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Impact of ultraviolet radiation on seed germination, growth and physiological response of Bengal gram (*Cicer arietinum L.*) and Horse gram (*Macrotyloma uniflorum L.*)

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ABSTRACT

Steady decrease of stratospheric ozone layer and the expansion of ultraviolet radiation intensity were watched in most recent twenty years of the twentieth century. In this study, Bengal gram (*Cicer arietinum L.*) and Horse gram (*Macrotyloma uniflorum L.*) were exposed to ultraviolet radiation at 253 nm for different periods of exposure time (0,1,3,5,7,9,11,13,15 and 17 minutes). The impact of UV rays were observed by measuring, percentage of germination, root length, shoot length, fresh weight, dry weight, number of leaves and branches of both Bengal gram (*Cicer arietinum L.*) and Horse gram (*Macrotyloma uniflorum L.*) respectively for various durations (0,5,10,15,20,25 and 30th days). The results indicated that, Bengal gram (*Cicer arietinum L.*) seeds shown significantly positive impact and Horse gram (*Macrotyloma uniflorum L.*) seeds shown negative impact on all growth and physiological parameters. The results also indicated that as the number of days increases the yellowing of leaves and fall down of leaves were observed in all treatments of Horse gram (*Macrotyloma uniflorum L.*) seeds, where a significant enhancement of growth observed in all treatments of Bengal gram (*Cicer arietinum L.*) seeds.

Keywords

Ultraviolet radiations, Germination, Physiological response, Bengal gram (*Cicer arietinum L.*), Horse gram (*Macrotyloma uniflorum L.*)

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Introduction

Plants are obligated to be presented to different abiotic and biotic stress factors throughout their life time, yet same of them can adjust to changing ecological parameters by various morphological, physiological and other abiotic substance [1,2]. Sun oriented UV radiation is exceptionally unique abiotic ecological factor of significant significance, which fills in as a basic prompt for development and separation forms in plants [3].

UV radiation is electromagnetic radiation of a wavelength shorter than that of the visible range, yet longer than delicate X-rays. It tends to be subdivided into near UV (380-200 nm wave length) what's more, extreme or pressure UV (200-10 nm). The range of UV wavelength is frequently subdivided into UV-A (380-315 nm), called long wave or dark light; UV-B (315-280 nm); called medium wave; and UV-C (280-10 nm) called short wave or germicidal. The UV-B and UV-C to the sun based ghostly irradiance is low, their capacity to cause natural harm is high a result of the energies related with these short wave lengths. At the point when plants are not acclimatized or are lighted with UV level over the current encompassing radiation, this radiation can effectively affect proteins, lipids and explicitly influence the photosystem by harming its layers and diminishing compound (enzymatic metabolisms) exercises and photosystem rates [4-6].

Numerous organic products, blooms also, seeds emerge all the more firmly from the foundation in UV wavelengths when contrasted with human. The plant seeds are put away dried up under states of low temperature and pressure. Solar UV illumination had the most malicious impact on life forms [7,8]. Various investigations have illustrated that expanded UV-B can specifically or in a roundabout way influence the development of plants [9,10]. Generally little data was accessible on the impact of UV radiation on woods tree species [11]. Tropical woods, however speaking to almost one portion of worldwide efficiency and a significant part of the all-out tree species assorted variety, have gotten almost no consideration concerning the ozone decrease issue. There is some data for mid-mild scope tree species; since they are seemingly perpetual trees present the chance to watch the more extended term combined impacts of UV-B introduction more than quite a while for similar people [11]. A barely any examinations have been embraced to explore the impacts of UV radiation on tree seeds germination and chlorophyll fixation.

Irradiation is a strategy that given to substances or plants or plant materials with radiation. During irradiation the high vitality radiation go through the substances and cause ionizing or electric or attractive unsettling influences that influence the inward structure or matter of plants. Amid the previous couple of decades, the ozone decrease issue has invigorated significant research on higher plant reactions to UV-radiation [12]. At the point when presented to raise UV radiation, the higher plants display different physiological and morphological changes [4,13-15] furthermore; there is significant variety among species [16-18] and among assortments inside similar species [19-22]. Taking all these factors into consideration the present investigation carried to determine the impact of ultraviolet radiation on germination and other physiological parameters of Bengal gram (*Cicer arietinum L.*) and Horse gram (*Macrotyloma uniflorum L.*).

Materials & methods

■ Preparation of experimental setup

Present experiments were conducted for 30 days (from 1/12/2018 to 31/12/2018) at Green Fields Institute of Agriculture Research & training, Ibrahimpatnam, Rangareddy, Telangana, India, to evaluate the impact of UV-radiation on Bengal gram (*Cicer arietinum L.*) and Horse gram (*Macrotyloma uniflorum L.*). For this the soil samples were collected from open fields located at research institute during the season of November-2018. The collected soil samples were dried under sunlight for four days and cleaned by removing all vegetation & solid unwanted materials. Then the samples were transferred into plastic tubes for further experiments.

Into a series of 10 plastic tubs equal quantity of soil (≈1.5 kg/tub) was transferred and tubs were denoted as C (control), T1, T2, T3, T4, T5, T6, T7, T8 and T9. The tubs T1 to T9 are the tubs for treatment seed which irradiated with UV light at different time intervals. All the experiments carried out in triplets and mean values were taken for results analysis.

■ Seed selection & seed treatment

The seeds Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) used in current investigation were purchased from local market located at Ibrahimpatnam & all the seeds are certified and pre-treated. Hence, there is no further pre-treatment performed before sowing the seeds into experimental tubs.

The set of 30 seeds irradiated separately with UV-light (253 nm) at different time periods i.e. 1,3,5,7,9,11,13,15,17 minutes. A set of 30 seeds were not irradiated and taken as control. The Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) were sown into respective tubs randomly and irrigated with bore well water immediately.

■ Irrigation

From the time of seed sowing the experimental tubs were irrigated regularly once in a day to maintain soil moisture at saturated level. The experimental setup kept in open for better sunlight and air.

■ Growth analysis

Growth analysis is a mathematical expression of environmental effects on growth and development of crop plants. This is a useful tool in studying the complex interactions between the plant and the environment. According to the purpose of the data, shoot measures, root measures and leaf measures and dry weights of component plant parts have to be collected at particular intervals. This data are to be used to calculate various indices and characteristics that describe the growth of plants and of their parts grown in different environments and the relationship between assimilatory apparatus and dry matter production. These indices and characteristics are together called as growth parameters. Accuracy in calculation of these parameters and their correct interpretation are essential aspect in growth analysis.

Advantages of growth analysis

- Can study the growth of the population or plant community in precise way with the availability of raw data on different growth parameters.
- These studies involve an assessment of the primary production of vegetation in the field i.e. at the ecosystem level of organization.
- The primary production plays an important role in the energetic of the whole ecosystem
- The studies also provide precise information on the nature of the plant and environment interaction in a particular habitat.
- It provides accurate measurements of whole plant growth performances in an integrated manner at different intervals of time.

Drawbacks of growth analysis

In classical growth analysis sampling for primary values consist of harvesting (destructively) representative sets of plants or plots and it is impossible to follow the same plants or plots throughout whole experiment.

Growth characteristics–definition and mathematical formulae

The following data are required to calculate different growth parameters in order to express the instantaneous values and mean values over a time interval. In the following discussion W, WL, WS and WR are used to represent the dry weights of total plant, dry leaves, stem and roots respectively whereas A is the leaf area.

Relative growth rate (RGR)

The term RGR was coined by Blackman. It is defined as the rate of increase in dry matter per unit of dry matter already present. This is also referred as Efficiency index, since the rate of growth is expressed as the rate of interest on the capital. It provides a valuable overall index of plant growth. RGR can be calculating by following formulae.

$$Relative\ Growth\ Rate = \frac{loge^{W_2} - loge^{W_1}}{T_2 - T_1}$$

Net assimilation rate (NAR)

The NAR is a measure of the amount of photosynthetic product going into plant material i.e. it is estimate of net photosynthetic carbon assimilated by photosynthesis minus the carbon lost by respiration. The NAR can be determined by measuring plant dry weight and leaf area periodically during growth and is commonly reported as grams of dry weight increase per square centimeter of leaf surface per a particular time period. This is also called as unit leaf rate because the assimilatory area includes only the active leaf area in measuring the rate of dry matter production. The mean NAR over a time interval from T_1 to T_2 is given by

$$NAR = \frac{W_2 - W_1}{T_2 - T_1} X \frac{loge^{A_2} - loge^{A_1}}{A_2 - A_1}$$

Leaf area ratio (LAR)

The LAR is a measure of the proportion of the plant which is engaged in photosynthetic process. It gives the relative size of the assimilatory apparatus. It is also called as capacity factor. It is defined as the ratio between leaf area in square centimeters and total plant dry weight. It represents leafiness character of crop plants on area basis.

$$Leaf\ Area\ Ratio = \frac{A}{W}$$

Leaf weight ratio (LWR)

It is one of the components of LAR and is defined as the ratio between grams of dry matter in leaves and total dry matter in plants. Since the numerator and denominator are on dry weight basis LWR is dimensionless. It is the index of leafiness of the plant on weight basis.

$$Leaf\ Weight\ Ratio(LWR) = \frac{W_L}{W}$$

Specific leaf area (SLA)

It is another component of LAR and defined as the ratio between leaf area in cm^2 and total leaf dry weight in grams. This is used as a measure of leaf density. The mean SLA can be calculated as follows:

$$Specific\ Leaf\ Area(SLA) = \frac{A}{W_L}$$

Specific leaf weight (SLW)

The reciprocal of SLA is called SLW. It is defined as the ratio between total dry weight and leaf area. It indicates the relative thickness of the leaf of different genotypes.

$$Specific\ Leaf\ Weight(SLW) = \frac{W_L}{A}$$

Leaf area duration (LAD)

It is usually expressed as a measure of leaf area integrated over a time period. Some takes into account both the magnitude of leaf area and its persistence in time. It also represents the leafiness of the crop growing period. Thus the unit of measurement of LAD may be in day or weeks or months.

$$Leaf\ Area\ Duration(LAD) = \frac{LA_1 + LA_2(T_2 - T_1)}{2}$$

■ Plant sampling and analysis

A seed was considered as germinated when root had emerged more than 2 mm. The number of germinated seeds per time was presented as seed germination rate. Germination percentage and tolerance indices determined by the following formula [23].

$$\%of\ Germination = \frac{Number\ of\ Seeds\ Germinated}{Total\ Number\ of\ Seeds\ Planted} X 100$$

$$Tolerance\ indices = \frac{Mean\ root\ length\ of\ treated\ seed}{Mean\ root\ length\ of\ control}$$

The inhibition of seedling growth was expressed according to the formula [24].

$$Percentage\ of\ inhibition = \frac{Length\ of\ control - Length\ of\ treated\ seed}{Lenght\ of\ control} X 100$$

Seedling vigor index

Seedling vigor index are those properties of the seed which determine the level of activity and performance of the seed during germination and seedling emergence. It is a single measurable property like germination describing several characteristics associated with various aspects of the performance of seed. Seedling vigor index is calculated by following formula: [25,26]

$$SVI = Germination\ percentage \times Seedling\ length$$

Percentage phyto-toxicity

Percentage phytotoxicity of UV light on root and shoot growth Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) were calculated at regular time interval (5 to 30 days of seedling growth). The following formula was used for calculating the percentage phytotoxicity [27]:

$$Percentage\ of\ Phytotoxicity = \frac{\frac{S}{R}\ length\ of\ control - \frac{S}{R}\ length\ of\ treated\ seed}{\frac{S}{R}\ length\ of\ control} X 100$$

■ Estimation of biochemical attributes

Biochemical attributes were studied in term of photosynthetic pigments. The chlorophyll-a, chlorophyll-b and total chlorophyll (a+b) were determined spectrophotometrically. Leaves were cut into small pieces, mixed thoroughly and 0.25 g of leaves was taken into a mortar to grind them finely by pestle with 25 mL of 80% acetone for 5 minutes. The homogenate was filtered through

filter paper (Whatman No. 42) and was made a volume of 25 mL with 80% acetone. The total Carbohydrates were determined by Anthrone method, total proteins by Biuret method and peroxidise activity by Odiansidine method which is an enzymatic method [28,29].

Extract monitoring by spectrophotometer

After the extraction, chlorophyll contents were monitored by UV-Vis spectrophotometer [30]. The optical density/absorbance of each solution was measured at 663 and 645 nm against 80% acetone blank in 1 cm quartz cuvette at room temperature. The Arnon's equation was used to calculate the amount of chlorophyll-a, chlorophyll-b and total chlorophyll (a + b) [31,32]:

Chl a (mg•g–1) = [(12.7 × A663) – (2.69 × A645)] × mL acetone/mg leaf tissue

Chl b (mg•g–1) = [(22.9 × A645) – (4.68 × A663)] × mL acetone/mg leaf tissue

Total Chl = Chl a + Chl b

■ Statistical analysis

Data were statistically analyzed using one-way ANOVA on Graphpad Prism 6.01 software [33]. The results are presented as means ± S.D. (standard deviation) and data from the different treatments and control were compared by Duncan's multiple-range test at $p<0.05$.

Results & Discussion

■ Impact of UV light on seed germination

This study investigated the germination, root lengths and shoot lengths, fresh and dry weights of Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) to varying time exposure of UV light. The effect on germination of all seeds were trended with UV light accured from control to 17 minutes continuous exposure with UV light on Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) taken for studies. The phytotoxic effect of UV light research carried out to examine the seed germination percentage of both Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) are shown in **Figures 1 and 2**. The results concluded that the effect of UV light on seed germination percentage of Bengal gram (*Cicer arietinum L.*) shown positive response at lower exposure period and significant change in germination observed at 13-17 minutes exposure periods and horse gram (*Macrotyloma uniflorum L.*) shown mixed type of effect. The germination percentages were recorded to be decreased gradually with progressive increase in exposure time of UV light in all treatments of horse gram. The effect of UV light on seed germination is more on horse gram (*Macrotyloma uniflorum L.*) compare with Bengal gram (*Cicer arietinum L.*).

Seed germination, root and shoot lengths of Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) were highly decreased with the treatment of UV light as compared to the control **(Figures 1 and 2)**. The seed germination of the green Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) was likewise affected by the higher time exposure. The toxicity levels were high in horse gram (*Macrotyloma uniflorum L.*) compare to Bengal gram (*Cicer arietinum L.*). The numbers of seedlings were decreased as progressive increase in crop period in both Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*). The Bengal gram (*Cicer arietinum* L.) root length is gradually increased as crop period increased when compare with control and shoot lengths were decreased compare with control, while the horse gram (*Macrotyloma uniflorum L.*) root and shoot lengths were affected grievous with exposure of UV light and shown very poor

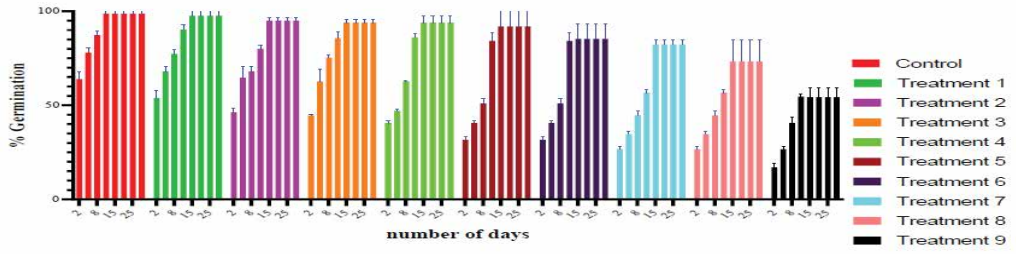

Figure 1. Impact of UV light irradiation on seed germination of Bengal gram (*Cicer arietinum L.*).

growth. These results were indicating longer period of exposure of UV light produced toxic effect in seed germination. Increasing duration of UV irradiation resulted essentially diminish the quality of germination as contrast with the most reduced convergence of overwhelming rays which have the slightest unsafe effect on the germination. The germination percentage significantly ($p<0.05$) affected at all time periods in both cases.

Also, the UV-irradiation as a positive and negative effect in a single treatment has been studied by many scientists. Rupiasih and Vidyasagar showed that a stimulated in the seed germination when wheat seeds exposed to UV-C radiation [34]. Peykarestan and Seify showed that percent germination and the rates of growth of sprouts of red bean seeds were inversely related to the UV irradiation doses [35]. Torres et al. [36] found that the percentage of normal seedlings of sunflower reduced when seeds exposed to UV-C radiation from 5 to 60 minutes. Siddiqui et al. [37] observed that an increment in shoot weight, shoot length, root length, root weight and leaf area of groundnut and mung bean when seeds exposed to UV-C radiation for 10, 15, 30 and 60 minutes period.

UV irradiation had significant effect on the germination of studied Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) seeds. The data obtained from both cases indicate that highly significant differences were found between seeds & exposure period. The germination of Bengal gram (*Cicer arietinum L.*) was significantly higher in all triplicates than the horse gram (*Macrotyloma uniflorum L.*) seeds shown in **Figures 1 and 2**.

The UV light exposure periods in both cases showed that the exposure periods were highly significant. The control treatment (no exposure) was significantly differed than other studied exposure periods. The seeds of Bengal gram (*Cicer arietinum L.*) shown almost similar shoot length at lesser period of exposure but significant at higher time period **(Figure 3)**. The seeds of horse gram (*Macrotyloma uniflorum L.*) showed a decreased shoot length as increase the exposure period **(Figure 4)**. The experiments also revealed that exposure of UV light promoted the growth of root in both the cases and root length is significantly higher than the control treatment in both Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) seeds. Plant root take up water and nutrients that are essential

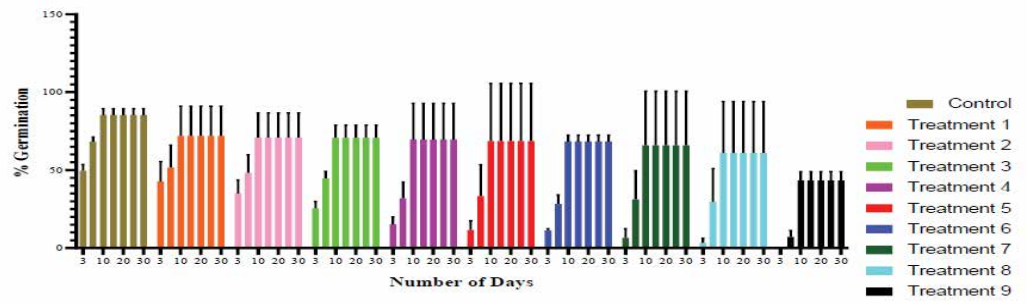

Figure 2. Impact of UV light irradiation on seed germination of Horse gram (*Macrotyloma uniflorum L.*).

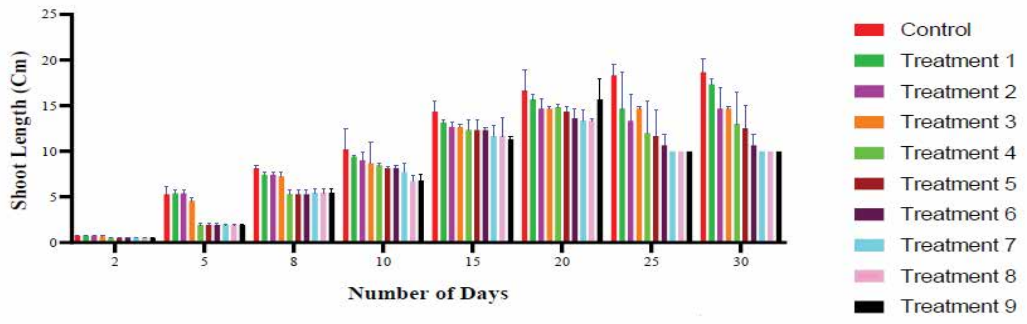

Figure 3. Impact of UV irradiation on shoot length of Bengal gram seeds (*Cicer arietinum L.*).

for plant growth. Generally root grows from a set of stem cells. The UV light enhances the mitotic division rate of the root tip cells and promotes the growth of root. The reports recorded from present investigation clearly indicates that both bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) seeds shown longer root formation compare with control treatment **(Figures 5 and 6)**. The similar types of results were reported by Feifeng et al. when exposed UV light on wheat somatic cells [38]. There are many reports indicate that UV rays results damage in plants and produced alterations in growth, development and morphology [39-41] while Ambaru et al. [42] reported an increase in the seed germination in UV-A irradiated *Capsicum annum*, Linn and Siddiqui et al. [37] reported that groundnut seedlings showed increment in shoot weight, root length and root weight, leaf area and number of nodules when seeds of groundnut were treated with UV-C for 10, 15, 30 and 60 minutes period as observes in the present study which shows an increase in seed germination, seedling growth and shoot and root elongation of Bengal gram (*Cicer arietinum L.*) with increasing exposure period up to 17 minute of UV-C irradiation as compared to control and horse gram (*Macrotyloma uniflorum L.*) seeds. The root development in Bengal gram (*Cicer arietinum L.*) is significantly greater than horse gram (*Macrotyloma uniflorum L.*). Hence Bengal gram (*Cicer arietinum L.*) shown positive growth when exposure to UV light where horse gram (*Macrotyloma uniflorum L.*) seeds effected and shown negative type result.

The fresh weight and dry weight of both Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) were shown in **Figures 7-10**. From the figures it is observed and concluded that the fresh and dry weight of Bengal gram (*Cicer arietinum L.*) seedling shown significant change at higher exposure period but similar at lower exposure periods. The fresh and dry weights of horse gram (*Macrotyloma uniflorum L.*) seedlings showed significant change even at lower exposure period. From the results it is clear that the Bengal gram (*Cicer arietinum L.*) seeds were the most tolerant to exposure to the UV light, where, horse gram (*Macrotyloma uniflorum L.*) seeds were the most sensitive to such radiations.

Physiological parameters such as % Phytotoxicity, % Inhibition, Seed Vigor Index (SVI) and Tolerance Indices of both Bengal gram (*Cicer arietinum L.*) and horse gram

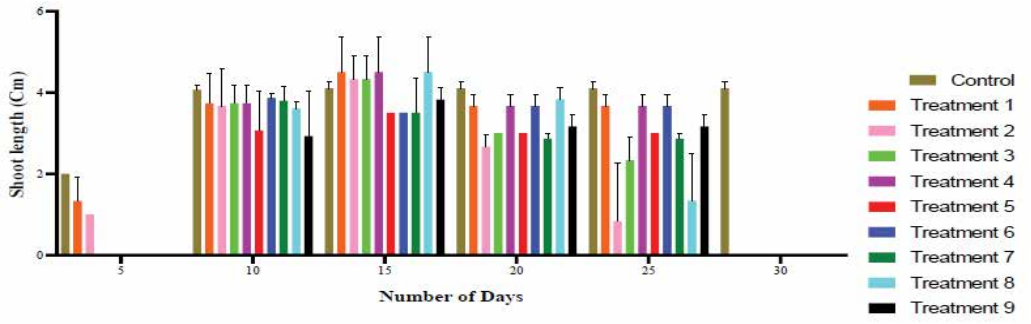

Figure 4. Impact of UV irradiation on shoot length of Horse gram (*Macrotyloma uniflorum L.*).

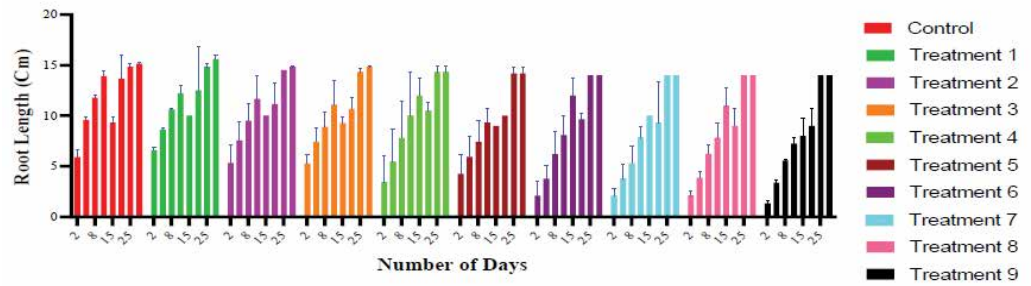

Figure 5. Impact of UV irradiation on root length of Bengal gram seeds (*Cicer arietinum L.*).

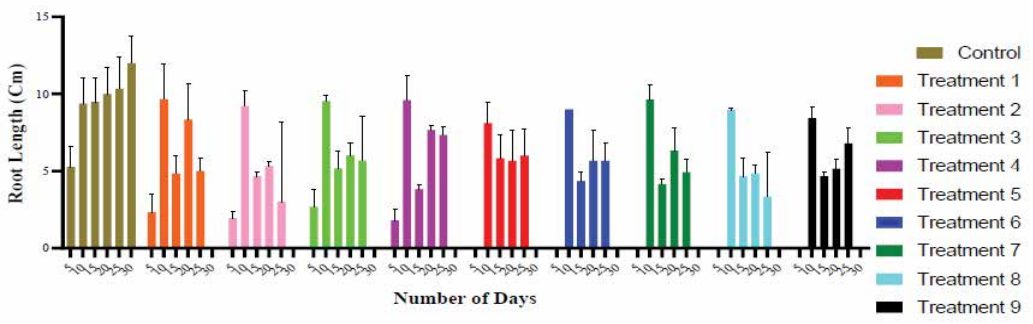

Figure 6. Impact of UV irradiation on root length of Horse gram (*Macrotyloma uniflorum L.*).

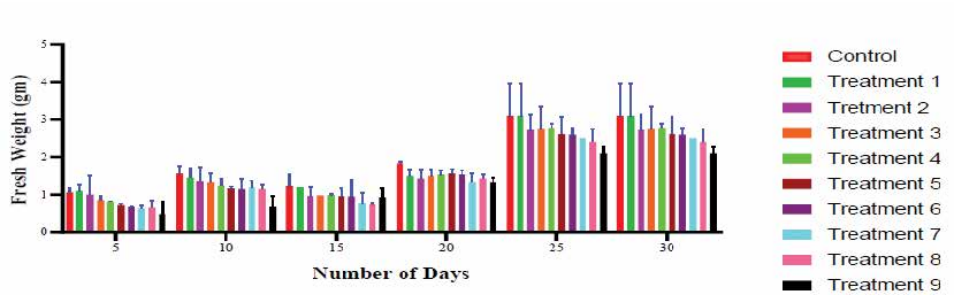

Figure 7. Impact of UV irradiation on fresh weight of Bengal gram (*Cicer arietinum L.*).

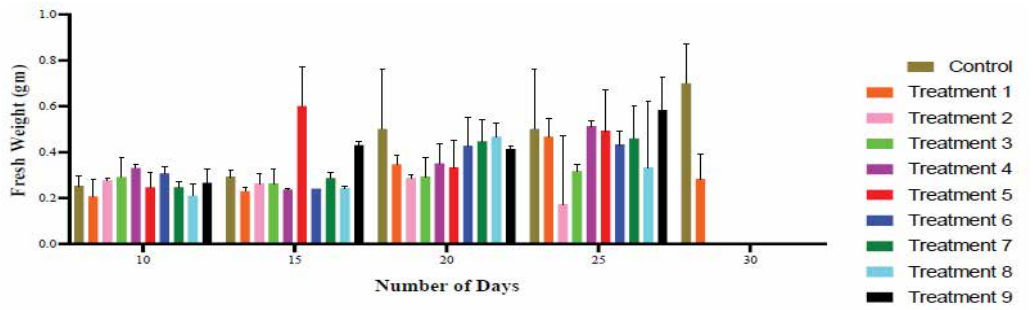

Figure 8. Impact of UV irradiation on fresh weight of Horse gram (*Macrotyloma uniflorum L.*).

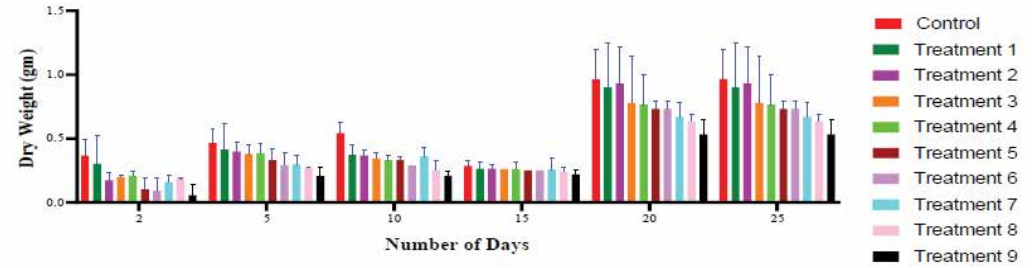

Figure 9. Impact of UV irradiation on dry weight of Bengal gram (*Cicer arietinum L.*).

(*Macrotyloma uniflorum L.*) were estimated and the UV irradiation showed higher phytotoxicity and inhibition with horse gram (*Macrotyloma uniflorum L.*) compare to control **(Figures 11-18)**. Positive report with Bengal gram (*Cicer arietinum L.*) concluding that exposure of UV

light promote the growth rate. Similar reports were reported by Neelamegam & Sutha. In his experiments open field experiment was carried out by split-plot method to record the effect of UV-C irradiation on seed germination, seedling growth and productivity of groundnut (*Arachis hypogaea* L.). The results indicated that UV-C irradiation up to 60 minutes increased the growth parameters of groundnut plant. The UV-C irradiation produced significant increase in seedling vigour and biomass production as compared to control and other treatments. The reports concluded that the UV-C irradiation treatments up to 60 minutes had no significant adverse effect on seed germination, seedling growth and productivity of groundnut plant [43]. In present investigation as the growth period is increased the change in color of leaves and stem observed in case of horse gram (*Macrotyloma uniflorum L.*) and finally between 18 to 20 days the seedlings 13, 15 and 17 minutes exposure treatments completely fall down due to higher phytotoxicity, lower tolerance and seed vigor index. From the results it is clear that the Bengal gram (*Cicer arietinum L.*) seeds were the most tolerant to exposure to the UV light, where, horse gram (*Macrotyloma uniflorum L.*) seeds were the most sensitive to such radiations.

■ Seedling growth analysis

The seedling growth analysis parameters such as Relative Growth Rate (RGR), Net Assimilation Rate (NAR), Leaf Area Ratio (LAR), Leaf Weight Ratio (LWR), Specific Leaf Area (SLA), Specific Leaf Weight (SLW), Leaf Area Duration (LAD) of both Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) seeds were estimated and the UV irradiation showed decreased growth with increase of exposure time and crop growth periods, compared to control in both experiments **Figures 19 and 20**. The results were depicted in **Tables 1 and 2**.

■ Biochemical attributes

To find out the biochemical response of the Bengal gram (*Cicer arietinum L.*) and horse gram (*Macrotyloma uniflorum L.*) at different exposure periods of UV light, the biomass allowed to check total carbohydrates (Anthrone method), total proteins (Biuret method) and peroxidase enzyme activity (O-dianisidine method) [44]. The results were illustrated in **Tables 3 and 4** respectively. From the results it is observed that total carbohydrates and proteins of horse gram (*Macrotyloma uniflorum L.*) seedlings were decreased with increase in UV exposure period.

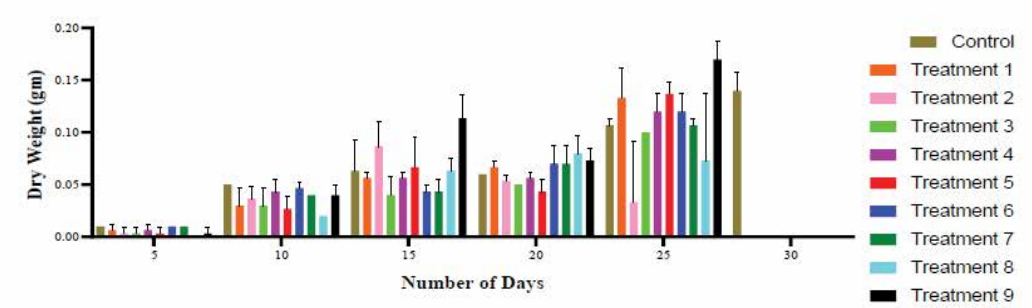

Figure 10. Impact of UV irradiation on dry weight of Horse gram (*Macrotyloma uniflorum L.*).

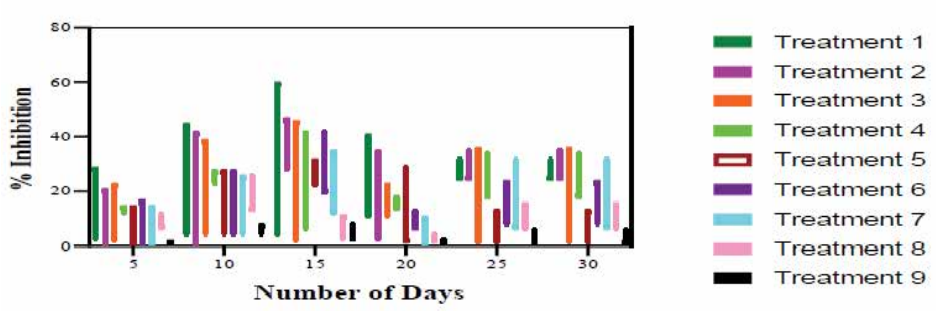

Figure 11. Impact of UV irradiation on % inhibition of Bengal gram seedlings (*Cicer arietinum L.*).

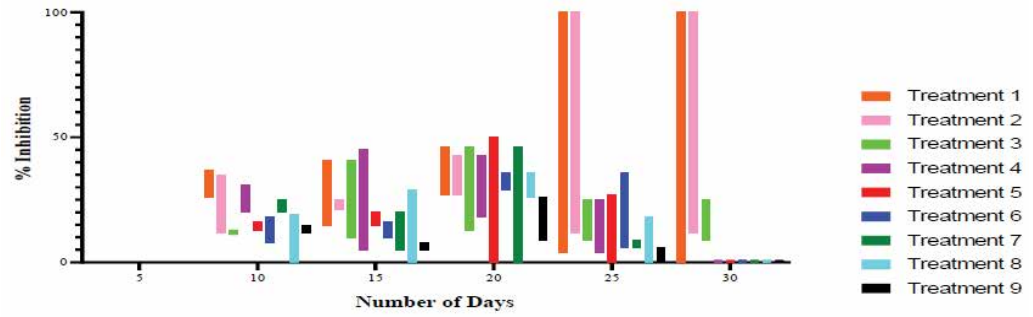

Figure 12. Impact of UV irradiation on % inhibition Horse gram seedlings (*Macrotyloma uniflorum L.*).

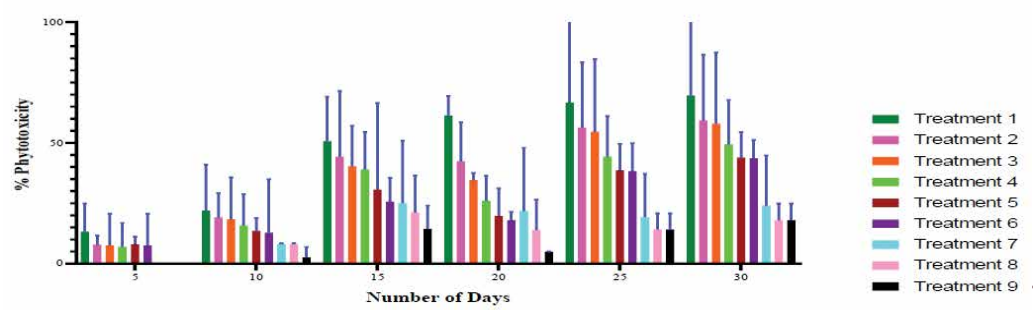

Figure 13. Impact of UV irradiation on % phytotoxicity of Bengal gram (*Cicer arietinum L.*) seedlings.

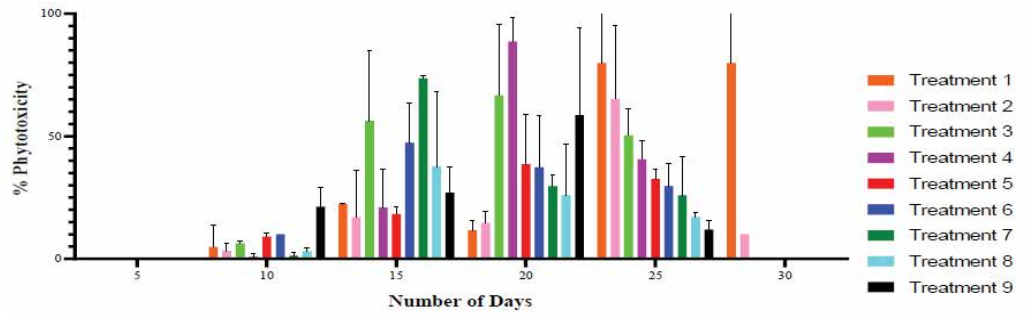

Figure 14. Impact of UV irradiation on % phytotoxicity of Horse gram (*Macrotyloma uniflorum L.*) seedlings.

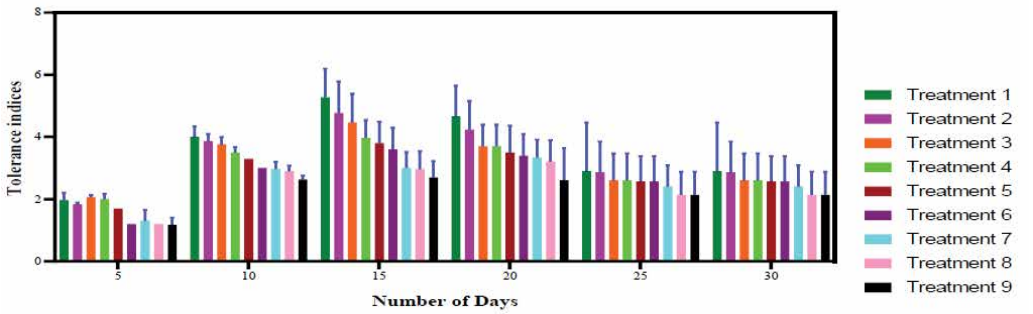

Figure 15. Impact of UV irradiation on tolerance indices of Bengal gram (*Cicer arietinum L.*) seedlings.

The sever effect on total carbohydrates and proteins were found at 7 to 17 minutes exposure period compare to control. The peroxidase enzyme activity decreased with increase in exposure period and crop growth duration. The decrease in enzyme activity significantly showed

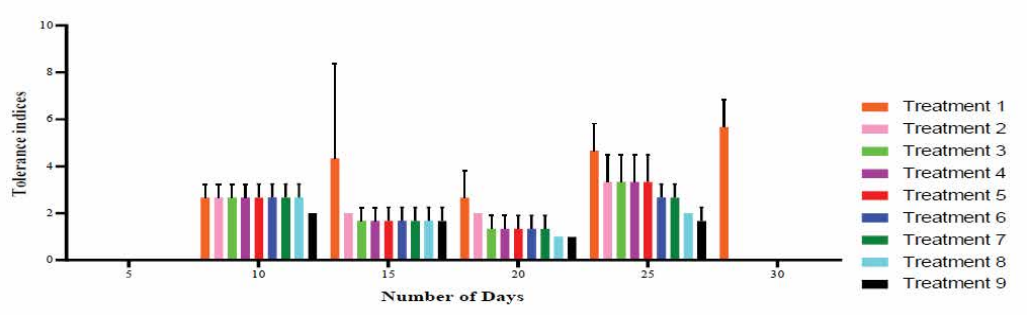

Figure 16. Impact of UV irradiation on tolerance indices of Horse gram (*Macrotyloma uniflorum L.*) seedlings..

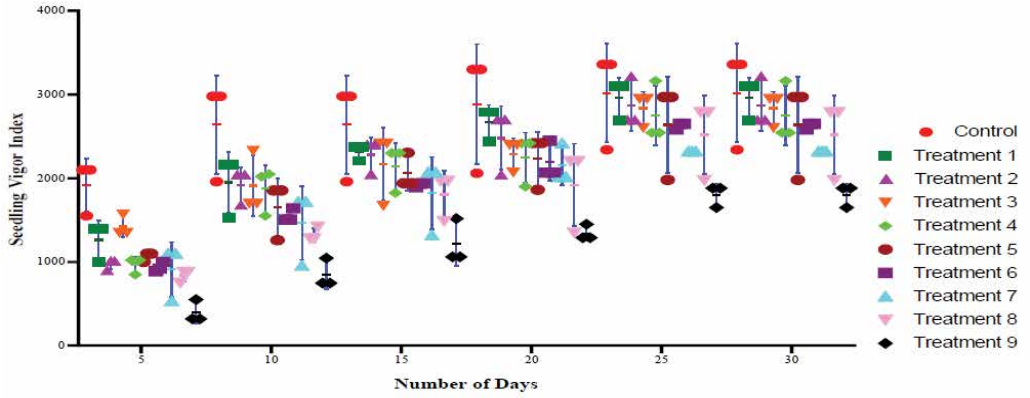

Figure 17. Impact of UV irradiation on seedling vigor index of Bengal gram (*Cicer arietinum L.*).

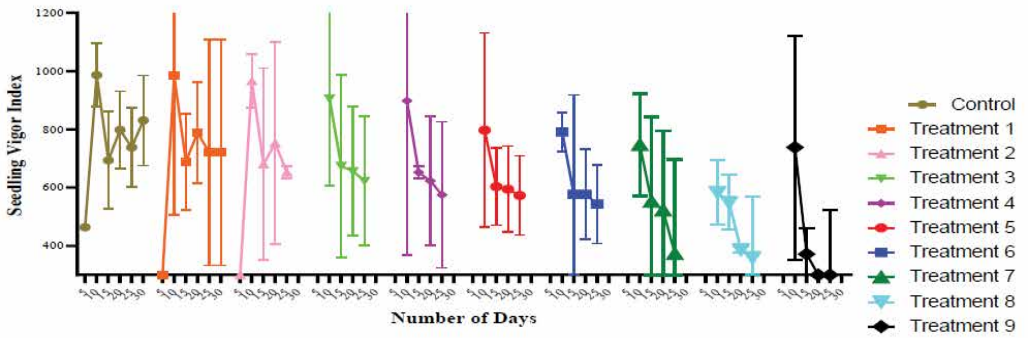

Figure 18. Impact of UV irradiation on seedling vigor index of Horse gram (*Macrotyloma uniflorum L.*).

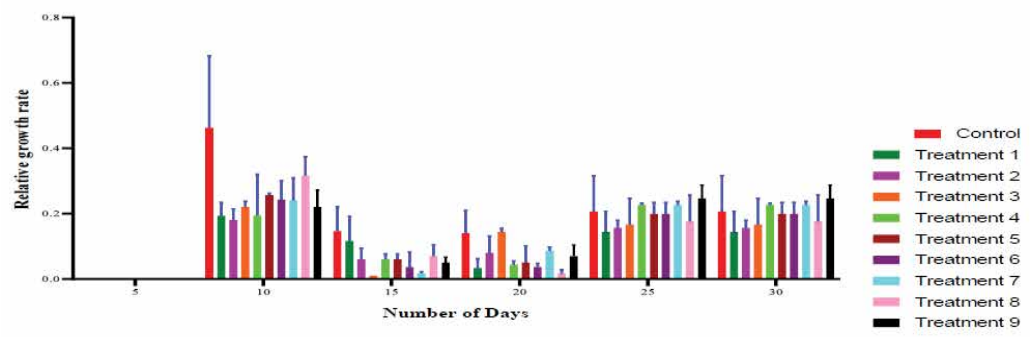

Figure 19. Impact of UV irradiation on relative growth rate of Bengal gram (*Cicer arietinum L.*).

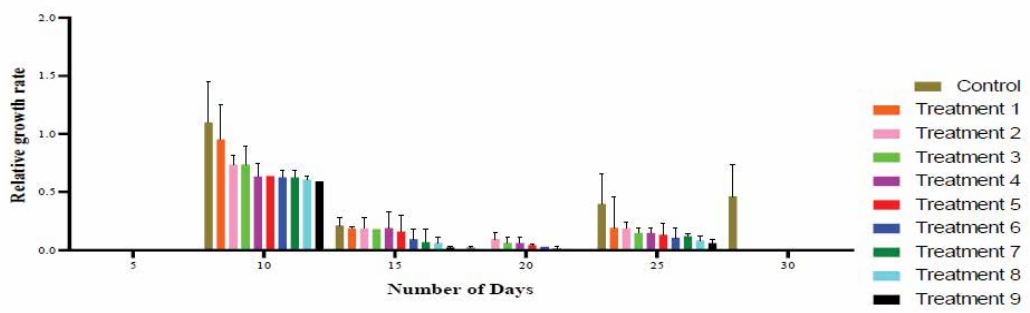

Figure 20. Impact of UV irradiation on relative growth rate of Horse gram (*Macrotyloma uniflorum L.*).

Table 1. Growth analysis & physiological response of Bengal gram (*Cicer arietinum* L.) under different exposure periods of UV light.

Days	Control						Treatment 1					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	126	0.33	727	0.006	81	0.02	125	0.33	157	0.005	76	0.01
15	201	0.33	251	0.004	135	6E-04	156	0.33	700	0.001	133	0.0001
20	204	0.33	487	0.004	146	-1E-04	198	0.33	483	0.002	141	0.0006
25	86	0.33	236	0.004	167	0.002	78	0.33	235	0.002	157	0.002
30	86	0.33	236	0.004	167	0.002	78	0.33	235	0.002	157	0.002
	Treatment -2						Treatment-3					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	112	0.33	202	0.004	70	0.01	91	0.33	140	0.006	69	0.01
15	151	0.33	347	0.003	124	1E-04	141	0.33	350	0.002	115	0.0001
20	198	0.33	516	0.002	129	-4E-04	165	0.33	626	0.001	128	-4E-04
25	65	0.33	234	0.007	147	0.001	63	0.33	146	0.005	137	0.002
30	0	0	0	0	0	0	0	0	0	0	0	0
	Treatment -4						Treatment- 5					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	82	0.33	199	0.006	63	0.009	68	0.33	337	0.003	61	0.006
15	120	0.33	339	0.002	111	1E-04	112	0.33	398	0.002	107	0.0002
20	164	0.33	439	0.002	124	-4E-04	154	0.33	505	0.002	124	-6E-04
25	63	0.33	228	0.004	129	0.002	62	0.33	194	0.005	121	0.0006
30	0	0	0	0	0	0	0	0	0	0	0	0
	Treatment -6						Treatment-7					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	64	0.33	848	0.003	57	0.007	55	0.33	352	0.001	50	0.006
15	110	0.33	1844	0.002	107	3E-04	105	0.33	590	0.001	106	0.0001
20	153	0.33	477	0.002	123	-3E-04	153	0.33	645	0.001	123	-4E-04
25	56	0.33	148	0.006	119	6E-04	50	0.33	257	0.003	118	0.001
30	0	0	0	0	0	0	0	0	0	0	0	0
	Treatment -8						Treatment-9					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	43	0.33	402	0.001	43	0.002	22	0.33	253	0.004	25	0.007
15	60	0.33	514	0.001	99	2E-04	46	0.33	331	0.003	90	0.0001
20	147	0.33	498	0.001	112	3E-04	145	0.33	512	0.001	112	-4E-04
25	48	0.33	187	0.005	116	0.002	37	0.33	115	0.008	114	0.002
30	0	0	0	0	0		0	0	0	0	0	0

effect on germination and other physiological parameters of horse gram (*Macrotyloma uniflorum L.*) seedlings. The Bengal gram (*Cicer arietinum L.*) showed positive result with exposure of UV light. The total carbohydrates, total protein content was increased with increase in UV light exposure duration. The peroxidase enzyme activity is increased with increased exposure duration of UV light. The altered gene expression promoted the activity of peroxidase

Table 2. Growth analysis & physiological response of Horse gram seeds (*Macrotyloma uniflorum* L.) under different exposure periods of UV light.

Days	Control						Treatment 1					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	594	0.33	889	0.001	43.5	0.001	420	0.33	1900	0.001	35.8	0.0009
15	440	0.33	874	0.002	65.2	2E-04	305	0.33	532	0.001	51.9	0.001
20	355	0.33	946	0.001	69.5	2E-04	331	0.33	866	0.001	68.1	0.0002
25	226	0.33	392	0.003	71.5	5E-04	205	0.33	430	0.003	68.5	0.0007
30	226	0.33	392	0.003	71.5	5E-04	205	0.33	430	0.003	68.5	0.0007
	Treatment -2						Treatment-3					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	438	0.33	1270	0.001	34.9	0.001	384	0.33	1077	0.001	33.3	0.001
15	239	0.33	418	0.001	44.4	1E-04	233	0.33	979	0.001	39.2	0.0005
20	315	0.33	644	0.001	60.3	2E-04	294	0.33	752	0.001	54.7	0.0002
25	163	0.33	111	0.003	64.4	1E-04	137	0.33	328	0.002	56.2	0.0001
30	163	0.33	111	0.003	64.4	1E-04	137	0.33	328	0.002	56.2	0.0001
	Treatment -4						Treatment- 5					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	332	0.33	1192	0.0008	30.8	0.001	330	0.33	1414	8E-04	30	0.001
15	224	0.33	653	0.001	39	6E-04	214	0.33	575	0.001	33.6	0.0005
20	258	0.33	801	0.001	48.1	0	255	0.33	1020	0.001	44.2	0.0003
25	125	0.33	498	0.002	53.6	4E-04	98	0.33	283	0.002	42.6	0.0006
30	125	0.33	498	0.002	53.6	4E-04	98	0.33	283	0.002	42.6	0.0006
	Treatment -6						Treatment-7					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	291	0.33	629	0.0008	24.5	0.001	284	0.33	896	7E-04	23.5	0.001
15	185	0.33	721	0.001	32.5	4E-04	174	0.33	1150	0.001	31.9	0.0001
20	264	0.33	698	0.001	42.2	4E-04	240	0.33	1230	0.001	37.8	0.0002
25	89	0.33	690	0.002	38.3	6E-04	86	0.33	648	0.001	34.4	0.0002
30	89	0.33	690	0.002	38.3	6E-04	86	0.33	648	0.001	34.4	0.0002
	Treatment -8						Treatment-9					
	LAR	LWR	SLA	SLW	LAD	NAR	LAR	LWR	SLA	SLW	LAD	NAR
10	202	0.33	1106	0.0007	21.8	0.001	202	0.33	624	7E-04	16.6	0.001
15	167	0.33	571	0.0008	30.5	-1E-04	133	0.33	735	8E-04	29	0.0006
20	208	0.33	774	0.0008	35.7	2E-04	203	0.33	1149	7E-04	31.2	0.0001
25	78	0.33	264	0.001	30.6	0.001	33	0.33	374	0.001	13.8	0.0006
30	78	0.33	264	0.001	30.6	0.001	33	0.33	374	0.001	13.8	0.0006

Table 3. Effect of UV irradiation on biochemical properties (carbohydrates, proteins and POD enzyme activity of horse gram (*Macrotyloma uniflorum* L.) seedling.

S.No	Test Treatment	Total Carbohydrates (mg/g)	Total Protein (mg/g)	Peroxidase enzyme activity (unit/mg of protein)
1	Control	4.597 ± 0.00	8.073 ± 0.10	7.226 ± 0.35
2	T1	4.413 ± 0.01	8.073 ± 0.01	5.720 ± 1.80
3	T2	4.449 ± 0.03	6.890 ± 0.01	4.230 ± 0.20
4	T3	4.523 ± 0.00	5.020 ± 0.00	3.222 ± 0.20
5	T4	3.250 ± 0.06	4.130 ± 0.02	2.260 ± 0.35
6	T5	2.450 ± 0.10	4.020 ± 0.00	1.40 ± 0.15
7	T6	1.990 ± 0.00	3.784 ± 0.01	0.900 ± 0.05
8	T7	1.727 ± 0.06	1.073 ± 0.06	0.300 ± 0.05
9	T8	0.663 ± 0.00	0.416 ± 0.01	0.280 ± 0.04
10	T9	0.267 ± 0.00	0.310 ± 0.01	0.150 ± 0.06

under stress condition. The positive response of Bengal gram (*Cicer arietinum L.*) seedling with UV light concluding the UV light enhances the growth of crop up to optimum.

Effect of UV light on chlorophyll contents

The effect of UV light on photosynthetic pigments of horse gram (*Macrotyloma uniflorum L.*) leaves was determined on 20th day **(Table 5)**. The photosynthetic pigment chlorophyll-a, chlorophyll-b and total chlorophyll of horse gram (*Macrotyloma uniflorum L.*) were decreased with increase in duration of UV light exposure. The mean amount of plant pigments of horse gram (*Macrotyloma uniflorum L.*) leaves treated with UV light depicted in **Table 5**. From the results it is observed that chlorophyll-a in horse gram (*Macrotyloma uniflorum L.*) decrease from 6.84 ± 0.00 to 6.52 ± 0.02, 6.36 ± 0.04, 6.02 ± 0.00, 5.63 ± 0.03, 3.52 ± 0.05, 1.64 ± 0.06, 0.92 ± 0.12, 0 and 0 with different treatments respectively. Similarly the chlorophyll-b in horse gram (*Macrotyloma uniflorum* L.) leaves were decreased significantly from 12.52 ± 0.03 to 12.03 ± 0.00, 11.63 ± 0.06, 10.56 ± 0.04, 9.17 ± 0.00, 6.37 ± 0.00, 1.69 ± 0.02, 1.06 ± 0.02, 0 and 0 with different treatments respectively. This decrease in pigment content indicates that the chlorophyll synthesis system and chlorophyllase activity affected by the exposure to UV light for longer period. The depletion in chlorophyll content under UV light stress may reduce the enzyme functions involves in the chlorophyll biosynthesis pathway.

The effect of UV light irradiation on photosynthetic pigments of Bengal gram (*Cicer arietinum L.*) leaves was determined on 20th day. From the results it is observed that photosynthetic pigments i.e. chlorophyll-a, chlorophyll-b and total chlorophyll of Bengal gram (*Cicer arietinum L.*) were constant and no significant change observed with all treatments compare with control. This outcome concludes that UV light enhances the chlorophyll biosynthetic path way in Bengal gram (*Cicer arietinum L.*).

Table 4. Effect of UV irradiation on biochemical properties (carbohydrates, proteins and POD enzyme activity in Bengal gram (*Cicer arietinum* L.) seedling.

S.No	Test Treatment	Total Carbohydrates (mg/gm)	Total Protein (mg/gm)	Peroxidase enzyme activity (unit/mg of protein)
1	Control	5.975 ± 0.00	7.524 ± 0.10	9.002 ± 0.01
2	T1	6.021 ± 0.35	7.628 ± 0.10	9.015 ± 0.06
3	T2	6.224 ± 0.01	7.974 ± 0.00	9.028 ± 0.04
4	T3	6.925 ± 0.02	8.011 ± 0.02	9.030 ± 0.05
5	T4	8.547 ± 0.00	8.127 ± 0.06	9.090 ± 0.05
6	T5	8.886 ± 0.62	8.378 ± 0.04	9.140 ± 0.04
7	T6	9.190 ± 0.00	8.402 ± 0.00	9.224 ± 0.32
8	T7	9.212 ± 0.00	8.413 ± 0.02	9.321 ± 0.20
9	T8	9.212 ± 0.00	8.502 ± 0.06	9.430 ± 0.20
10	T9	9.217 ± 0.01	8.689 ± 0.01	9.572 ± 0.12

Table 5. Effect of UV irradiation on chlorophyll content (a, b, total) in Horse gram (*Macrotyloma uniflorum* L.).

UV light exposure time	Chlorophyll-a (mg/g/wt)	Chlorophyll-b (mg/g/wt)	Total Chlorophyll (mg/g/wt)
Control	6.84 ± 0.00	12.52 ± 0.03	19.36 ± 0.03
T1	6.52 ± 0.02	12.03 ± 0.00	18.55 ± 0.02
T2	6.36 ± 0.04	11.63 ± 0.06	17.99 ± 0.10
T3	6.02 ± 0.00	10.56 ± 0.04	16.58 ± 0.04
T4	5.63 ± 0.03	9.17 ± 0.00	14.8 ± 0.03
T5	3.52 ± 0.05	6.37 ± 0.00	9.89 ± 0.05
T6	1.64 ± 0.06	1.69 ± 0.02	3.33 ± 0.08
T7	0.92 ± 0.12	1.06 ± 0.02	1.98 ± 0.14
T8	0 totally dried	0	0
T9	0 totally dried	0	0

Conclusion

The UV radiation (253 nm) affected significantly both of seed germination and chlorophyll concentration in horse gram (*Macrotyloma uniflorum L.*). Increased UV radiation (exposure periods) can decrease chlorophyll-a, chlorophyll-b and chlorophyll- a+b (total chlorophyll) concentration of the seedlings. Seed germinations are also a sensitive to respond to increase to UV radiation. From the results, it is clear that Bengal gram (*Cicer arietinum L.*) seeds were the most tolerant to the exposure to the ultraviolet (253 nm.) radiation, horse gram (*Macrotyloma uniflorum L.*) seeds were the most sensitive. Chlorophyll-a, b and a+b concentration of Bengal gram (*Cicer arietinum L.*) were higher than those found in horse gram (*Macrotyloma uniflorum L.*) after exposure to UV in different treatments. Numerous studies have shown that impact of UV-B and UV-C radiation on plant development can be miscellaneous. Exceeding ambient radiation intensity caused damage or negative impact on different plant cell, membrane, photosynthesis system, hormones, but no studies were concerned with the UV-C and their impact on plant development and health status of horse gram (*Macrotyloma uniflorum L.*) and Bengal gram (*Cicer arietinum L.*). Further studies are required to understand the mechanism of the UV-C radiation on the crop growth, crop development, and cellular and sub cellular response.

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