Seed germination, Seedling growth & UV-C Irradiation.

INTRODUCTION-

Calligonum polygonoides Linn., a psammophyte shrub, forms a significant part of the scrub vegetation in the Thar Desert. Locally known as "Phog," this plant plays a crucial role in binding soil on the dunes of Western Rajasthan and enhancing soil fertility. The plant is valued for its food and medicinal uses in the region; its buds and seeds are consumed by the local population. The buds, referred to as 'Phogla' in the local language, are used to prepare "Raita." The seeds are typically eaten raw. The branches of *C. polygonoides* are employed in zinc purification, while its roots and thick branches serve as fuel. An aqueous paste of the plant acts as an antidote against opium overdose and the toxic effects of *Calotropis procera*. Additionally, locals use the plant extract to treat typhoid (Kumar *et al.*, 2015).

Irradiation is a method in which substances, plants, or plant materials are treated with radiation. During irradiation, high-energy radiation passes through matter, causing ionising, electric, or magnetic disturbances that affect the internal structure or composition of plants. When exposed to higher plants with UV radiation, they exhibit various physiological and morphological changes (Bjorn, 1996; Greenberg *et al*., 1997; Rozema *et al*., 1997; Caldwell *et al*., 1998), with significant variation among species and among varieties within the same species (Barnes *et al*., 1990; Day, 1993; McLeod and Newsham, 1997; Ziska *et al*., 1992; Corlett *et al*., 1997; Correia *et al*., 1998, 1999).

Neelamegam and Sutha (2015) found that seeds with high water content are more susceptible to radiation, and free radical production increases in the presence of oxygen. This is a well-established concept; the influence of water content on the effects of physical and chemical mutagens is recognised (Conger et al., 1968). Water content seems to facilitate the mobility and action of free radicals and oxygen with physical mutagens (Ehrenberg, 1961).

The present study was conducted to observe the effect of UV-C irradiation treatment on water-soaked seeds on germination and seedling growth of *Calligonum polygonoides* L. under field conditions.

Materials and Methods-

Seeds of *C. polygonoides* were collected from different sites located in the Churu and Bikaner districts of Rajasthan. Seeds are reddish brown with hairlike bristles. Seeds were scraped off their bristles with coarse sandpaper, and medium-sized seeds were selected for study (Plate 5.1). After preliminary selection for uniformity (criteria being the size and colour of seeds), the seeds were surface sterilised with 0.1% $HgCl_2$ for two minutes and thereafter repeatedly washed with distilled water (Mishra, 1968).

Experimental Design-

Seeds were soaked for 24 hrs in aqueous solutions of different durations of UV-C treated seeds after treatment with radiation for 5, 10, 15, 20, 25, and 30 minutes, with a control. Treated seeds were then kept for germination in Petri-plates over filter paper, kept moist by distilled water. Three replicates, each with 10 seeds, were used for each duration of UV-C. The experiments were performed under laboratory conditions. After pretreatments of seeds, they were allowed to germinate in Petri plates on wet filter paper for 15 days.

Sampling and data collection-

On the day of termination (16th day) of the experiment, the number of seed germinated and the seedling growth parameters, *viz*., hypocotyl and radicle length, were recorded and tabulated. All the data collected from experiments were analysed statistically by calculating the mean and standard deviation following standard methods. The significance level was analysed by using one-way ANOVA.

The growth of *Calligonum polygonoides* L. seedlings was observed throughout the study period, and the growth parameters, such as the number of seedling survival and seedling growth (total length, shoot length, root length) were recorded (Plate-I). Besides, Seedling Vigour Index was calculated by using the formula (SVI = % seed germination x Total length proposed by Abdul-Baki and Anderson (1973); Seedling Tolerance Index was calculated by using the formula (STI = Mean length of the longest root in treatment/ mean length of the longest root in control x 100) proposed by Turner and Marshal (1972).

UV-C irradiation treatment of *Calligonum polygonoides* L. seeds for 5, 10, 15, 20, 25 and 30 min., durations for seed germination percentage and seedling growth data in tabulated form were recorded. All parameters for control *vs* treatment for seed germination and during radicle length were statistically analysed. (Tables 1, 2 & 3, Figs 1, 2, 3, 4 & 5 and Plate I)

Table 1: Effect of ultraviolet light on seed germination percentage (%) of *Calligonum polygonoides* (values are means of three replicates each).

S.No.	Duration (Min.)	% Germination
1.	Control	26.66
2.	5	10.66
3.	10	23.33
4.	15	33.33
5.	20	3.33
6	25	0.00
7.	30	

Source	DF	SS	MSS	F
Replication	2	3.112	1.556	1.107^{NS}
Cont. *vs* Treatment	1	8.012	8.012	5.702^{*}
Among ultraviolet	5	14.266	2.853	2.030^{NS}
Error	10	14.056	1.405	

D.F.= Degree of freedom, S.S.=Sum of Squares, M.S.S.=Mean Sum of Squares, *=Significant at 5% level of significance, NS=Not Significant

Table 2: Effect of ultraviolet light on hypocotyle length (cm) of *Calligonum polygonoides* (values are means of three replicates each).

S.No.	Duration (Min.)	Hypocotyle length (cm)
1.	Control	2.1
2.	5	1.36
3.	10	1.21
4.	15	2.39
5.	20	1.33
6	25	0.00
7.	30	0.00

Source	DF	SS	MSS	F
Replication	2	1.855	0.927	0.670^{NS}
Cont. *vs* Treatment	1	1.786	1.786	1.292^{NS}
Among ultraviolet	5	8.51	1.702	1.231^{NS}
Error	10	13.826	1.382	

D.F.= Degree of freedom, S.S.=Sum of Squares, M.S.S.=Mean Sum of Squares, *=Significant at 5% level of significance, NS=Not Significant

Table 3: Effect of ultraviolet light on radicle length (cm) of *Calligonum polygonoides* (values are means of three replicates each).

S.No.	Duration (Min.)	Radicle length (cm)
1.	Control	3.33
2.	5	3.00
3.	10	3.57
4.	15	4.65
5.	20	1.00
6	25	0.00
7.	30	0.00

Source	DF	SS	MSS	F
Replication	2	3.318	1.659	1.188^{NS}
Cont. *vs* Treatment	1	1.194	1.194	0.855^{NS}
Among ultraviolet	5	49.322	9.864	7.066^{*}
Error	10	13.962	1.396	

D.F.= Degree of freedom, S.S.=Sum of Squares, M.S.S.=Mean Sum of Squares, *=Significant at 5% level of significance, NS=Not Significant

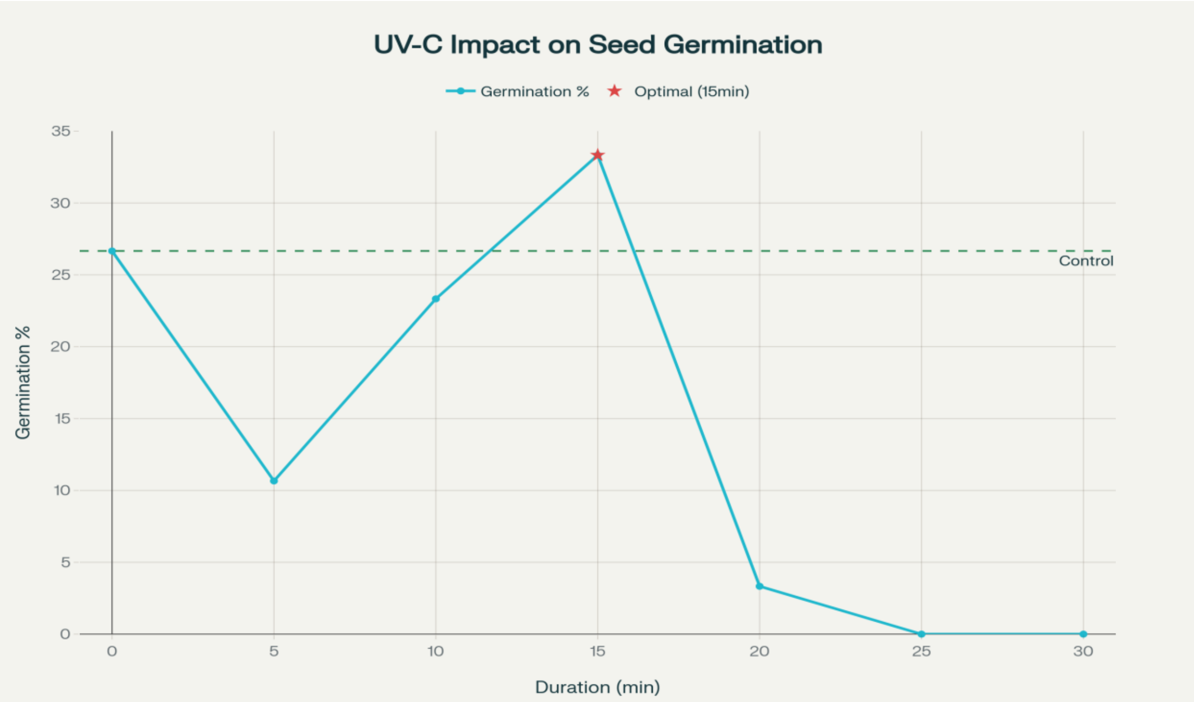


Fig. I- UV-C radiation dose-response curve for seed germination in Calligonum polygonoides.

This graph shows the classic hormetic response pattern where germination percentage initially decreases at short exposures, peaks at 15 minutes (33.33%), then drastically declines with longer exposures.

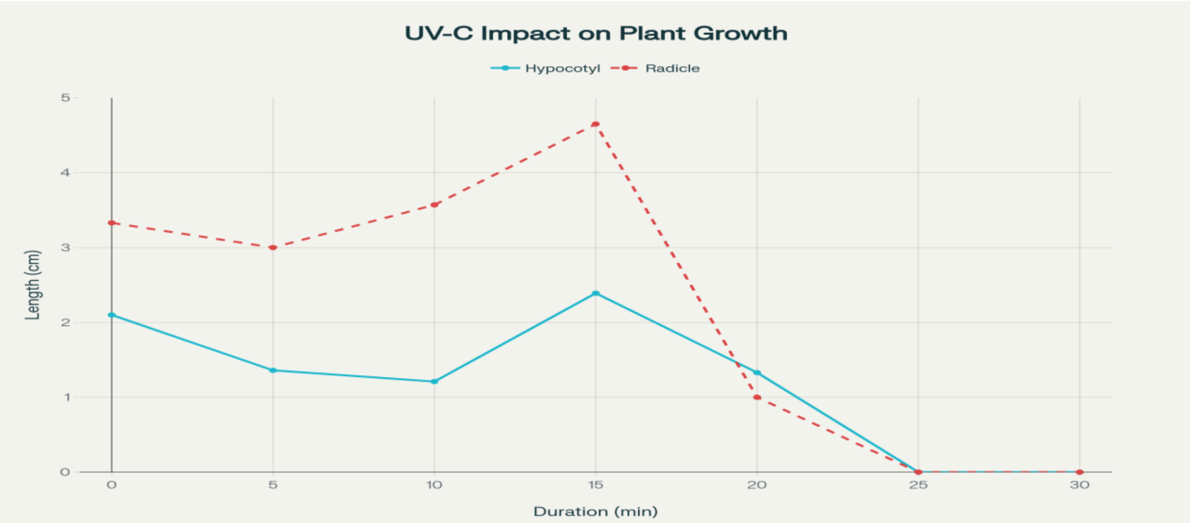


Fig. II- Comparative growth response of hypocotyl and radicle to UV-C radiation exposure

This dual-line graph compares hypocotyl and radicle development across treatments, clearly showing that both growth parameters follow similar patterns with optimal enhancement at 15-minute exposure.

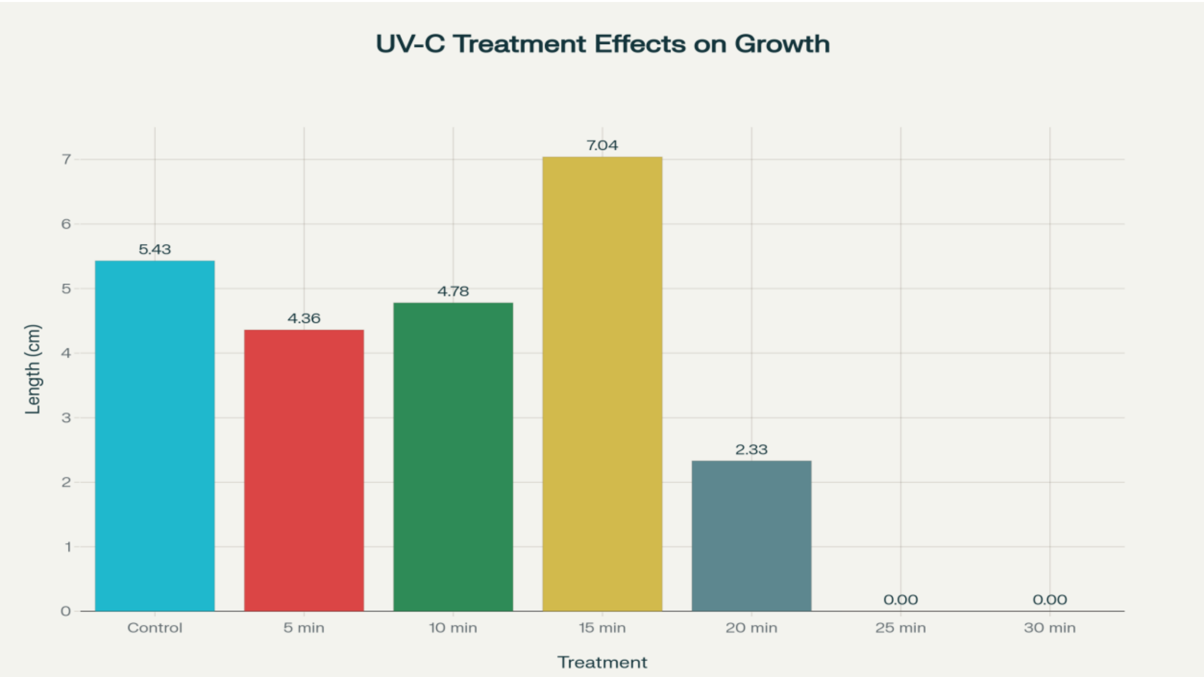


Fig. III- Total seedling length comparison across UV-C radiation treatments

This bar chart displays the combined growth (hypocotyl + radicle) for each treatment, making it easy to identify the 15-minute treatment as producing the longest seedlings (7.04 cm total length).

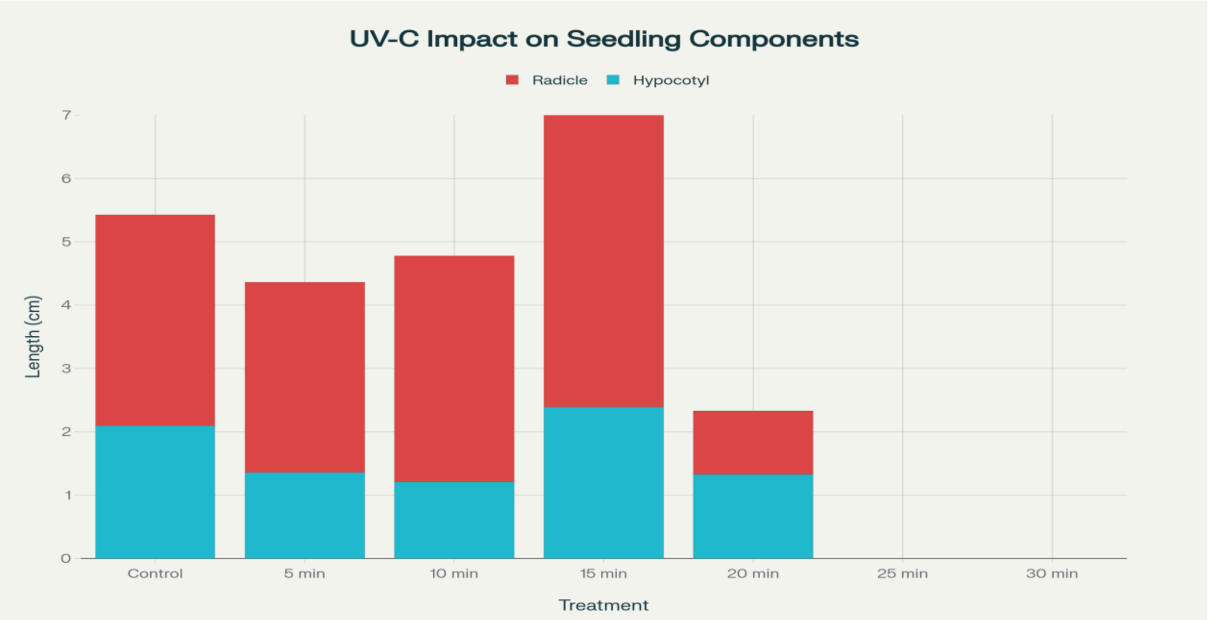


Fig. IV- Stacked composition of seedling growth components under UV-C treatments

This stacked bar chart shows how hypocotyl and radicle components contribute to total seedling length, revealing that radicle growth is more responsive to UV-C treatment than hypocotyl growth.

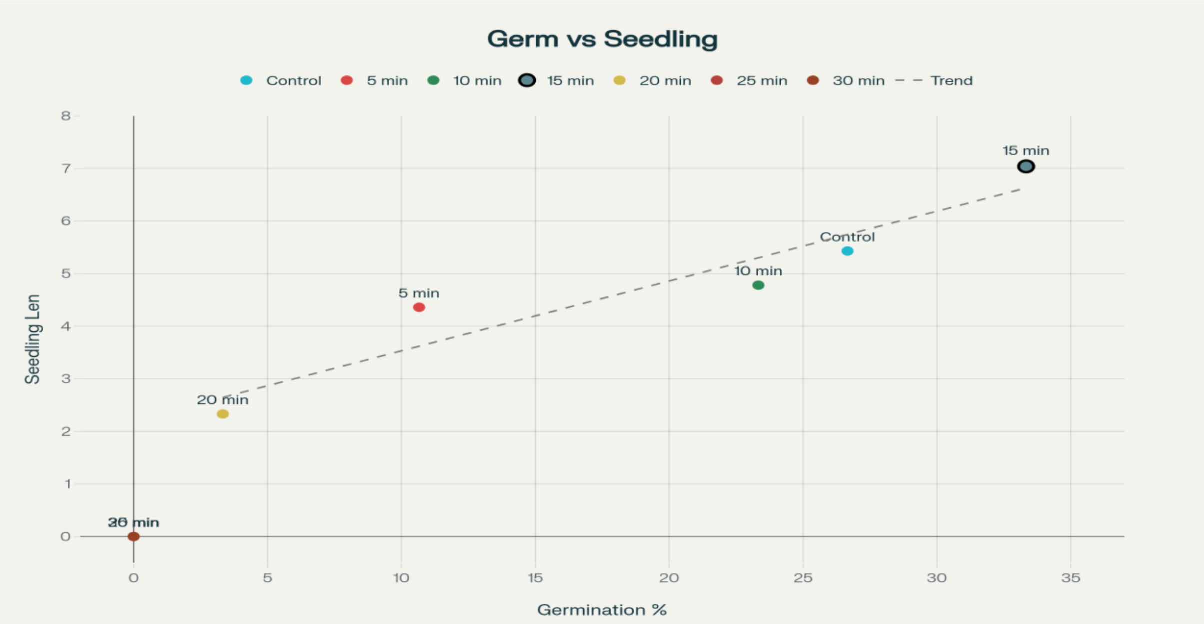
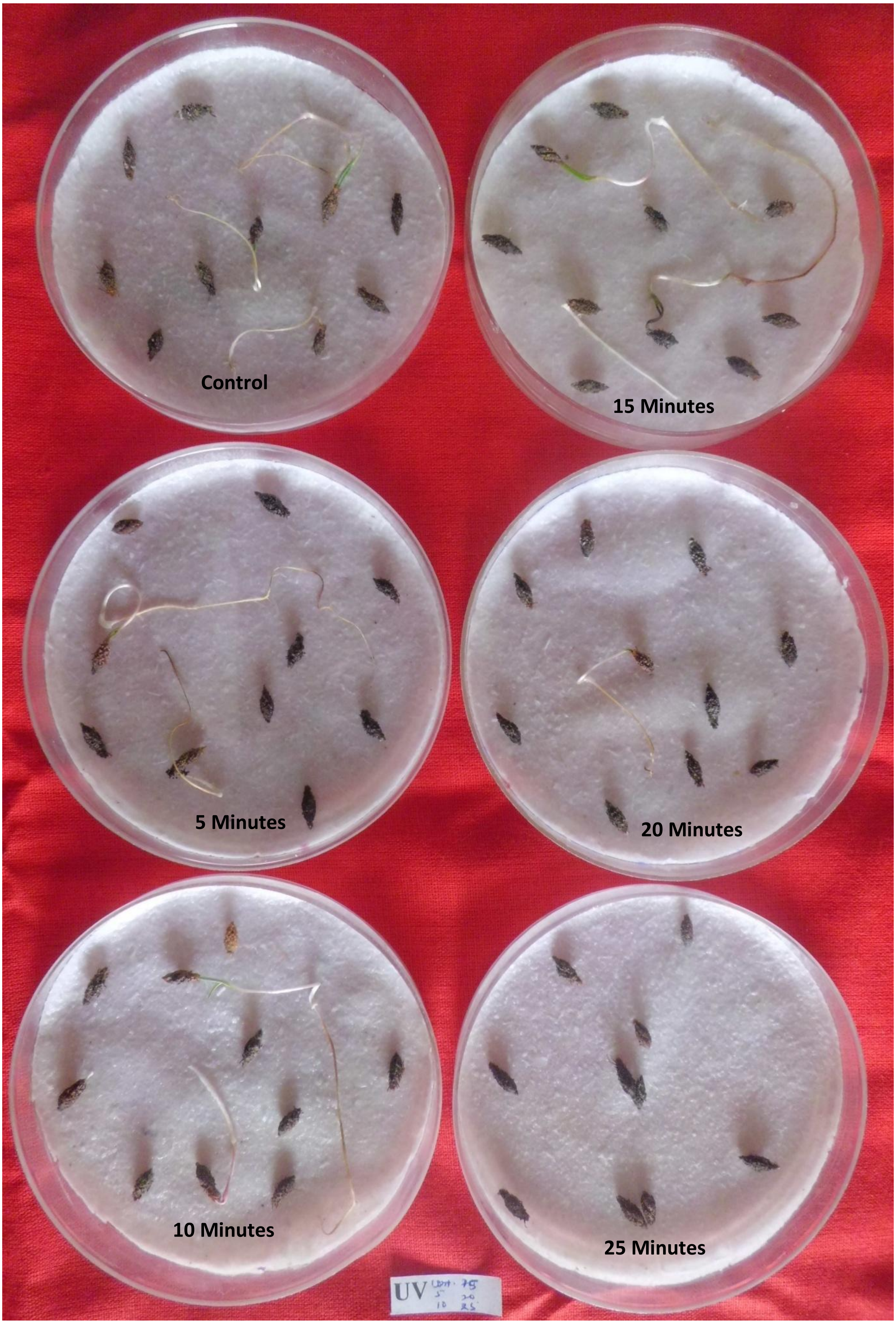


Fig. V- Correlation between germination success and seedling growth vigour

This scatter plot demonstrates the strong positive correlation between germination success and seedling vigour, with the 15-minute treatment showing optimal performance in both parameters.


Control
15 Minutes
5 Minutes
20 Minutes
10 Minutes
25 Minutes
UV

Results and Discussion-

Ultraviolet radiation is known to produce the excitation of biological molecules and is a powerful mutagenic agent. Rupert and Harm (1966) and Vyas and Agarwal (1970) reported that ultraviolet irradiations resulted in a decreased percentage of seed germination in *Dalbergia sissoo*. A small improvement in seed germination percentage was noticed on exposure to low light of 254, 265, 334 and 405 nm in lettuce (Wagne, 1966). Pandey (1969) found maximum germination in *Anagallis arvensis* under ten minutes of exposure to ultraviolet radiation. Similar results were observed in *Commiphora wightii* (Sharma, 1993) and in *Boswellia serrata* (Sharma, 1998). In *Aptenia cordifolia,* healthy seed treated with UV-B for 45, 90, & 120min. durations and transfer in *Petri* plates in a dark environment at 25° C to allow germination. After seed germination found that the maximum seed germination per cent was at 90 min and decreased at 120 min compared to the control. The present study also showed that higher UV-C exposure reduced germination and seedling growth compared to the control (Notaraj et al. 2019).

The influence of UV-B radiation on germination and early seedling growth was examined for many vegetables (tomato, radish, cucumber, lettuce, and bean) and field crops (wheat, cotton, soybean, and millet). Continuous exposure of seeds for 3 days to UV-B radiation (280–320 nm) at 25° C, had a slight effect on the fresh weight of seedlings but no appreciable influence on germination percentage or dry weight of seedlings (Krizek, 1975). UV exposure for all durations (5 to 30 minutes) enhanced germination percentage in *Sterculia urens*, but seeds of *Helicteres isora* and *Gauzuma tomentosa* did not respond to UV exposure (Ahrodia, 2006).

Noble (2002) reported the effects of UV-irradiation on the germination of kale, cabbage, radish and agave seeds. In all cases, UV light speeds up the germination of these seeds, but the subsequent growth of the seedlings was markedly retarded.

Peykarestan and Seify (2012) reported that irradiated (220 to 400 nm UV rays) seeds of Bean Sayad and Bean Derakhshan, grown in an incubator for 8 days at 25°C. Seed germination percentage and growth rate of sprouts were inversely related to the irradiation doses. Shaukat *et al*. (2013) studied seed germination and seedling growth in *Vigna mungo* L. and reported that the germination rate substantially increased, but the final germination percentage remained significantly suppressed by UV-irradiance. Both root and shoot growth of the seedlings were markedly reduced by enhanced UV-B radiation. Elfadil and Abdallah (2013) studied the impact of UV on Dura Sorghum species along different time periods, showing a negative effect on growth.

Garbeles *et. al*. (2024) studied moderate UV-C exposure (30–60 minutes), which had a beneficial effect on waxy corn seed germination, with significantly higher germination percentages, but longer exposure times (90–120 minutes) had a detrimental impact on germination. Similarly, in the present study, higher UV-C exposure is very toxic on all parameters.

Similar non-significant results were observed by Lazim and Nasur (2017) and Sadeghianfar *et. al.* (2019) on seed germination percentage and seedling growth in Sorghum and Maize when seeds were exposed to irradiation with UV-C radiation at 254 nm for durations of 0 min (control), 30 min, 2 h, 4 h, 8 h, and 12 h in six replicates of 30 seeds per replicate and sterilised petri dishes under laboratory conditions. In UV-C irradiated seeds, the results showed no significant effects on germination percentage and the length of the roots and seedlings, while exhibiting a significantly negative impact on the speed of germination, seedling length, and the number of leaves. The results also showed no significant combined effect between a magnetic field and UV-C in all studies' characteristics, except for the characteristic related to the length of the root seedlings in Sorghum (Lazim and Nasur, 2017).

The present study showed that 15 minutes of UV exposure enhanced seed germination percentage, hypocotyl and radicle length. Higher exposure of UV showed a toxic effect on seed germination and seedling growth.

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