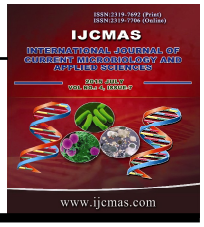
International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 4 Number 8 (2015) pp. 430-443**
http://www.ijcmas.com



Original Research Article

UV-C Irradiation Effect on Seed Germination, Seedling Growth and Productivity of Groundnut (*Arachis hypogaea L.*)

R. Neelamegam* and T. Sutha

P.G. Department of Botany & Research Centre, S.T. Hindu College,
Nagercoil -629 002, Tamil Nadu, India
**Corresponding author*

Keywords

UV-C irradiation, Groundnut, Arachis hypogaea, Seedling growth,

A B S T R A C T

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 indicate that UV-C irradiation up to 60min. increased the growth parameters of groundnut plant recorded. The UV-C irradiation produces significant increase in seedling vigour and biomass production as compared to control and other treatments. The results of present study reveals that the UV-C irradiation treatments up to 60 min. has no significant adverse effect on seed germination, seedling growth and productivity of groundnut plant.

Introduction

Irradiation is a method that given to substances or plants or plant materials with radiation. During irradiation the high energy radiation pass through the matter and cause ionizing or electric or magnetic disturbances that affect the internal structure or matter of plants. During the past few decades, the ozone reduction problem has stimulated considerable research on higher plant responses to UV-radiation (Caldwell and Flint, 1994). When exposed to elevated UV-radiation, the higher plants exhibit various physiological and morphological changes (Bjorn, 1996; Greenberg *et al.*, 1997; Rozema *et al.*, 1997; Caldwell *et al.*, 1998) and there is considerable variation among species (Barnes *et al.*, 1990; Day, 1993; Mc Leod and Newsham, 1997) and among varieties within the same species (Ziska *et al.*, 1992; Corlett *et al.*, 1997; Correia *et al.*, 1998, 1999). Seeds are more susceptible to radiation when they have high water content. Presence of oxygen increased the free radical production (Arvind Kumar and Purohit, 1998). The role of water content influencing the effects of physical and chemical mutagens is well established (Conger *et al.*, 1968). Water content appears to involve in 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 and productivity of groundnut (*Arachis hypogaea* L.) under field condition.

Materials and Methods

Preparation of field experimental plots

Field experiment was conducted for 90 days (from 28/09/2011 to 26/12/2011) in the Botanical Garden, Dept. of Botany, S. T. Hindu College Nagercoil, to evaluate the effect UV-C irradiation on water pre-soaked groundnut seeds germination growth and productivity.. The experimental field with an area of about 10 x 5 = 50m^2 was thoroughly cleaned by removing all vegetation and other solid unwanted materials. Then the soil was softened turned down manually and then plots were laid out. The plot size adopted in this experimental design was 150cm length x 100cm breadth x 15cm depth. Between plot 30cm gap was allotted while between rows the gap was 50cm (Fig. 1).

Experimental Design

Split-Plot Design lay out in the experimental field as follows as shown in the Plate-I.

Seed treatment and seed sowing

For field experiment, healthy, dry and uniform size groundnut seeds were pre-soaked in distilled water for 24 hours and then four sets of seeds were immediately irradiated separately with UV-C at different period of exposure (5, 10, 20, 30 and 60 minutes) in a ST 51 G/W 51UV tube with a wavelength of about 280nm. Dry and water presoaked groundnut seeds not treated with UV-C irradiation were maintained as control. All the treatments were done in 3 replications. Then the seeds of groundnut were sown in the experimental plots (30 seeds/ plot) on 28. 09. 2011. The seed germination and seedling growth of groundnut was observed up to 90 DAS.

Irrigation, Weeding and Thinning

From the time of seed sowing the experimental plots were irrigated regularly once in a day to maintain the soil moisture at saturated level. Weeding was done at regular intervals (once in 15 days) and maintains the plot free from weeds through out the study. Thinning was done after every sampling day that is on 15^{th}, 30^{th} 60^{th} and 90^{th} day after seed sowing. The number of seedlings maintained in the experimental plots was calculated at the time of sampling day in each treatment (Table 1).

Sampling and data collection

Plant sampling was made on 15^{th}, 30^{th}, 60^{th} and 90^{th} DAS for recording growth parameters of groundnut seedlings (Plate-I). At the time of every sampling five plants were taken from each plot of all treatments including control. The plants were collected randomly from each plot and the roots are washed with running water to remove the soil particles.

The growth of groundnut seedling were observed through out the study period and the growth parameters like number of seedling survival and seedling growth (total length, shoot length, root length); number of branches; leaf growth – (number of leaf, leaf length and breadth; date of flowering, no. of flowers and pods developed; and biomass production – (seedling/ pod fresh weight and dry weight), etc., were recorded at all sampling days (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 is control x 100*) proposed by Turner and Marshal (1972); Root/Shoot Ratio, Leaf Area Index calculated by using the following formula (*LAI = length x breadth x 0.69*) proposed by Kalra and Dhiman (1977), Absolute Growth

Rate was calculated by using the formula (*AGR = W_2-W_1/t_2-t_1;* where, W_1 and W_2 refers to weight of total dry matter at the time t_2 and t_1, respectively) suggested by Redford (1967); Relative Growth Rate was estimated using the formula (*RGR =loge W_2–Loge W_1/ t2–t1*; where, Loge = 2.3026) proposed by Briggs *et al.* (1920) and Net Assimilation Rate were also calculated by the formula (*NAR = Loge L_2–Loge L_1/L_2–L_1 x W_2–W_1/t_2–t_1*; where, L_2 and L_1 denote leaf area per plant at the time t_2 and t_1, respectively) proposed by Gregory (1926).

All the data, collected from experiments, were analysed statistically by calculating mean and standard deviation following standard methods. The significance level was analyzed by using one-way ANOVA computerized software (AGDATA & AGRES) developed by TNAU, Madurai in Tamil Nadu.

Results and Discussion

UV-C irradiation treatment on groundnut seeds generally promoted the seed germination. The increasing duration of UV-C irradiation (up to 60min) increased the promotery effect on the seed germination of groundnut as compared to dry and soaked seed control (Table 1). Maximum germination of 83.33% was recorded at 60 min UV-C irradiation treatment, while it was low (63.33%) at 5 min UV-C treatment. UV-C irradiation treated groundnut seeds generally increased the seedling (root and shoot) growth at all exposure periods of UV-C irradiation as compared to dry and soaked seed control at all sampling days (Table 2–4; Fig. 1 & 2). The increasing exposure period of UV-C irradiation gradually increased the groundnut seedling (root and shoot) growth. The seedling root and shoot growth of groundnut was more in UV-C irradiated water soaked seeds as compared to dry groundnut seeds (Fig. 1 & 2). When compared to root growth, the increase of shoot growth was more at all sampling days and the root/shoot ratio of groundnut seedling was decreased with increasing age (Table 2–4; Fig. 3). The total seedlings (root & shoot length) growth of groundnut was general more in seeds treated with UV-C irradiation than controls (Table 2–4; Fig. 4). UV-C irradiation increased the number of branches (Fig. 5) and number of leaves (Fig. 7) in groundnut seedling at all sampling days as compared to control, while decreased the root nodules in 60th day samples and increased in 30th and 90th day samples (Table 2–4; Fig. 6).

UV-C irradiation seed treatment shows no significant effect on leaflet length, leaflet breadth and leaflet area of groundnut seedling as compared to control at all sampling days (Fig. 9 to 11). The total leaf area per plant was increased by UV-C irradiation seed treatment as compared to controls at all sampling days (Fig. 12).

The number of flowers produced per plant was increased at low exposure period of UV-C irradiation (5min) in 30th day sample followed by a reduction with further increasing period of exposure as compared to control (Fig. 8), while it was increased up to 20min exposure of UV-C irradiation followed by decrease in 90th day sample. In 60th day sample, the flower production increased at all treatments (Fig. 8) than the controls.

In 60th day sample, the number of pedicels without pod was less in UV-C treatments (Fig. 13), while it was more in 90th day samples as compared to controls. UV-C irradiation seed treatment generally increased the mature and immature pods in both sampling days and it was increased with increasing period of UV-C radiation (Fig. 14–16). The dry weight of 100 pods with seeds was maximum (98gm) in 10min

and 20 min UV-C exposures (Table 3) as compared to controls and other UV-C treatments. Similarly, UV-C irradiation seed treatment shows maximum dry weight of 100 seeds (41gm) in 10min UV-C exposure than all other treatments including control (Table 3).

Seedling fresh root, shoot and pod biomass of groundnut was generally increased at 30th and 90th day samples with increasing period of UV-C exposure (Fig. 17–20) as compared controls. But in 60th day sample, the biomass production was reduced with increasing UV-C exposure than controls. UV-C irradiation seed treatments increased the root and shoot dry weight of groundnut in 30th day samples than controls. But, in 60th and 90th day samples, the root dry biomass of groundnut seedling was increased initially (5min UV-C irradiation) followed by a reduction with increasing period of UV-C exposure than control (Fig. 21). On the other hand the shoot dry weight of groundnut seedling was increased with increase period of UV-C exposure in 90th day sample, while it was decreased in 30th day sample than control (Fig. 22). UV-C irradiation seed treatment increased pod dry weight initially followed by reduction in both sampling days as compared to controls (Fig. 23). Similar trend was also noted in the total dry biomass production of groundnut seedling (Fig. 24).

Table.1 Number of seedlings stand at the time of sampling (DAS)

Treatment	Plot No	Number of seedling stand on			
		10thDAS	30thDAS	60thDAS	90thDAS
T_1 –Control- dry seed	1	26	10	7	4
	2	22	10	7	4
	3	16	10	7	4
T_2 – Soaked Seed (SS)	4	18	10	7	4
	5	23	10	7	4
	6	17	10	7	4
T_3 –SS+ UV-C ‘5min’	7	17	10	7	4
	8	22	10	7	4
	9	18	10	7	4
T_4 –SS+ UV-C ‘10min’	10	19	10	7	4
	11	18	10	7	4
	12	19	10	7	4
T_5 – SS+ UV-C ‘20min’	13	22	10	7	4
	14	20	10	7	4
	15	21	10	7	4
T_6 – SS+ UV-C ‘30min’	16	17	10	7	4
	17	19	10	7	4
	18	26	10	7	4
T_7 – SS+ UV-C ‘60min’	19	25	10	7	4
	20	20	10	7	4
	21	30	10	7	4

Table.2 Effect of UV-C irradiation seed treatment on seedling growth (30 DAS) of groundnut

Seedling growth parameters	Treatments							CD	F-
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	(P=0.05)	value@
1. Root Length (cm/pl)	9.11	9.28	9.33	9.89	10.01	10.45	10.67	3.39	NS
	±0.91	±1.44	±1.15	±1.84	±1.33	±1.39	±2.08		
2. Shoot length (cm/pl)	12.67	12.84	13.11	13.22	13.45	13.55	15.67	2.7	NS
	±2.17	±0.87	±2.45	±0.75	±0.98	±0.85	±0.33		
3. Total length (cm/pl)	21.78	22.12	22.45	23.12	23.46	23.99	26.34	5.03	NS
	±3.02	±2.27	±3.59	±1.58	±3.72	±2.03	±2.33		
4. Root/shoot ratio	0.73	0.72	0.72	0.75	0.74	0.77	0.68	0.23	NS
	±0.07	±0.06	±0.05	±0.17	±0.23	±0.07	±0.12		
5. No of branches/pl	4.56	4.89	4.67	5.00	4.89	5.13	5.23	0.98	NS
	±0.83	±0.39	±0.67	±0.33	±0.39	±0.40	±0.51		
6. No. of root nodules/pl	41.33	43.33	49.33	43.67	38.33	35.00	33.67	14.68	NS
	±3.79	±8.09	±4.04	±6.66	±7.77	±10.44	±13.01		
7. Number of leaves/pl	14.00	14.45	16.23	17.11	17.11	17.45	21.00	7.11	NS
	±2.73	±4.91	±2.59	±4.48	±5.35	±4.54	±1.20		
8. Leaflet length (cm/leaf)	5.29	5.49	5.58	5.58	5.41	5.15	5.05	1.75	NS
	±0.33	±0.29	±.28	±0.23	±0.33	±0.59	±0.45		
9. Leaflet breadth (cm/leaf)	2.85	2.87	2.91	2.81	2.69	2.64	2.54	0.5	NS
	±0.10	±0.14	±0.41	±0.12	±0.08	±0.10	±0.50		
10. Leaflet area index	10.41	10.81	11.15	10.81	10.05	9.37	8.82	3.57	NS
	±0.94	±1.08	±4.43	±0.91	±0.34	±1.25	±1.23		
11. Leaf area index (cm^2/pl)	586.00	642.00	750.00	736.00	686.00	663.00	738.00	450.68	NS
	±138	±282	±396	±182	±204	±229	±73		
12. Seedling vigour index	1316.00	1342.00	1433.00	1521.00	1635.00	1721.00	2171.00	438.35	*
	±154	±251	±365	±253	±199	±219	±272		
13. Seedling tolerance index	1.00	1.03	1.04	1.09	1.12	1.16	1.19	0.39	NS
	±0.00	±0.20	±0.22	±0.23	±0.45	±0.25	±0.29		
14. Root fresh weight (g/pl)	0.84	0.87	0.87	0.89	0.93	0.95	0.99	0.33	NS
	±0.20	±0.05	±0.28	±0.03	±0.32	±0.14	±0.31		
15. Shoot fresh weight (g/pl)	13.49	14.81	15.29	15.33	15.57	15.84	19.02	5.32	NS
	±2.51	±4.26	±1.27	±1.83	±4.10	±1.67	±2.39		
16. Total fresh weight (g/pl)	14.34	15.69	16.17	16.21	16.50	16.78	20.00	5.33	NS
	±2.31	±4.26	±1.03	±1.80	±4.13	±1.60	±2.70		
17. Root dry weight (g/pl)	0.06	0.07	0.08	0.08	0.08	0.09	0.09	0.06	NS
	±0.04	±0.02	±0.06	±0.02	±0.01	±0.02	±0.02		
18. Shoot dry weight (g/pl)	1.36	1.40	1.47	1.52	1.54	1.57	1.69	0.52	NS
	±0.19	±0.17	±0.17	±0.18	±0.40	±0.36	±0.52		
19. Total dry weight (g/pl)	1.43	1.47	1.55	1.60	1.62	1.66	1.78	0.52	NS
	±0.18	±0.15	±0.22	±0.20	±0.41	±0.36	±0.50		
20. No of flowers/pl	8.67	9.33	10.00	8.67	8.67	8.00	7.00	5.22	NS
	±3.79	±2.08	±4.58	±0.58	±4.04	±4.36	±2.64		
21. Seed germination (%)#	54.44	61.11	63.33	65.55	69.99	72.22	83.33	20.42	NS
	±18.36	±13.88	±8.82	±6.94	±3.34	±12.61	±16.67		

#Seed germination was calculated on 10th day after sowing; Values are mean of three replications;
± -Standard Deviation @ -One way ANOVA *-Significance at 5% level NS –Non-significance

Table.3 Effect of UV-C irradiation seed treatment on seedling growth (60 DAS) of groundnut

Seedling growth parameters	Treatments							CD	F-
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	(P=0.05)	value@
1. Root Length (cm/pl)	14.50	14.89	15.00	15.00	15.34	15.51	17.95	3.79	NS
	±0.60	±1.35	±1.32	±2.33	±1.30	±2.02	±3.52		
2. Shoot length (cm/pl)	38.34	40.78	40.84	41.00	41.78	43.34	44.89	8.10	NS
	±5.42	±9.06	±6.05	±5.03	±3.59	±5.45	±6.36		
3. Total length (cm/pl)	52.84	55.67	55.84	56.01	57.12	58.84	62.84	8.83	NS
	±5.96	±7.91	±7.22	±6.33	±3.51	±6.20	±7.04		
4. Root/shoot ratio	0.38	0.38	0.37	0.37	0.37	0.36	0.41	0.12	NS
	±0.04	±0.12	±0.03	±0.05	±0.05	±0.05	±0.09		
5. No of branches/pl	4.22	4.56	4.67	4.85	4.94	4.89	5.78	1.57	NS
	±1.07	±0.84	±0.89	±1.03	±1.10	±0.39	±1.02		
6. No. of root nodules/pl	40.67	40.99	37.89	38.22	45.34	50.11	57.45	18.90	NS
	±6.43	±6.73	±7.40	±9.09	±5.46	±17.29	±11.67		
7. Number of leaves/pl	54.11	63.12	67.34	69.11	71.33	72.34	90.56	6.57	NS
	±10.18	±15.31	±4.36	±18.41	±7.13	±15.64	±21.73		
8. Leaflet length (cm/leaflet)	6.46	6.50	6.51	6.54	6.65	6.61	6.19	0.43	NS
	±0.25	±0.27	±0.20	±0.16	±0.24	±0.22	±0.29		
9. Leaflet breadth (cm/leaflet)	3.16	3.09	3.26	3.20	3.09	3.09	3.05	0.49	NS
	±0.65	±0.27	±0.18	±0.09	±0.14	±0.13	±0.09		
10. Leaflet Area Index	12.02	13.87	14.66	14.43	14.24	14.13	13.04	2.39	NS
	±2.35	±0.95	±1.08	±0.69	±1.14	±1.03	±0.97		
11. Leaf area index (cm^2/pl)	2659.00	2889.00	3566.00	4021.00	4084.00	4113.00	4723.00	1951.08	NS
	±981	±1446	±738	±1249	±738	±1063	±1234		
12. Seedling vigour index	3186.00	3340.00	3508.00	3685.00	4010.00	4281.00	5211.00	990.41	**
	±171	±405	±361	±667	±384	±1078	±1060		
13. Seedling tolerance index	1.00	1.03	1.03	1.03	1.06	1.07	1.25	0.27	NS
	±0.00	±0.11	±0.06	±0.14	±0.06	±0.13	±0.29		
14. No of flowers/pl	3.34	3.56	3.76	3.89	4.11	4.11	5.11	1.93	NS
	±0.88	±1.64	±1.35	±0.69	±0.19	±0.83	±1.83		
15. No of immature pods/pl	9.34	12.01	12.12	10.67	8.56	7.89	7.45	6.23	NS
	±3.60	±1.15	±4.67	±4.98	±1.83	±2.22	2.50±		
16. No. mature pods/pl	16.12	16.45	16.89	17.56	17.67	18.33	21.56	9.53	NS
	±4.53	±6.53	±2.99	±2.83	±5.48	±3.53	±7.08		
17. Total No. of pods/pl	25.46	28.46	29.01	29.35	26.45	26.23	25.67	8.89	NS
	±33.29	±7.60	±7.31	±2.32	±2.03	±5.75	±2.64		
18. No. of pedicels without	10.89	12.78	12.11	7.23	5.84	5.78	5.78	7.27	NS
	±3.07	±2.83	±1.19	±3.36	±3.61	±3.02	±2.88		
19. Root fresh weight (g/pl)	2.08	2.17	2.54	2.28	2.18	2.10	2.04	0.67	NS
	±0.53	±0.01	±0.34	±0.28	±0.55	±0.06	±0.45		
20. Shoot fresh weight (g/pl)	115.78	122.11	123.78	108.89	106.89	103.89	103.00	51.30	NS
	±35.69	±15.28	±11.65	±31.87	±50.16	±17.35	±7.55		
21. Root dry weight (g/pl)	0.80	0.89	1.03	0.92	0.92	0.91	0.80	0.44	NS
	±0.21	±0.31	±0.12	±0.16	±0.53	±0.19	±0.36		
22. Shoot dry weight (g/pl)	23.91	24.51	36.61	30.87	28.18	26.96	26.17	20.62	NS
	±2.47	±2.85	±13.34	±16.39	±19.71	±9.77	±10.21		
23. Pod fresh weight (g/pl)	81.48	81.77	82.00	73.33	73.00	68.33	66.33	3.21	NS
	±6.08	±6.35	±11.53	±19.86	±21.28	±3.15	±22.55		
24. Pod dry weight (g/pl)	10.98	13.16	13.32	13.74	19.02	13.94	13.72	4.28	NS
	±1.39	±2.47	±1.09	±1.22	±3.78	±3.49	±0.52		
25. Total fresh biomass (g/pl)	199.34	207.05	208.32	184.50	182.07	174.33	171.38	66.84	NS
	±42.09	±19.03	±23.49	±42.41	±69.36	±16.59	±30.19		
26. Total dry biomass (g/pl)	35.69	38.56	50.96	45.53	48.11	41.80	40.68	19.85	NS
	±3.26	±2.71	±12.91	±15.76	±19.99	±9.64	±9.89		

Values are mean of three replications; ± -Standard Deviation @ -One way ANOVA
**-Significance at 1% level NS –Non-significance

Table.4 Effect of UV-C irradiation seed treatment on seedling growth (90 DAS) of groundnut

Seedling growth parameters	Treatments							CD	F-
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	(P=0.05)	value@
1. Root Length (cm/pl)	13.63	15.27	16.17	16.33	16.33	16.87	17.63	3.70	NS
	±3.16	±3.21	±1.01	±2.04	±2.77	±1.71	±0.55		
2. Shoot length (cm/pl)	63.95	66.48	68.33	70.67	72.35	74.00	74.83	12.09	NS
	±10.40	±1.41	±4.25	±5.35	±6.48	±9.50	±0.58		
3. Total length (cm/pl)	77.58	81.75	83.50	87.00	88.68	90.87	92.47	11.82	NS
	±8.45	±0.50	±3.54	±4.52	±8.78	±9.82	±0.03		
4. Root/shoot ratio	0.22	0.23	2.24	0.24	0.23	0.23	0.24	0.10	NS
	±0.08	±0.03	±0.03	±0.04	±0.04	±0.04	±0.01		
5. No of branches/pl	5.17	5.17	5.17	6.00	5.83	5.83	5.67	1.38	NS
	±0.76	±0.29	±1.53	±0.50	±0.29	±0.29	±1.53		
6. No of root nodules/pl	74.00	77.50	83.00	95.10	89.17	89.17	88.00	42.47	NS
	±6.95	±21.34	±10.83	±43.34	±19.2	±35.16	±19.18		
7. Number of leaves/pl	83.67	127.00	131.83	135.33	157.00	168.83	200.83	79.25	NS
	±13.36	±42.54	±3.05	±43.57	±30.00	±86.04	±7.22		
8. Leaflet length (cm/leaflet)	6.43	6.48	6.52	6.72	6.57	6.49	6.25	0.62	NS
	±0.17	±0.25	±0.21	±0.43	±0.31	±0.48	±0.42		
9. Leaflet breadth (cm/leaflet)	2.82	2.84	3.07	3.26	3.16	3.15	2.86	1.07	NS
	±0.24	±0.24	±0.09	±0.48	±0.14	±0.18	±0.37		
10. Leaflet Area Index	12.52	12.70	13.81	15.08	14.37	14.13	12.42	3.02	NS
	±1.06	±1.31	±0.74	±1.99	±1.77	±2.31	±2.36		
11. Leaf area index (cm^2/pl)	4187.00	6391.00	7287.00	7975.00	9102.00	9180.00	9947.00	3866.91	NS
	±736	±2022	±558	±1677	±2318	±3603	±1699		
12. Seedling vigour index	4727.00	5000.00	5278.00	5710.00	6190.00	6556.00	7705.00	1864.69	NS
	±822	±1166	±655	±743	±356	±1285	±1541		
13. Seedling tolerance index	1.00	1.17	1.22	1.60	1.60	1.29	1.33	0.28	NS
	±0.00	±0.33	±0.19	±0.39	±0.45	±0.38	±0.27		
14. No. of flowers/pl	6.33	6.33	6.33	7.00	7.67	7.33	6.33	5.52	NS
	±1.53	±4.04	±4.93	±3.46	±2.52	±2.08	±1.15		
15. No. of pedicle without	44.33	45.33	50.67	54.33	89.33	73.67	70.00	34.00	NS
	±18.56	±9.45	±15.82	±12.50	±15.69	±34.03	±18.68		
16. No. of mature pods/pl	40.00	40.67	43.67	46.00	47.67	48.00	61.00	13.50	NS
	±7.00	±9.50	±10.69	±6.93	±9.29	±8.66	±8.54		
17. No. of immature pods/pl	6.33	6.67	7.00	7.67	12.67	9.66	6.33	5.46	NS
	±1.15	±3.06	±4.00	±2.52	±2.89	±3.78	±1.53		
18. Total no. of pods/pl	46.33	47.33	50.67	53.67	60.33	57.67	67.33	12.74	*
	±5.86	±9.07	±10.12	±7.09	±11.23	±7.02	±9.9		
19. Root fresh weight (g/pl)	2.31	3.01	3.41	3.29	3.29	3.57	4.50	1.77	NS
	±0.76	±0.68	±0.29	±1.15	±1.05	±1.53	±1.00		
20. Shoot fresh weight (g/pl)	203.20	237.50	242.50	265.00	301.17	309.17	315.83	76.30	**
	±15.76	±7.50	±59.10	±63.09	±40.73	±16.64	±9.46		
21. Root dry weight (g/pl)	1.12	1.16	1.26	1.28	1.10	1.06	1.03	0.77	NS
	±0.27	±0.54	±0.17	±0.35	±0.45	±0.77	±0.02		
22. Shoot dry weight (g/pl)	52.60	54.46	61.11	61.63	72.25	75.24	75.95	25.25	NS
	±6.73	±4.22	±9.40	±7.59	±18.19	±27.40	±12.31		
23. Pod fresh weight (g/fruit)	126.00	128.33	134.33	185.33	175.67	160.34	156.67	62.61	NS
	±27.22	±17.56	±26.00	±63.31	±27.23	±33.66	±53.93		
24. Pod dry weight (g/fruit)	70.00	70.67	73.33	88.67	80.00	79.67	75.67	29.90	NS
	±8.89	±12.74	±4.72	±29.48	±20.07	±7.77	±23.44		
25. Total fresh weight (g/pl)	331.51	368.85	380.24	451.62	480.12	473.07	477.00	92.52	*
	±20.04	±22.36	±84.73	±123.81	±52.34	±35.51	±47.64		
26. Total dry weight (g/pl)	123.72	126.29	135.70	151.57	153.28	155.97	152.65	34.52	NS
	±4.27	±14.67	±13.96	±37.08	±20.19	±29.23	±12.67		
27. Dry weight of 100 pod with	95.00	97.00	93.67	98.67	98.00	92.00	89.00	15.37	NS
	±11.79	±5.57	±6.81	±4.16	±12.12	±7.94	±7.55		
28. Dry weight of 100 seeds	36.00	36.67	36.67	41.00	40.67	36.00	35.00	7.58	NS
	±4.36	±4.04	±2.52	±5.29	±6.43	±1.73	±5.00		

@-One way ANOVA; NS –Non-significance; Values are mean of three replications;
*/** -Significance at 5% and 1% level, respectively

Table.5 Effect of UV-C irradiation seed treatment on AGR, RGR and NAR of groundnut seedlings

Parameters	Growth Period	Treatments							CD	F-
	(days)	T1	T2	T3	T4	T5	T6	T7	(P=0.05)	value@
1. AGR – Absolute	30-60	1.25	1.27	2.20	1.68	1.55	1.34	1.30	0.75	NS
Growth Rate (g/day)		±0.09	±0.08	±0.66	±0.42	±0.65	±0.32	±0.34		
	60-90	2.82	2.89	3.16	3.56	3.64	3.80	3.73	1.57	NS
		±0.22	±0.50	±0.30	±1.71	±1.10	±1.24	±0.73		
2. RGR –Relative	30-60	2.90	2.93	5.07	3.65	3.57	3.08	2.98	1.67	NS
Growth Rate (g/day)		±0.24	±0.21	±1.53	±0.99	±1.50	±0.73	±0.79		
	60-90	6.50	6.65	6.84	7.99	8.07	8.76	8.59	3.70	NS
		±0.51	±1.16	±1.42	±3.98	±2.98	±2.84	±1.68		
3. NAR –Net	30-60	2.88	2.91	5.07	3.65	3.56	3.08	2.98	1.70	NS
Rate ($g/m^2/day$)		±0.21	±0.19	±1.53	±0.99	±1.51	±0.72	±0.79		
	60-90	6.50	6.65	6.83	8.19	8.24	8.76	8.59	3.65	NS
		±0.51	±1.16	±1.41	±3.94	±2.99	±2.84	±1.68		

@ -One way ANOVA; NS –Non-significance; Values are mean of three replications;

Table.6 Effect of UV-C irradiation seed treatment on biomass production and pod yield (90DAS) of groundnut seedlings

Treatment	Productivity (kg/hectare)	
	Vegetative Biomass	Pod yield
T1	8236 ±1383	2143 ±1060
T2	9330 ±1710	2150 ±0926
T3	9640 ±3707	2177 ±1671
T4	9727 ±3781	2533 ±1837
T5	12493 ±1470	2623 ±1603
T6	13140 ±4829	2720 ±2572
T7	15483 ±0707	3393 ±3403
CD (P=0.05)	4089.55	1615.21
F-value@	*	NS

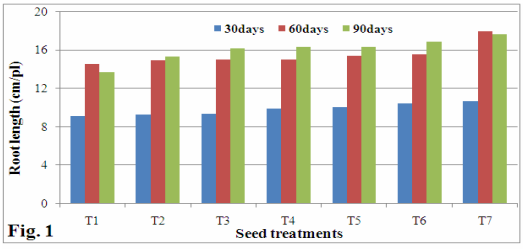


Fig. 1

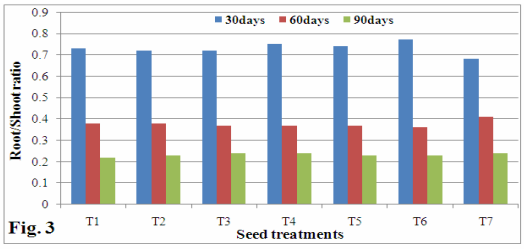


Fig. 3

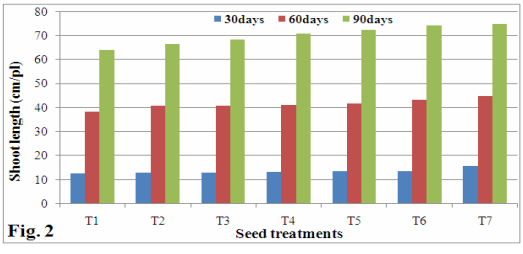


Fig. 2

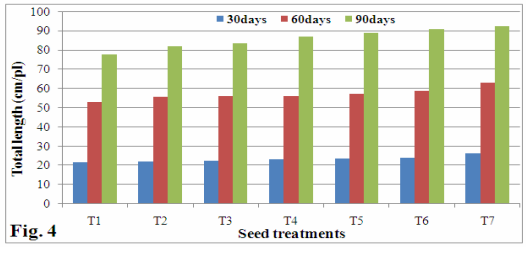


Fig. 4

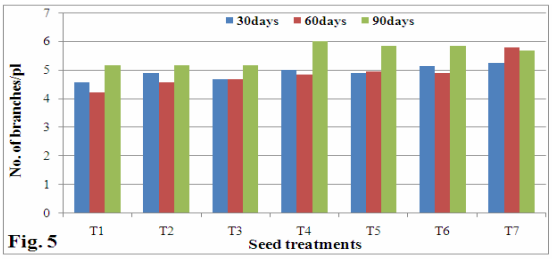


Fig. 5

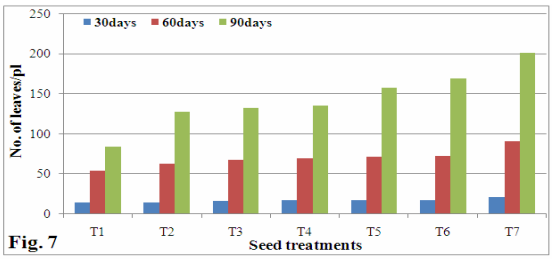


Fig. 7

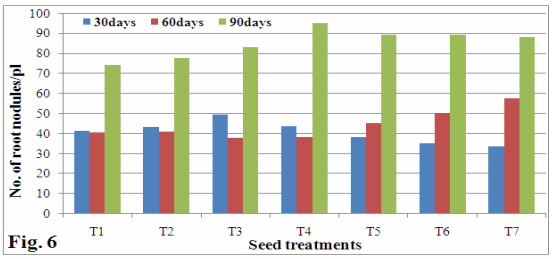


Fig. 6

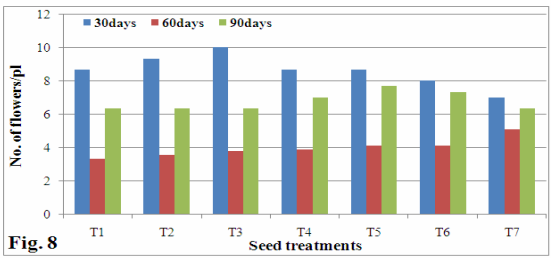


Fig. 8

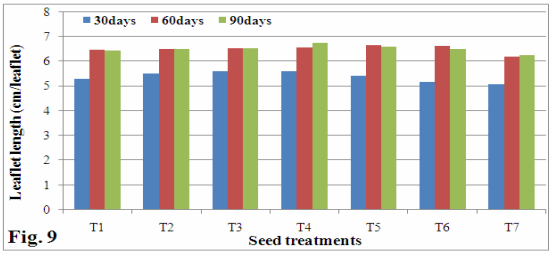


Fig. 9

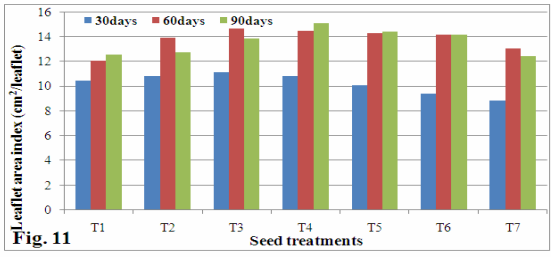


Fig. 11

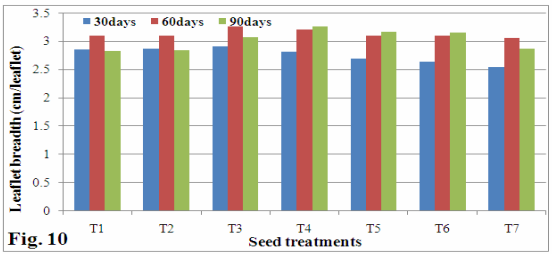


Fig. 10

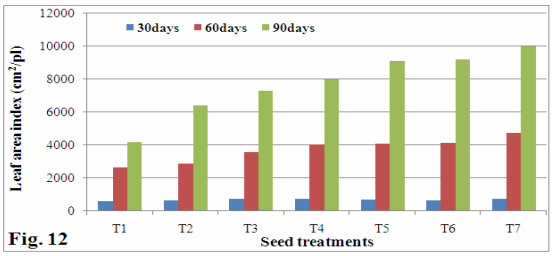


Fig. 12

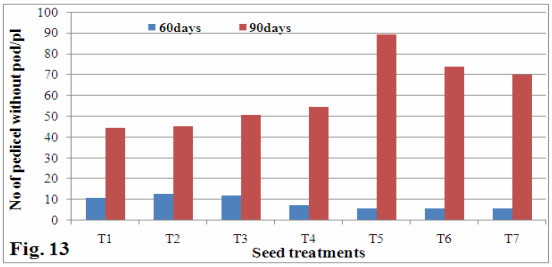


Fig. 13

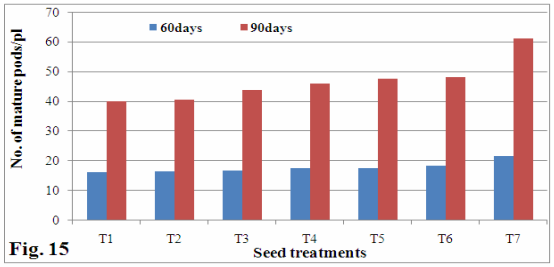


Fig. 15

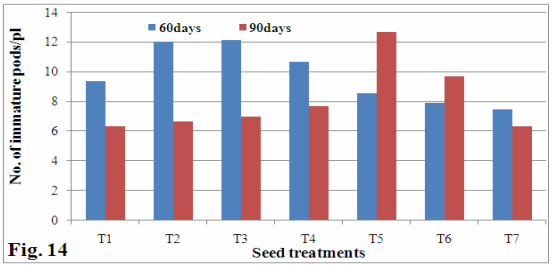


Fig. 14

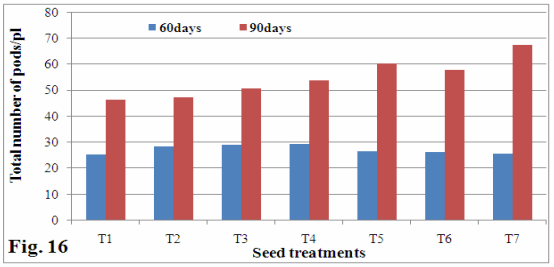


Fig. 16

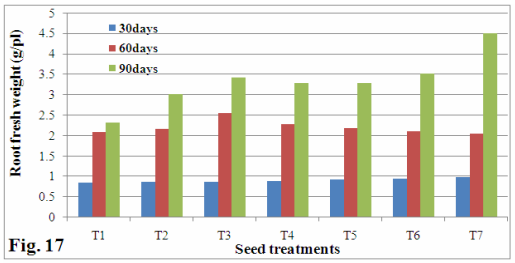


Fig. 17

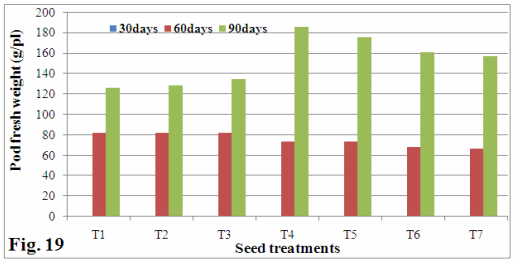


Fig. 19

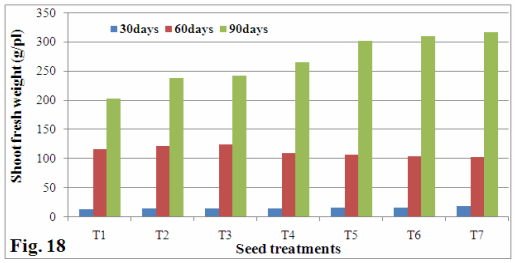


Fig. 18

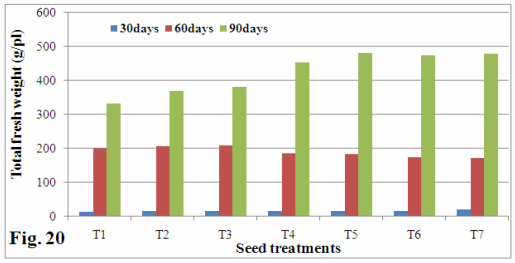


Fig. 20

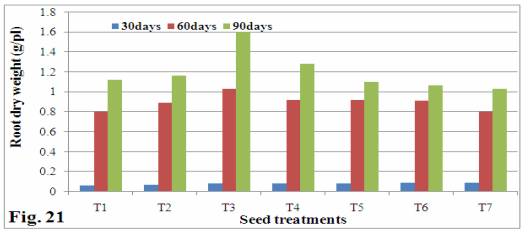


Fig. 21

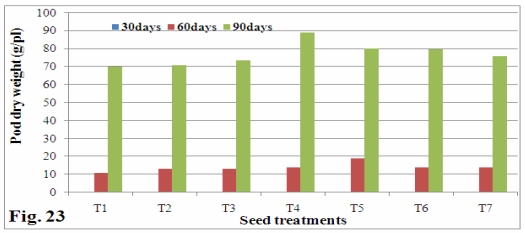


Fig. 23

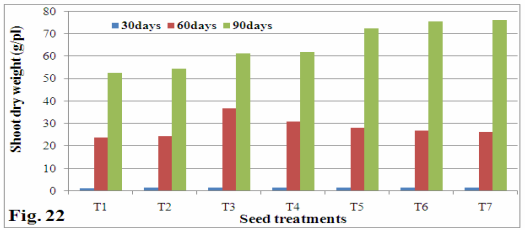


Fig. 22

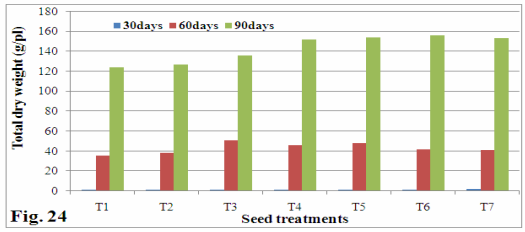


Fig. 24

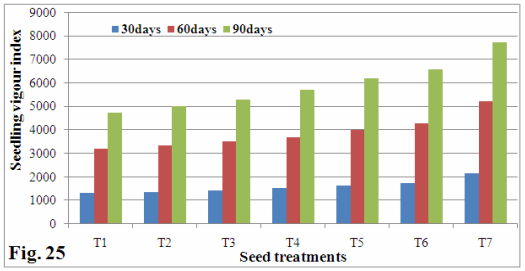


Fig. 25

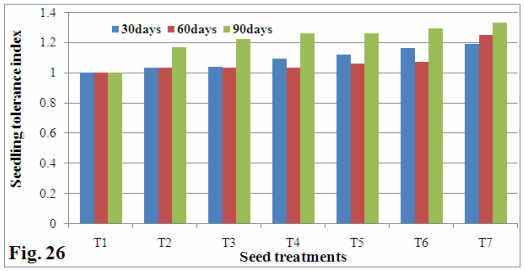


Fig. 26

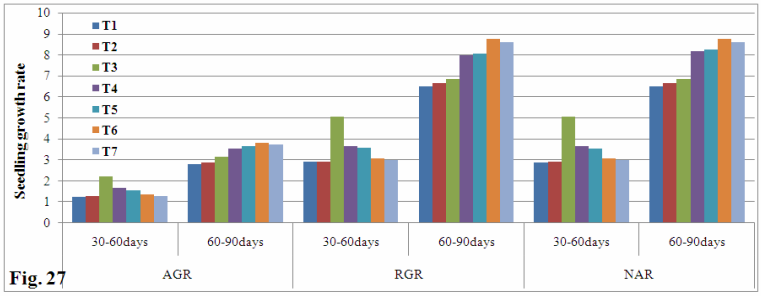
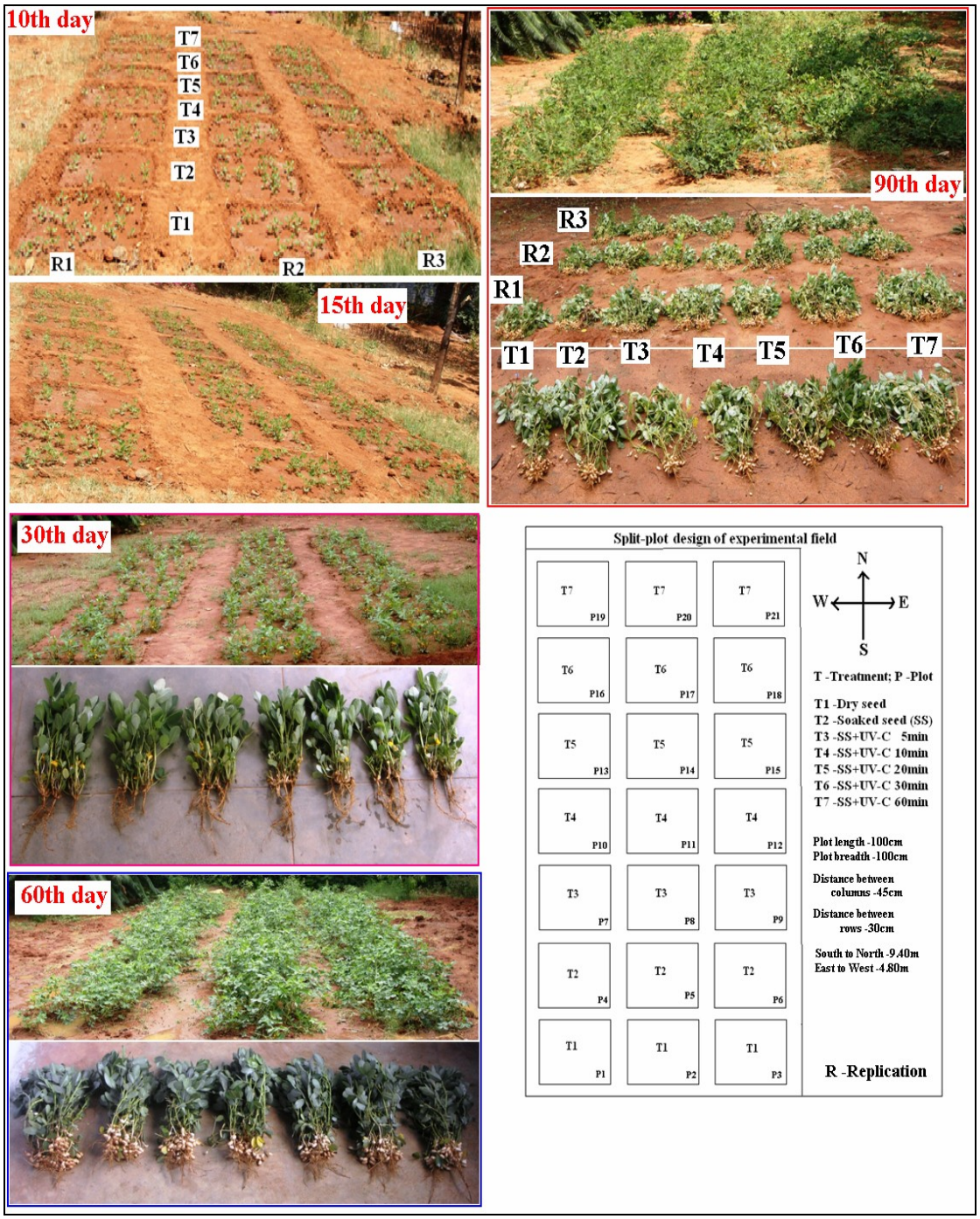


Fig. 27

Plate.1 Effect of UV-C irradiation seed treatment on seedling growth and productivity of groundnut



In general, UV-C irradiation seed treatment progressively increased the fresh vegetative biomass production and pod yield at all treatments as compared to control (Table 6). Maximum increase of fresh vegetative biomass (15483kg/hectare) and pod yield (3393kg/hectare) was recorded in 60min exposed seeds to UV-C irradiation.

The seedling vigour index of groundnut was

more in UV-C irradiated water soaked seeds as compared to dry groundnut seeds (Fig. 25). UV-C irradiation generally promoted the SVI of groundnut at all sampling days as compared to controls (Table 2 to 4; Fig. 25). The tolerance index of groundnut seedlings towards the UV-C treatment was increased at all sampling days than dry and soaked seed controls (Table 2 & 4; Fig. 26).

The seedling growth rates -absolute growth rate (AGR), relative growth rate (RGR) and net assimilation rate (NAR) of groundnut were estimated and the UV-C treatment showed initial increase of AGR, RGR and NAR followed by a reduction between 30-60 days period of growth (Table 5; Fig. 27) as compared to controls. On the other hand, between 60-90 days, UV-C irradiation seed treatment showed promotery effect on AGR, RGR and NAR as compared to controls.

Many reports indicate that UV rays results damage in plants and produced alterations in growth, development and morphology (Strid *et al.*, 1997; Flint *et al.*, 2003; Rathore *et al.*, 2003) while Ambaru Purna Sudha Bindhu and Kakoli Das Sharma (2004) reported an increase in the seed germination in UV-A irradiated *Capsicum annum*, Linn and Anum Siddiqui *et al.* (2011) 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 60min period as observes in the present study which shows an increase in seed germination, seedling growth and productivity of groundnut with increasing exposure period up to 60min of UV-C irradiation on water soaked seeds as compared to control. Many researchers observed that pre-sowing treatment of seeds with UV was effectively used to increase crop productivity (Jdanova, 1962; Dubrov, 1977; Ghallab and Omar, 1998; Shiozaki *et al.*, 1999).

Thus, UV-C irradiated water soaked groundnut seeds, generally, showed an increase of seed germination and all seedling growth parameters with increasing period of UV-C exposure up to 60min as compared to dry and soaked seed controls at all sampling days (30, 60 and 90th days).

Acknowledgement

The authors express sincere thanks to the Management Authorities, Principal. S.T. Hindu College, and HOD, Department of Botany & Research Centre, S. T. Hindu College, Nagercoil, Kanyakumari District, Tamil Nadu, India for providing necessary facilities and encouragement.

References

Abdul-Baki, A.S., Anderson, J.O. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Sci*., 13: 630–633.

Ambaru Purna Sudha Bindhu, M.S., Kakoli Das Sharma, 2004. Effect of ultraviolet radiation on *Capsium annum*, Linn. mutation research, *Agrobios. News Lett.*, 2(9): 23–24.

Anum Siddiqui, Shahnaz Dawae, Javed Zaki, M., Neelofar Hamid, 2011. Role of ultraviolet (UV-C) radiation in the control of root infecting fungi on groundnut and mung bean. *Pak. J. Bot*., 43(4): 2221–2224.

Arvind Kumar, Purohit, S.S. 1998. Plant physiology: fundamentals and applications, Vol. 668. Agrobios (India), Agro House. Pp. 670–671.

Barnes, P.W., Flint, S.D., Caldwell, M.M. 1990. Morphological responses of crop and weed species of different growth forms to Ultraviolet-B radiation. *Am. J. Bot*., 77: 1354–1360.

Bjorn, L.O. 1996. Effects of ozone depletion and increased UV-B on terrestrial ecosystems. *Int. J. Environ*., 23: 555–561.

Briggs, G.E., Kidd, F., West, 1920. Quantitative analysis of growth. *Ann. Appl*. *Biol*., 7: 103–202.

Caldwell, M.M., Bjorn, L.O., Bornman, J.F., Flint, S.D., Kulandaivelu, G., Teramura, A.H., Tevini, M. 1998. Effects of increased solar ultraviolet radiation on terrestrial ecosystems. *J. Photochem. Photobiol.,* 46: 40–52.

Caldwell, M.M., Flint, S.D. 1994. Stratospheric ozone reduction, solar UV-B radiation and terrestrial ecosystems. *Climatic Change*, 28: 375–394.

Conger, B.V., Nilan, R.A., Konzak, C.E. 1968. Post irradiation oxygen sensitivity of barley seeds varying slightly in water content. *Radiat*. *Bot*., 8: 31–36.

Corlett, J.E., Stephen, J., Jones, H.F., Woodfin, R., Mepsted, R., Paul, N.D. 1997. Assessing the impact of UV-B radiation on the growth and yield of field crops. In: Lumsden, P. (Ed.), Plants and UV-B responses to environmental change. Cambridge University Press, Cambridge. Pp. 195–211.

Correia, C.M., Areal, E.L.V., Torres-Pereira, M.S., Torres-Pereira, J.M.G. 1998. Intraspecific variation in sensitivity to Ultraviolet-B radiation in maize grown under filed conditions. I. Growth and Morphological aspects. *Field Crops Res.*, 59: 81–89.

Correia, C.M., Areal, E.L.V., Torres-Pereira, M.S., Torres-Pereira, J.M.G. 1999. Intraspecific variation is sensitivity of Ultraviolet-B radiation in maize grown under field conditions. II. physiological and biochemical aspects. *Field Crops Res.*, 62: 97–105.

Day, T.A. 1993. Relating UV-B radiation screening effectiveness of foliage to absorbing composed concentration and anatomical characteristics in a diverse group of plants. *Oecologia*, 95: 542–550.

Dubrov, A.P. 1977. *Physiological and biophysical study of ultraviolet irradiation influence on plants on early stages of development*. Ph.D. Thesis. Leningrad.

Ehrenberg, A. 1961. Research on free radicals in enzyme chemistry and irradiation biology. In: Free radicals in biological system. Academic Press, New York. Pp. 337–350.

Flint, S.D., Ryel, R.J., Caldwell, M.M. 2003. Ecosystem UV-B experiments in terrestrial communities: a review of recent findings and methodologies. *Agr. Forest Meteoral.,* 120: 177–189.

Ghallab, A.M., Omar, M.M. 1998. Wheat productivity as affected by seed irradiation with laser rays. *Ann. Agricult. Sci. Moshtohor,* 36(1): 261–274.

Greenberg, B.M., Wilson, M.I., Huang, X.D., Duxbury, C.L., Gerhaddt, K.E., Gensemer, R.W. 1997. The effects of ultraviolet-B radiation on higher plants. In: Wang, W., Goursuch, J., Hughes, J.S. (Eds.) Plants for environmental studies. CRS Press, Boca Ration, FI. Pp. 1–35.

Gregory, F.C. 1926. The effect of climatic condition on the growth of barley. *Ann*. *Bot*., 40(1): 26–28.

Jdanova, E.B. 1962. About ultraviolet irradiation influence on germination and growth of rye. Kagan VE, Fabisiak Japan. *Proc. Agricult. Acad.,* 77: 451–455.

Kalra, G.S., Dhiman, S.D. 1977. Determination of Leaf Area of Wheat plants by a rapid method. *J. Indian Bot. Sci*., 56: 261–264.

Mc Leod, A.R., Newsham, K.K. 1997. Impacts of elevated UV-B on forest ecosystem. In: Lumsden, P. (Ed.), Plants and UV-B responses to environmental change. Cambridge University Press, Cambridge. Pp. 247–281.

Rathore, D., Agarwal, S.B., Singh, A. 2003. Influence of supplemental UV-B radiation and mineral nutrients on biomass, pigments and yield of two cultivars of wheat *Triticum aestivum* L. *Int. J. Biotronics*, 32: 1–15.

Redford, 1967. Physiological analysis of growth and yield of pigeon pea (*Cajanus cajan* (L) Millsp). *Ad. Plant Sci*., 21(II): 553–556.

Rozema J.V., Bjorn, L.O., Caldwell, M.M. 1977. UV-B as an environmental factor in plant life: stress and regulation. *Trends Ecol. Evolut.*, 12: 22–28.

Shiozaki, N., Hattori, I., Tezuka, T. 1999. Activation of growth nodulation in a symbiotic system between pea plants and leguminous bacteria by near UV radiations. *J. Phytochem. Photobiol. B: Biol.*, 50: 33–37.

Strid, A., Chow, W.S., Anderson, J.M. 1997. UV-B damage and protection at the molecular level in plant. *Photosynth. Res*., 39: 475–489.

Turner, R.C., Marshal, 1972. Accumulation of zinc by sub cellular fraction of root growth *Agrostis tenuis* in relation of zinc tolerance. *New Phytol*., 71: 671–676.

Ziska, L.H., Termura, A.H., Sullivan, J. 1992. Physiological sensitivity of plants along on elevations gradient to UV-B radiation. *Am. J. Bot*., 79: 863–871.