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EFFECT OF UV-B AND MICROWAVE RADIATION ON SEED GERMINATION AND PLANT GROWTH IN CORN AND OKRA

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Abstract

The effects of radiations (Microwave and Ultraviolet) on seed germination (*in vitro* and *in vivo*) and plant growth in Corn (*Zea mays* L.) and Okra (*Abelmoschus esculentus* L.) were studied. The experiment was divided in two sets. In set one, corn and okra seeds were exposed to Microwave radiation (2450 MHz) for0 (control), 1, 2, 3, and 5 seconds while in other set of experiment, seeds were exposed to Ultraviolet radiation (253.7nm) for 0 (control), 5, 10, 30 and 60 minutes. Treated seeds were sown in plastic pots containing 300g soil fertilizer mixture (3:1). After 48days of seeds sowing plants were harvested and their shoot, root length, fresh and dry weighs were recorded. It was observed that though okra plants were more resistant to radiations than corn plants but there were no significant difference among different treatments.

Introduction

The term "radiation" covers a wide variety of energy, from the non-ionizing radiations to the ionizing radiations. Radiation at different wavelengths differs in its effects which may be harmful or beneficial (Jeannie., 2001).Ultraviolet-B radiation comprises only a small portion of the electromagnetic spectrum but has a disproportionately large photo biological effect. (Teramura and Sullivan, 1991).Increased occurrence of Ultraviolet (UV) radiation due to ozone depletion also affects plant growth, productivity and reduces plant genome stability (Kunz *et al*., 2006) Ultraviolet radiation affects plant growth and development in many ways. A higher exposure could have direct and indirect complex effects. According to researchers, exposure to UV-B decreased plant height, leaf area and plant dry weight, increased auxiliary branching and leaf curling (Dai *et al*., 1995; Greenberg *et al*., 1997, Furness *et al*., 1999).Some plant species show sensitivity to present levels of UV-B radiation (Bogenrieder and Klein, 1978).It was also observed that UV-B radiation show higher degree of effects in thin leaved plants compared to those with thick leaves (Zuk-Golaszewska, 2003).According to other workers some plants are apparently unaffected by UV radiations (Becwar*et al*., 1982). The presence of secondary compounds such as flavonoids which may act as solar screens, absorbing UV and not allowing it to reach sensitive tissue layers in the epidermis of leaves (Robberecht and Caldwell, 1978). Increased levels of anthocyanins and flavonoids in response to UV-B have been reported (Shaukat *et al*., 2011)

Microwave are electromagnetic waves with wave lengths ranging from 10^8 -10^{11} Hz (Moeller, 1992).Microwave has not only effect humans and different mammals but also plants. However Microwave radiation effects depend on radiation frequency, exposure period and the environmental conditions (Khalafallahand Sallam, 2009). Some studies reported the harmful effects of Microwave radiations (Urech, *et al.,* 1996) while, (Magone, 1996; Murakami *et al.,* 2001) supported that Microwave radiation enhanced plant growth. Generally, the low Microwave radiation frequencies lead to growth acceleration, while high frequencies tend to reduce plant growth (Khalafallahand Sallam 2009). In Pakistan very little work has been carried out therefore, there is a need to study the effect of Microwave and Ultraviolet radiations on germination and growth of plants.

In the present study Corn (*Zeamays* L.) and Okra (*Abelmoschus esculentus* L.) were used as test plants. Corn belongs to Poaceae family of monocot flowering plants.Cornis one of the significant crops, which serves as food and oil for human consumption, as feed for livestock and used as raw a material for industry (Khatoon*et al*., 2010; Ullah*et al*., 2010). Okra belongs to Malvaceae family of dicot flowering plants. It is valued for its edible green seed pods. Okra is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds. It is among the most heat and drought tolerant vegetable species in the world (http://en.wikipedia.org/wiki/Okra).

Materials and Methods

Two experimental trails were conducted for Microwave treated Seeds and Ultraviolet treated seeds. In Microwave trail, seeds were exposed to Microwave radiation (2450 MHz)for 0 (control), 1, 2, 3, and 5 seconds, while in case of Ultraviolet experiment seeds were exposed to Ultraviolet radiation (253.7 nm) for 0 (control), 5, 10, 30 and 60 minutes. In each treatment, fifteen seeds of corn and fifteen seeds of okra were used.

In the *in vitro* trail, treated seeds were germinated in Petri plates for germination test which contained sterilized wet filter paper while *in vivo* experiment after treatment, seeds were sown in 7 cm diameter plastic pots containing 300g mixture of garden soil and fertilizer in ratio of 3:1.Three seeds were sown in each pot. Pots were watered daily. Each treatment was replicated three times. Untreated seeds were used as control. The pots were kept in screen house benches in a complete randomized manner and pots were watered daily.

Germination test: Germination was recorded every day and the germination percentage was calculated with the help of following formula:

Speed of germination was also calculated by formula following: (Khandakarand Bradbeer, 1983)

Measurement of plants growth rate: After germination, plant stem length was measured after every 10th days up to the uprooting of plants for the calculation of growth rate. Different leaves were selected from each treatment including control, for the measurement of growth rate in leaves (length and breadth). Measurements were taken every two days. Rate of growth was calculated by following formula: (Sinnot, 1960)

After 48 days of seeds sowing, plants were taken out from pots. Plant roots were washed with tap water. Root and shoot length were recorded. Shoot length was measured from the crown to the tip of the shoot and root length was measured from the crown to the tip of the root. Plants root and shoot fresh weights were taken. Roots, shoots were put in paper bags separately and kept in oven at 70℃ for 48 hours. After 48 hours, plants were taken out from paper bags. Dry weight of roots and shoots were recorded.

Results

Germination (*in vitro)*

Microwave radiations: For germination test, seeds were kept in Petri dishes containing wet satirized filter paper after exposure to Microwave radiations. In corn seeds (100%) germination were observed in control as well as in all treatments, while in okra maximum germination (100%) was observed in seeds which exposed for 2 seconds and control. The germination percentage was decreased in seeds which were exposed for 1 second (80%) and 5 seconds (40%). Minimum germination (25%) was recorded in okra seeds exposed for 3 seconds.

Ultraviolet radiations: In this experiment, corn seeds had 100% germination in control and treated seeds. Okra also showed 100% germination however 20% to 40% germination was observed in treated seeds. Minimum germination (20%) was recorded in seeds which got minimum exposure (5 minutes).

Germination (*in vivo)*

Microwave radiations:

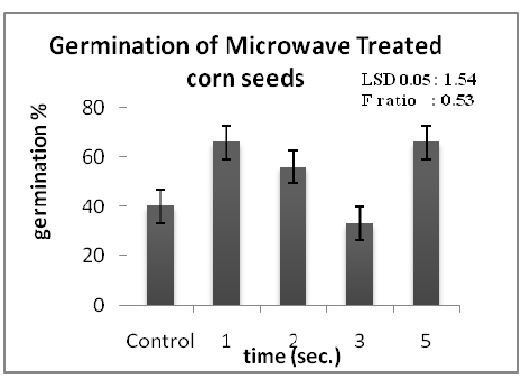

Fig.1. Germination of Microwave Treated corn seeds.

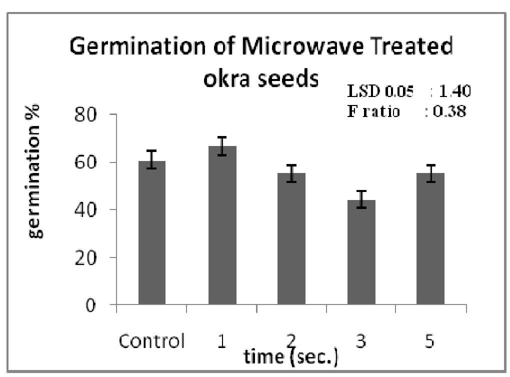

Fig.2.Germination of Microwave Treated okra seeds.

The seeds of okra and corn after being exposed with microwave radiation sown in plastic pots separately. Maximum germination was observed in 1 second treated okra 67% (fig.2) and cornseeds66% (fig.1).In control 61% germination was recorded in okra and 40% in corn. Minimum germination of 44%and 33% was observed in both seeds at 3 second treatment that were okra and corn respectively.

Ultraviolet radiations:

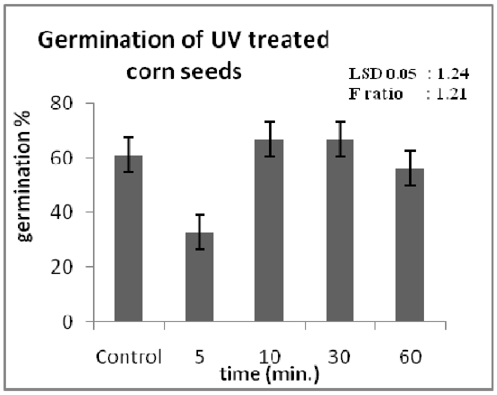

Fig.3. Germination of UV treated corn seeds.

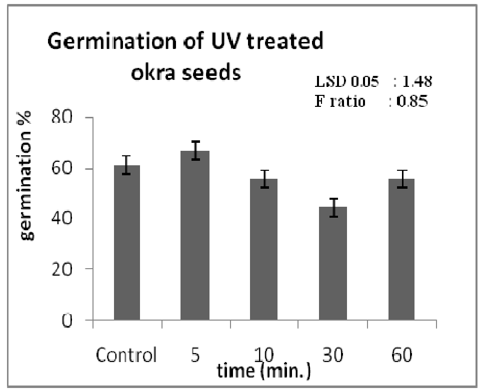

Fig.4. Germination of UV treated okra seeds.

In Ultraviolet radiation trail maximum germination 67% in okra (fig.4) and 78% in corn (fig.3) were recorded that were exposed for 10 and 30 minutes as compared to control where 61% in okra and 40% in corn was recorded. Minimum germination was (33%) observed in okra which received 5minute Ultraviolet radiation(fig.4) while in corn 44% germination was observed in seeds which received 60 minutes radiation (fig.3).

Speed of germination

Microwave radiations: Maximum speed of germination (41%) in okra was recorded in 1 second exposed seeds as compared to control (34%). In corn maximum germination speed (52%) was recorded in seeds which received 5 second radiation as compared to control (10%).Whereas in 2 and 5 seconds exposed seeds of okra 39%and 37% germination speed was recorded respectively. It was also observed that germination speed was decreased in 1 second (44%) and 2 seconds (30%) exposed seeds of corn. Minimum speed of germination was observed in both plants which received 3 second Microwave radiations that were13% in okra and 27% in corn.

Ultraviolet radiations: Maximum speed of germination of okra (46%) recoded in 60 minutes exposure seeds as compared to control (34%) where as in corn maximum speed of germination(47%) were observed in 10 minutes exposed seeds as compared to control (10%). In okra, minimum germination speed (24%) was observed which received minimum (5 minutes) Ultraviolet radiations. In 10 and 30 minutes exposure of okra seed 35% and 26% speed of germination were recorded respectively while corn seeds showed 38%, 42% and 40% speed of germination at 5, 30 and 60 minutes Ultraviolet treatments.

Rate of growth

Okra: Among control, Microwave and Ultraviolet plants, the maximum growth rate(0.03 cm/20days of leaf length and 0.02 cm/20days of leaf breadth)was observed in plants developed from Microwave exposed seeds. Plants developed from untreated (control) and Ultraviolet exposed seeds showed low growth rate of leaves (0.01 cm/20days of leaf length and 0.01 cm/20days of leaf breadth).

Corn: Maximum rate of growth (0.03 cm/16days of leaf length) was observed in control and 0.02 cm/16days of leaf length in Ultraviolet radiation. Whereas minimum leaf growth (0.01 cm/16days of leaf length) was observed in plants developed from Microwave exposed seeds.

Stem length (before harvesting)

Plants length was recorded after every 10^{th} days up to the uprooting of plants.

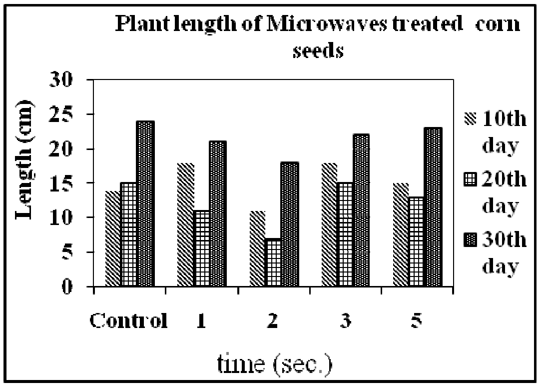

Fig.5. Plant length of Microwaves treated corn seeds.

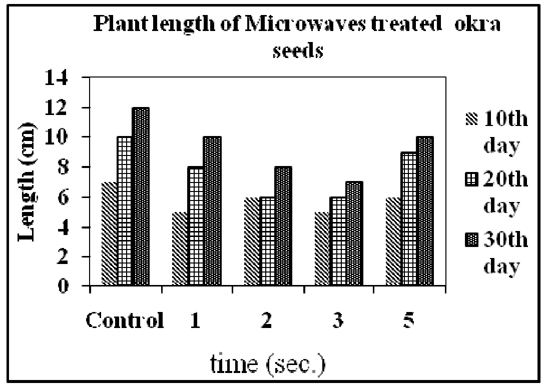

Fig.6. Plant length of Microwaves treated okra seeds.

Table 1. Plants length LSD of microwave treated seeds.

Length	Corn		Okra	
	LSD 0.05	**F ratio**	**LSD 0.05**	**F ratio**
10th day	13.34	2.13	4.221	0.80
20th day	13.34	2.90	4.313	2.86
30th day	13.34	1.78	5.121	2.86

Microwave radiations: Maximum length (12cm, 24cm) was observed in okra (fig.6) and corn (fig.5) respectively in control plants at 30th day period. Minimum length (7cm) in okra was observed in plants which received 3 second exposed radiations (fig.6) but in corn minimum length (18cm) was recorded in plants which received 2 second exposure radiations (fig.5). Length of other Microwave radiations treated plants (fig.5 and fig.6) were recorded less than control in both plants. In statistical analysis ANOVA (analysis of variance Fisher, 1925) and Duncun's multiple range test (Duncun, 1955), non-significant difference were found among different Microwave treatments in 10, 20 and 30 days.

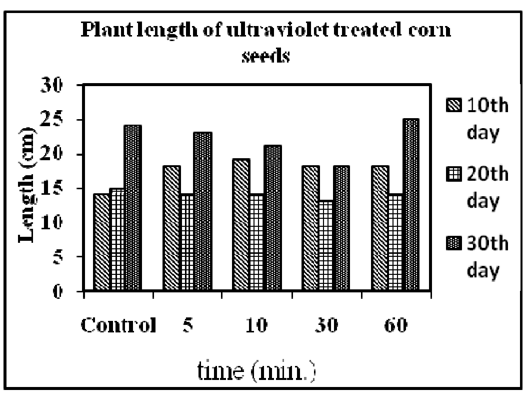

Fig.7.Plant length of ultraviolet treated corn seeds.

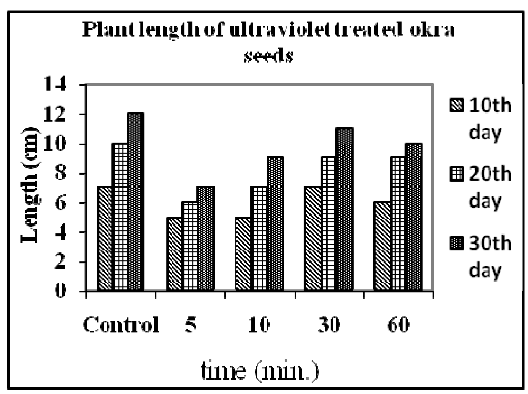

Fig.8.Plant length of ultraviolet treated okra seeds.

Table 2. Plants length LSD Ultraviolet treated seeds.

Length	Corn		Okra	
	LSD 0.05	**F ratio**	**LSD 0.05**	**F ratio**
10th day	13.34	0.87	4.665	1.260
20th day	13.34	1.89	6.357	1.588
30th day	13.34	1.14	7.142	1.640

Ultraviolet radiations: Maximum 12cm length was observed in control okra plants (fig.8) and (25cm) in 60 minutes exposed corn plant as compared to control corn plant(fig.7) where 24cm length was recorded at 30th days. Minimum length (7cm) was observed in okra plants (fig.8) which received 5 minutes exposed radiations but in corn minimum length (18cm) was observed in 30 minutes exposed seeds (fig.7). It is also observed in fig.8 that okra plant length was gradually increased (9cm and 11cm) in 10 and 30 minute exposure respectively as compared to 5minute but again in 60 minute plant length slightly decreased (10cm). Length of Ultraviolet radiations treated plants were recorded less than control in both plants. In statistical analysis ANOVA and Duncan's multiple range test non-significant difference was observed.

Fresh and dry weight: After uprooting from pots, Plants roots, shoots fresh and dry weight were recorded.

Table 3. Plants weight of microwave treated seeds.

Treatment (sec)	Corn						Okra					
	Fresh wt.(g)	LSD 0.05	F. ratio	**Dry wt.(g)**	LSD 0.05	F. ratio	**Fresh wt.(g)**	LSD 0.05	F. ratio	**Dry wt.(g)**	LSD 0.05	F. ratio
Control	1.9			0.4			1.9			0.3		
1	2.2			1.5			0.7			0.2		
2	Plant burnt	1.91	2.66	Plant burnt	0.319	1.75	0.8	0.597	2.161	0.1	0.1975	1.429
3	1.5			0.3			0.6			0.1		
5	1.8			0.3			1.5			0.1		

Microwave radiations: Microwave radiations affected okra and corn plants differently in case of fresh and dry weight (Table3). It was observed that in okra maximum weight was observed in control (1.9gand 0.3g) as compared to treated seeds whereas in corn maximum weight(1.9g and 1.5g) was observed in 1sec. treated seeds as compared to control. Minimum fresh and dry weight in both plants was recorded in 3 seconds treated seeds (0.6gand 0.1g) in okra and (1.5gand 0.3g) in corn plants (Table3). It was also observed that in corn some plants were burnt which received 2 seconds microwave treatment before uprooting from pots it may be due to some environmental stresses.

Table 4. Plants weight of ultraviolet treated seeds.

Treatment (min)	Corn						Okra					
	Fresh wt.(g)	LSD 0.05	F. ratio	**Dry wt.(g)**	LSD 0.05	F. ratio	**Fresh wt.(g)**	LSD 0.05	F. ratio	**Dry wt.(g)**	LSD 0.05	F. ratio
Control	1.9			1.5			1.9			0.29		
5	1.8	2.26	0.79	0.4	0.431	0.418	Plant burnt	0.585	4.028	Plant burnt	0.191	2.5 26
10	1.7			0.5			1.8			0.15		
30	1.6			0.3			0.66			0.12		
60	3.0			0.6			0.73			0.15		

Ultraviolet radiations: Maximum fresh and dry weight (1.9g and 0.2g) in okra plants were recorded in control as compared to treated plants (Table4), while in corn plant maximum fresh and dry weight (3.0g and 0.6g) was observed in 60 minutes treated seeds as compare to control where 1.9g and 1.5gwas recorded (Table4). Minimum fresh and dry weight (0.7g and 0.1g) were observed in those both plants which received 30minutes radiations in okra and 1.6g and 0.3g in corn plant. It was also observed that okra plants developed from seeds received 5 minutes Ultraviolet radiations were burn after germination (Table4), it may also be due to different environmental factors.

Root and shoot length: After 48 days of seeds sowing plants were taken out from pots and their root and shoot length were recorded.

Table 5. Root / Shoot length of microwave treated seeds.

Treatment (sec)	Corn						Okra					
	Shoot length (cm)	LSD 0.05	F. ratio	**Root length (cm)**	LSD 0.05	F. ratio	**Shoot length (cm)**	LSD 0.05	F. ratio	**Root length (cm)**	LSD 0.05	F. ratio
Control	33			29			14			8		
1	23			27			13			7		
2	Plant burnt	28.35	1.85	Plant burnt	22.05	2.43	10	6.321	4.753	9	6.007	1.580
3	26			18			12			10		
5	32			18			15			9		

(Table 5) Maximum shoot length (15cm) of Microwave treated okra seeds were observed in 5 seconds while maximum root length (10cm) was observed in 3 seconds treated seeds. In corn maximum shoot length (33cm) and root length (29cm) were observed in control. Minimum shoot length (10cm) in okra was recorded in 2 seconds radiation exposed seeds and minimum root length (7cm) was recorded in 1 second Microwave treated seeds as compared to control which had 14cm shoot length and 8cm root length where as in corn minimum shoot length was recorded (23cm) in 1 second radiated seeds and minimum root length (18cm) was observed in 3 and 5 seconds treatments. It was also observed that in okra shoot and root length were decreased, (13cm and 12cm) shoot length were observed in 1second and 3 seconds treatment, respectively and 9cm root length were observed in 2 seconds and 5 seconds Microwave treated seeds(Table5). In corn shoot length of 3 and 5 second treatment (26cm and 32cm) respectively and root length (27cm) were decreased as compare to control plants of corn. It was also observed that 2 seconds Microwave treated corn seeds were burnt before uprooting from pots which may be due to some environmental stresses because the other plants that received more radiation than 2 seconds were alive. Microwave, in treated plants root and shoot length showed non-significant differences.

Table 6. Shoot and root length of plants that developed from ultraviolet treated seeds

Treatm-ent (min)	**Corn**						**Okra**					
	Shoot length (cm)	LSD 0.05	F. ratio	**Root length (cm)**	LSD 0.05	F. ratio	**Shoot length (cm)**	LSD 0.05	F. ratio	**Root length (cm)**	LSD 0.05	F. ratio
Control	33	27.59	0.94	29	22.73	0.80	14	9.581	4.065	8	3.229	12.14
5	32			22			Plant burnt			Plant burnt		
10	32			21			13			7		
30	27			23			12			8		
60	41			39			14			6		

In okra (Table6), maximum shoot length (14cm) was observed in control and 60 minutes treated seeds and maximum root length (8cm) was observed in control and 30 minutes Ultraviolet treated seeds while in corn maximum shoot (41cm) and root length (39cm)were observed in 60 minutes treated seeds as compared to control where shoot length (33cm) and root length (29cm) were recorded. Minimum shoot length (12cm) of okra was recorded in 30 minutes treated seeds and minimum root length (6cm) was recorded in plant which received 60 minutes UV radiations. In corn (Table6) minimum shoot length was observed in 30minutes (27cm) and minimum root length (21cm) was recorded in10 minutes exposed seeds. It was also observed that okra plants of 5 minutes Ultraviolet treated seeds were burnt before uprooting. In Ultraviolet irradiated seeds significant results were not obtained.

Discussion: Radiation from the sun has always been playing an important role in our environment and affects nearly all living organisms including plants (Jeannie, 2001). In the present study, the effect of shortwave radiations (Microwave and Ultraviolet) on seed germination and plant growth were studied. A small amount of radiation would have no or little effect on the seeds or plants but radiation at high level, causes inhibited sprouting, slow seedling growth and with increasing dose, reduced plant fertility and induced chromosome aberrations (Martínez*et al*., 2003; Soja*et al*., 2003; Belyavskaya, 2001; Tanner and Romero-Sierra, 1974; Pavel,*et al*., 1998).

In this study, okra and maize seeds were exposed to radiations (Microwaves and Ultra violet) for different time intervals to observe the effect of radiation on plant germination and growth. Many researchers reported that ionizing radiation produced inhibitory effects on seed germination in wheat and barley (Ajayi, 1992; Ajayi and Larsoon, 1991; Sparrow 1962, 1965; Sparrow and Sparrow, 1965). It was observed that different plant species have its own physical requirement and behave differently it may be anticipated, that different results are due to difference in specie.

Reduced seed germination and inhibited plants growth were observed in okra and these results confirmed the findings of Ajayi (1992),who reported that ionizing radiations produce inhibitory effects on growth of plants .Whereas in maize ionizing radiations enhanced the germination. Our results are in agreement with Magone (1996) and Murakarmi *et al.*,(2001) who observed that low Microwave radiation frequencies lead to growth acceleration while high frequencies reduced plant growth or have no effect. With the reduction of seed germination, reduced length of plants was also observed in this experiment as compare to control plants in .It was observed that radiation, affect germination, growth and other morphological character of plants specially those plants which develop from seeds which exposed for 3 seconds in Microwave while in Ultraviolet radiation, difference showed in 5minute exposed okra seeds and 60 minute in maize respectively.

Cadwell *et al.,* (1989) have reviewed the studies on morphological, physiological and biochemical responses of plant to enhanced Ultraviolet radiation. Physiological functions are however, relatively sensitive at exposure dose (Ambasht *et al*. 1995).In the present study ,it was observed that plants of different treatments were died just after germination i.e. in okra the seeds which receive radiation for 5 minute. In Ultraviolet radiation plants were burnt just after germination; similar results were also obtained by Singleton (1955), Grosch and Hopwood, (1997).They observed that radiation caused death in the embryonic state, inability to reproduce, increased susceptibility to disease. While in maize 2 seconds irradiated seeds were died after germination the reason of death is unknown and may not be related with radiation dose because the seeds radiated with radiation more or less than 2 seconds produced healthy plant.

It was also reported that monocot plants are less affected by radiation then dicots because of their leaf orientation, protective basal sheath and concealed apical meristem (Cline and Salisbury, 1996).

It may be concluded that different radiations (Microwave and Ultraviolet) did affect plant germination , growth and other morphological characters .In present study, both beneficial and harmful effects on seed germination and plants growth were observed but no significant results were obtained among different treatments of radiations. Further research is suggested to examine the effects of radiation on plant germination and growth.

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