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Full Length Research Paper

UV-B Induced Aberrant Chromosomal Behaviour in Egyptian clover and Fennel plants

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Abstract

Mutagenesis is a stepping stone in the field of plant genetics and breeding researches as a means of inducing novel genetic variations in the existing genotypes of crop plants. Radiation played a very notable role in causing several types of genetic changes in plants. In recent years, due to industrialization and anthropogenic activities, depletion of the stratospheric ozone layer is increasing which thereby increases the threshold quantity of UV-B radiation reaching the earth's surface. The present experiment was carried out to study the comparative effect of increasing UV-B irradiation, *i.e.* 20, 40, 60, 80min on chromosomal organization in two plants: *Trifolium alexandrinum* L. and *Foeniculum vulgare* Mill. The doses of UV-B irradiation were found to be more chromotoxic on *Foeniculum vulgare* Mill. than on *Trifolium alexandrinum* L. Among the two plants, *Foeniculum vulgare* showed high mitotic index (MI) in comparison to *Trifolium alexandrinum* L. at all the treatment sets. The significant decline in MI and increasing total abnormality percentage (TAB%) was observed along with the increase in doses of UV-B radiation in both plants. A wide range of cytological aberrations were observed.

Keywords: *Foeniculum vulgare*; Mutagenesis; *Trifolium alexandrinum*; UV-B rays; Total abnormality percentage.

INTRODUCTION

All living organisms (plants and animals) use sun-light. Plants use sunlight for photosynthesis mainly and play a pioneering role in food-web as a producer. All the energy in living organisms enters through photosynthesis and transferred through one tropic level to the next. The properties of light (wavelength, frequency) greatly affect the rate. The UV (Ultra Violet) spectrum is generally divided into three classes: UV-A, UV-B, UV-C (Kumar and Bhardwaj 2019). The classes are divided on the basis of their wavelength. UV-C region of the spectrum has wavelength below 280nm. These highly energetic wavelength lights are powerfully absorbed by ozone in the stratosphere layer of the atmosphere, hence, these rays do not reach on the earth's surface. In contrast, UV radiation in the UV-B region, light (280-320nm) is a natural component of the sunlight reaching maximum on the earth's surface. Due to much more availability of the UV-B radiation on the earth's surface, it has received much attention in recent years, because radiation from this spectral region (280-320nm) will increase as the atmospheric O_3 concentration decreases (Tabazadeh et al., 2000). Though nowadays due to a successful implementation of Montreal Protocol on substances responsible for the depletion of the ozone layer, there has been a reduction in incoming solar UV-B radiation (WMO 2010), however, terrestrial ecosystem appears to be sensitive due to the variation in UV-B irradiation (Ballare et al., 2011). Although, UV-B irradiation is used as a mild physical mutagen Strong absorption of UV-B photons by biologically important macromolecule i.e protein and nucleic acid has a considerable effect on the plant and animals metabolism (Heisler et al., 2003). Among the living organisms, plants are vulnerable to increased UV-B radiation as they are absolutely dependent on solar radiation for their survival. High energy UV-B radiation directly absorbed by several biologically active molecules such as nucleic acid, proteins and lipids, get damaged (Zeeshan and Prasad 2009). The findings have shown that UV-B radiation can

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affect growth and physiological processes in plants (Musil et al., 2002; Mishra et al., 2009). Similar results were also reported by (Chattergi 2015) on the growth parameter like height and leaf area in wheat, rice, maize, rye, soyabean, sunflower and cucumber. UV-B significantly reduces these parameters. Physical mutagen as UV-B has a very frequent effect on the cytology and the chromosome morphology. Thus, the present study has been done to determine the comparative mitoclastic effects of UV-B irradiation on root meristems of *Trifolium alexandrinum* L. and *Foeniculum vulgare* Mill.

Berseem (*Trifolium alexandrinum* L.) one of the most important forage plants belonging to Fabaceae family, is a native crop of Mediterranean region and Middle-East. Berseem is an annual, sparsely hairy, erect, high quality green forage legume and its high up to 30 to 80 cm (Hackney et al., 2007; Hannaway et al., 2004; Suttie 1999). Berseem clovers are multi cut green fodder, it should be cut 50 to 60 days after planting and then every 30- 40 days (Suttie 1999). The highest yield of protein with a relatively low yield of fibre was obtained by cutting the plant, play a significant role in Indian agriculture and in food web of animal husbandry. Five to six cuttings can be done under irrigation and one or two at the end of the cool season in dryland (Göhl 1982). *Trifolium alexandrinum* L. is important in maintaining the nitrogen content of agricultural fields and nutrient value in cattle diet due to high protein content.

Almost two-third world flora have medicinal value, used for the cure of a wide range of cardiovascular and inflammatory diseases (Amin et al. 2019). *Foeniculum vulgare* Mill. is an important spice crop of India and is also a medicinal plant belonging to Umbelliferae (Apiaceae) family, a small, erect and aromatic herb. Fennel is also used as traditional folklore medicine for a wide range of sickness related to digestive, endocrine, reproductive, and respiratory systems (Khan and Musharaf 2014). *Foeniculum vulgare* Mill. mainly controls numerous infectious disorders of bacterial, fungal, viral, mycobacterium, and protozoal origin. Some of the literature on this plant stated that *Foeniculum vulgare* Mill. has a special kind of memory-enhancing effect and can reduce stress (Koppula and Kuma 2013). A previous biochemical study by *researchers* on this particular plant revealed that it has antioxidant, antitumor, chemopreventive, cytoprotective, hepatoprotective, hypoglycemic, and oestrogenic activities. *Foeniculum* species are characterized by the presence of essential oils (Ozbek et al. 2003), and secondary metabolites *viz* sterols, coumarins and flavonoids (Parejo et al. 2004). By the production of different type of essential oil and medicinal properties, it becomes necessary to increase the yield of fennel and also encourage the cultivation of new varieties of plants on a large scale. Comparative analysis of UV-B exposure on two plants (Barseem and Sauf) of different families gives a significant idea about morphological changes that occur in chromosome frequency.

MATERIALS AND METHODS

Berseem (clover) seeds and saunf seeds obtained from SHUATS (Sam Higginbottom University of Agriculture Technology and Science Allahabad), were sterilized with 10% sodium hydrochloride for 10 min. and were then soaked in distilled water to germinate at 25^0c in seed germinator.

Experimental design, UV-B treatment and Fixation

These germinated seeds with uniform size root tips were selected. The selected germinated seeds were put in Petriplates. which is divided into four sets as B_T, C_T, D_T, E_T and B_F, C_F, D_F, E_F, (each X_T Petriplate for *Trifolium alexandrinum* and X_F for *Foeniculumvulgare* seed, respectively), irradiated with UV-B rays for 20, 40, 60, and 80 minutes. Set A_T and A_F was used as the control for *Trifolium alexandrinum* and *Foeniculum vulgare* respectively. Early root tips (5- 25mm) were irradiated with fluorescent UV-B (280-320 nm) lamps along with visible light. After treatment, irradiated seeds were left for one hour before the recovery process. All the irradiated seeds of comparative sets of plants *T.alexandrinum* and *F.vulgare* i.e B_T, C_T, D_T, E_T and B_F, C_F, D_F, E_F, along with control sets A_T and A_F were fixed in Carnoy's fixative in their labeled bottles for cytological study. After 24 hours of fixation, Carnoy's fixative was removed and sets were transferred into 90% alcohol.

Mitotic Preparation

For the study of chromosome morphology, the squash technique was applied. 2% Acetocarmine was used as staining dye, for half an hour. After that 10 slides were prepared for each dose of UV-B irradiation. Slides were observed under Nikon Research Electron Microscope while photographs were clicked using software PCTV Vision. Data were prepared by recording nearly 8 microscopic field views of each slide.

Formula Used for Scoring of Data

To calculate Mitotic Index (MI %) and Total Abnormality Percentage (TAB %), the following formulae were followed**:-**

Mitotic index (MI) % = (Total number of dividing cells/Total number of observed cells)*100

Total abnormality percentage (TAB) % = (Total number of abnormal cells/Total number of observed cells) *100

RESULT

Cytological Observations

Mitosis was found to be normal in the control sets and showed regular arrangements of chromosomes at metaphase (2n=16 in *Trifolium alexandrinum* and 2n=22 in *Foeniculum vulgare*) and having equal separation (16:16 and 22:22, respectively) at anaphase. However, various chromosomal abnormalities were recorded in root meristems of treated seeds.

Effect on mitotic index

The cytological estimation of UV-B irradiation shows an impact on the cytology of root meristems in the two plants *Trifolium alexandrianum* L. and *Foeniculum vulgare* Mill. Various doses of UV-B radiation cause a significant change to the mitotic activity and chromosomal morphology. Table 1 represents complete comparative data of MI% in these two plants. The computed active MI for varying UV-B irradiation doses and an inverse association between respective doses and MI% were observed. The evaluated MI in case of control of *Trifolium alexandrium* L. was 10.07±0.29% which decreased along with increasing radiation doses, as in 20 *min*. Exposer MI% was 9.34±0.30% that declined to 6.30±0.10% at 80 *min* treatment. In the case of *Foeniculum vulgare* Mill. calculated MI in control was 12.49±0.16% which was decreased along with increasing radiation i.e 20 *min* 11.42±0.21% to 80 *min* 8.08±0.36%. Comparatively, in these two plants, the MI% is more in *Foeniculum* rather than the *Trifolium alexandrium* L.

Effect on Total abnormality percentage and chromosomal morphology

From the present study, it was recorded that as the treatment duration of the UV-B irradiation increases the rate of chromosomal abnormalities, as witness in *Trifolium alexandrianum* L. and *Foeniculum vulgare* Mill. Mitotic disturbance after UV-B irradiation was considerably encountered at metaphase and anaphase as shown in Figure 1. The rate of chromosomal aberrations was documented in the form of Total Abnormality Percentage (TAB%) in Table 1. It was increased from 1.63±0.27 to 5.13±0.21 in *Trifolium alexandrinum* and 2.09±0.11 to 6.68±0.52 in *Foeniculum vulgare* with respect to time duration *viz* 20 *min* to 80 *min* of UV-B irradiations. From the result, it was deduced that higher doses are more mitotoxic and impose more aberration in treated sets as compared to lower doses and control. Result also inferred that UV-B higher dose is more chromotoxic for *Foeniculum vulgare* Mill. rather than *Trifolium alexandrinum* L. belonging to Apiaceae and Fabaceae family, respectively. It was retrieved that frequency of TAB% was more in *Foeniculum vulgare* as compared to *Trifolium alexandrinum.* Some of the abnormalities Figure 2 and 3 recorded are stickness, scattering, precocious movement, unorientation at metaphase and stickness, bridge formation, scattering, laggared movement at anaphase. Stickiness at metaphase was found to be most dominant anomaly in *Trifolium alexandrinum* L. while scattering at metaphase was most dominant anomaly in *Foeniculum vulgare* Mill. induced by UV-B irradiation. Bridges and laggard formation at anaphase were recorded at higher two doses of UV-B in case of *T. alexandrinum* while in *F. vulgare*, laggards were recorded only at 80 *min* duration whereas bridges were present at 40 to 80 *min* of UV-B doses. Results show that UV-B irradiation induces more abnormalities at metaphase rather than anaphase in both the plants. This result also deduced that comparative metaphasic and anaphasic abnormalities were higher in *Foeniculum vulgare* as compared to in *Trifolium alexandrinium* as mentioned in Figure 1.

DISCUSSION

UV-B radiation has a distinctive role in the regulation of plant growth and development. Although high doses of UV-B can cause a stressful condition that leads to damaging impacts on chromosomal morphology and Chromosomal aberration is related to genome instability. In the present study, we have investigated the effect of UV-B on the root meristems of the *Trifolium alexandrinum* L. and *Foeniculum vulgare* Mill. with a wide range of doses and compared its actions on both the plants. The data collected from this study show a significant decrease in the mitotic index (MI) along with increased doses. As we increase UV-B irradiation doses, chromosomal aberrations were also subsequently increased in the root meristems of both the plants. Similar results were recorded by Hopkines et al. (2002). DNA is most sensitive to UV-B during replication. Reduced MI successively inhibits the cell DNA replication (doubling of DNA), transcription (mRNA generation) and translation (protein synthesis) which is the possible outcome of self- protection mechanism of cell (Liu et al., 2015). According to Sudhakar et al. (2001), the decline in MI% is due to mitodepressive action of higher UV-B exposure duration and inhibitory effect of DNA synthesis at telophase. Physical mutagen as UV-B irradiation producing wide range of chromosomal abnormalities, recorded in the experimental plants *Trifolium alexandrinum* and *Foeniculum vulgare*. According to Mohajer et al. (2015), UV-B induced photoproducts as cyclobutane- pyrimidine dimars could induce the formation of chromosomal aberration which is a genetical danger for plant. Paul et al. (2013) reported that stickiness is a type of physical adhesion involving a prominently proteinaceous matrix of

Table 1. Comparative analysis of all metaphasic and anaphasic abnormalities in Trifolium alexandrinum L. and Foeniculum vulgare Mill.

Plant	UV-B Treatment	MI (%) (Mean ± SE)	Metaphasic abnormalities % (Mean ± SE)				Anaphasic abnormalities % (Mean ± SE)					Others % (Mean ± SE)	TAB (%) (Mean ± SE)
			Sc	**St**	**Un**	**Pr**	**Sc**	**St**	**Un**	**Br**	**lg**		
Trifolium alexandrinum	Control	10.07 ± 0.29^{a}	-	-	-	-	-	-	-	-	-		
	20 min	9.34 ± 0.30^{b}	0.24±0.01	0.57±0.09	0.17±0.08	-	0.17±0.08	0.32±0.06	-	-	-	0.17±0.08	1.63±0.27
	40 min	8.48 ± 0.09^{c}	0.39±0.14	0.65±0.10	0.32±0.06	0.32±0.07	0.16±0.08	0.32±0.08	0.24±0.14	-	-	0.16±0.08	2.54±0.20
	60 min	7.40 ± 0.26^{d}	0.5±0.14	1.13±0.04	0.25±0.14	0.25±0.15	0.16±0.08	0.5±0.01	0.25±0.14	0.25±0.15	0.16±0.08	-	3.49±0.16
	80 min	6.30 ± 0.10^{e}	0.58±0.12	1.23±0.17	0.34±0.10	0.24±0.13	0.65±0.04	0.74±0.15	0.4±0.06	0.31±0.15	0.56±0.19	0.24±0.13	5.13±0.21
Foeniculum vulgare	Control	12.49 ± 0.16^{a}	-	-	-	-	-	-	-	-	-	-	-
	20 min	11.42 ± 0.21^{a}	0.77±0.12	0.44±0.10	-	-	0.66±0.20	0.22±0.11	-	-	-	0.22±0.11	2.09±0.11
	40 min	10.26 ± 0.14^{b}	0.88±0.12	0.55±0.11	0.22±0.11	0.34±0.20	0.77±0.10	0.33±0.18	-	0.22±0.11	-	0.32±0.18	3.63±0.19
	60 min	9.36 ± 0.12^{b}	1.12±0.23	0.78±0.10	0.44±0.22	0.45±0.11	0.78±0.11	0.56±0.11	0.46±0.11	0.34±0.20	-	0.22±0.11	5.16±0.34
	80 min	8.08 ± 0.36^{c}	1.72±0.18	0.92±0.13	0.47±0.23	0.46±0.10	0.91±0.09	0.57±0.29	0.47±0.23	0.45±0.28	0.46±0.10	0.45±0.11	6.68±0.52

Where,
MI(%)-Mitotic Index; Sc- Scattering; St- Stickiness; Un- Unorientation; Pr-Precocious movement; Lg- Laggard; Br-Bridge formation, TAB (%)- Total Abnormality Percentage.
Means followed by lowercase letter are statistically significant at $p < 0.05$ in Duncan's Multiple Range Test (DMRT).

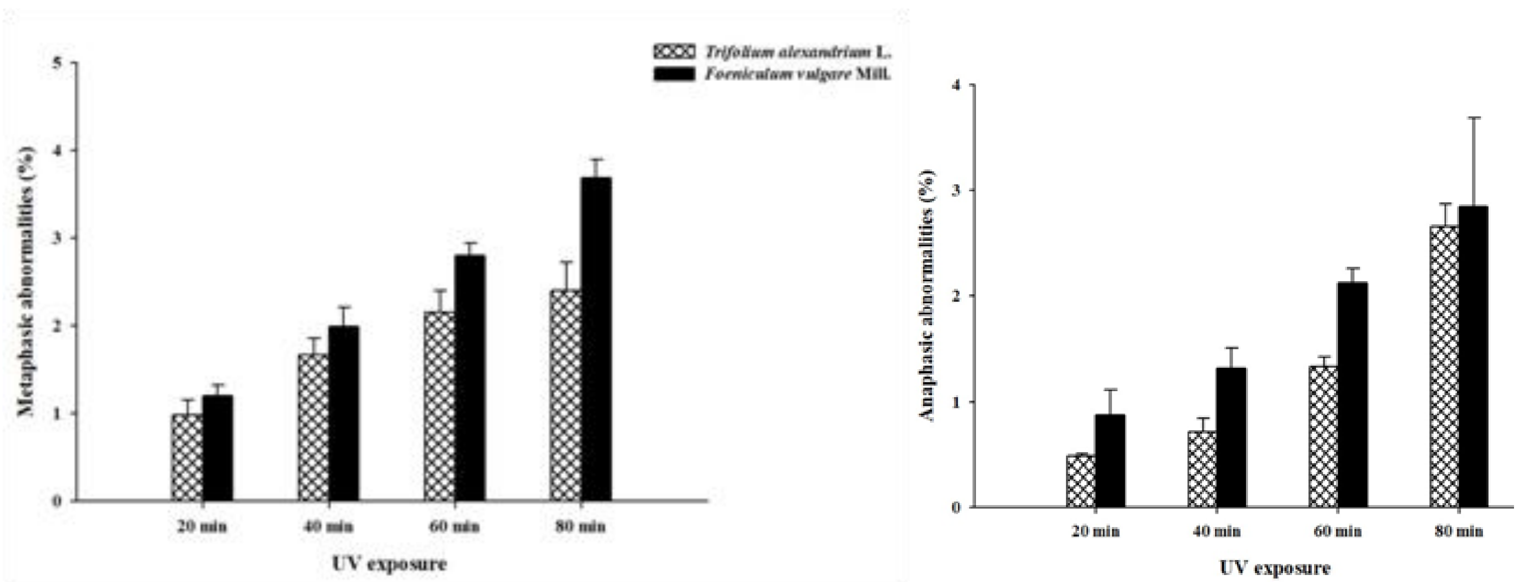

Figure 1. A, B Comparative analysis of metaphasic and anaphasic abnormalities in *Trifolium alexandrianum* L.and *Foeniculum vulgare* Mill.

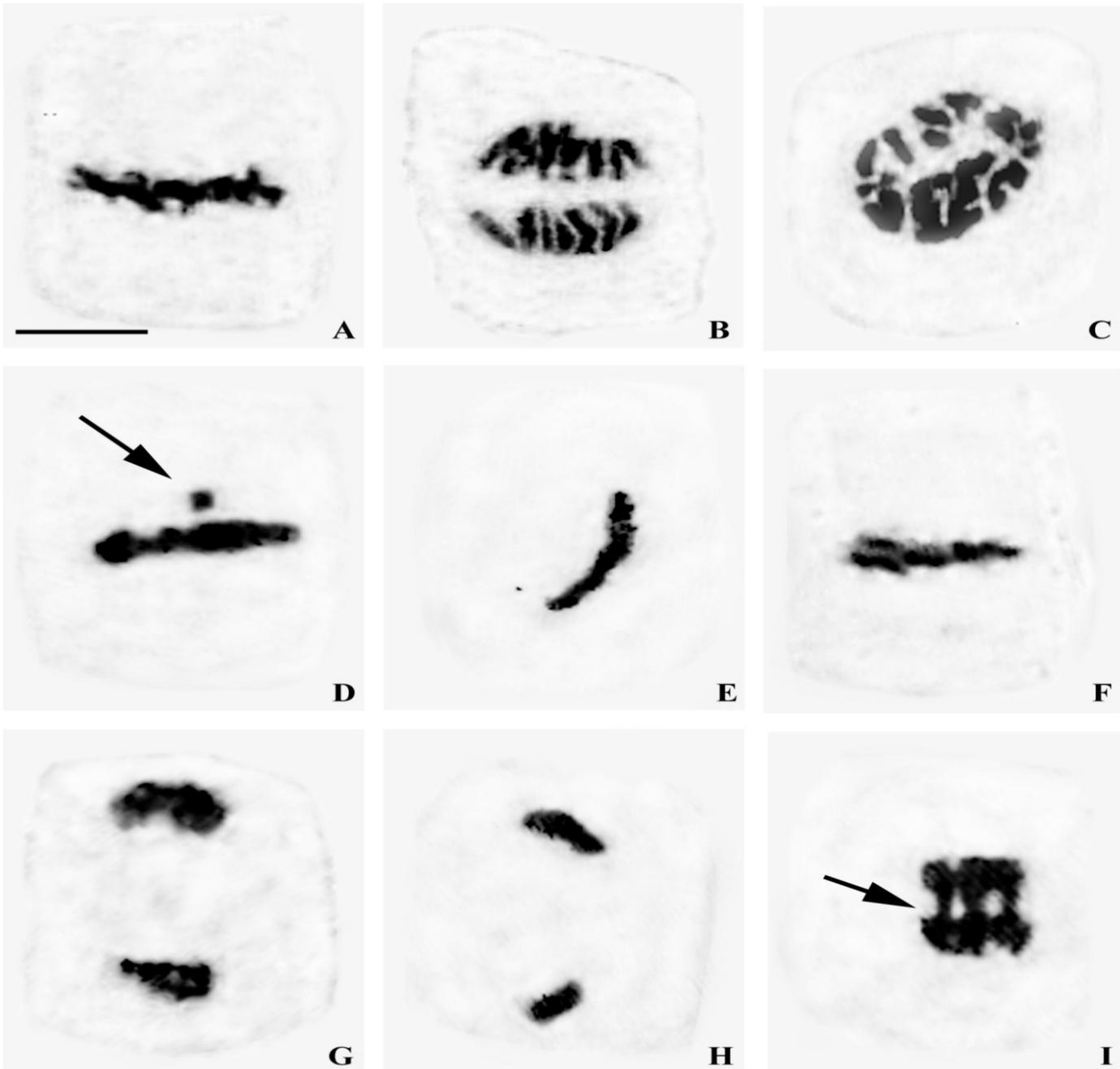

Figure 2. Mitotic Abnormalities of *Foeniculum vulgare* induced by UV-B radiation-A. Normal Metaphase (2n=22) B. Normal anaphase (22:22 separation), C-Scattaring at metaphase, D. One precocious chromosome with sticky metaphase, E. Unorientation at metaphase, F. Stickness at metaphase G. Stickness at anaphase, H. Unorientation at anaphase, I. Multiple bridge formation at anaphase, [Scale bar: 6.28µm].

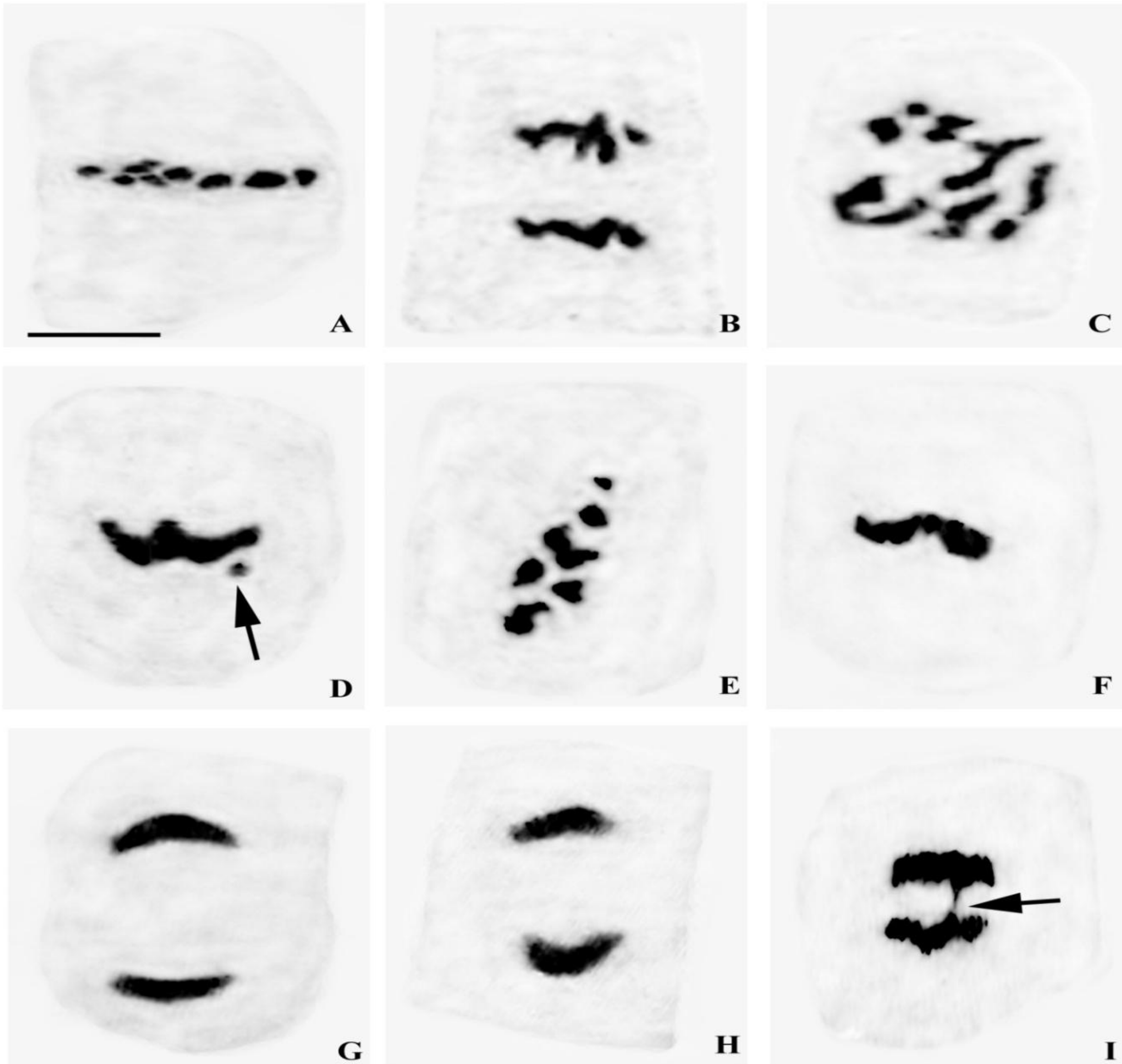

Figure 3- Mitotic abnormalities of *Trifolium alexandrianum* induced by UV-B radiation-A. Normal Metaphase (2n=16) B. Normal anaphase (16:16 separation), C-Scattaring at metaphase , D. One precocious chromosome with sticky metaphase, E. Unorientation at metaphase, F. Stickness at metaphase G. Stickness at anaphase, H. Unorientation at anaphase, I. Single bridge formation at anaphase, [Scale bar: 6.28µm]

chromatin material. Han et al. 2007 found that chromosomal stickiness lead to inactivation of DNA replication which increases chromosomal contraction and condensation, probably leading to cell death. Partial dissociation or mutagenic treatment of the nucleoprotein and changes in their pattern of organization could be due to depolymerisation of nucleic acid. Precocious movement of chromosome at metaphase might be formed due to deformed chromosome morphology and chromosome pairing. In precocious movement one or few chromosomes float in the cytoplasm rather than arranged at equatorial plate. An orientation and scattering of the chromosomes at metaphase were observed in both plants *i.e T. alexandrinum* and *F. vulgare*, which may be either due to inhibition of spindle fiber formation or destruction (Kumar and Rai, 2007). Chromosomal bridges were another anomaly in both the plants encountered prominently at anaphase. It might have occurred at high dose of UV-B irradiation, making chromosomal breaks, then these broken chromosomes, healed, producing double centromere chromosome i.e chromosomal bridges. Formation of bridges could be credited to chromosomal stickiness (Kumar and Srivastava, 2017) and chromosome breakage and gathering that proceed due to loss of genetic material (Kumar and Rai, 2007). Such chromosomal abnormalities may affect adversely the vigour, fertility and yield of exposed plant (Kumar and Srivastava, 2015).

CONCLUSION

Geneticists and plant breeders have pronounced the need for additional development in harnessing turn to good account of genetic variability so Several approaches (such as mutagens) are accessible to assess the diversity of genotypes (Tahir et al., 2018). Both of the selected plants *viz. Trifolium alexandrinum* and *Foeniculum vulgare* both are the core eudicot plants under rosids and asteroids taxa. Although these two plants are phylogenetically not very close(APG-4). Saunf plant is highly medicinal because of the high value of secondary metabolites, have a large impact of UV-B irradiation as comparative to clover plant. Increasing UV-B irradiation in atmosphere is more mitotoxic and chromotoxic for saunf. An additional, important approach to dissecting plant responses to UV radiation is genetic (Mohajer et al., 2015). Increased UV radiation level from ozone layer reduction will reach plants, and plants will respond. Much more work will be required to define the exact mechanisms of the various UV-B induced cytological and molecular responses. In particular, action spectra of UV-B irradiation give more information's about the chromosomal abnormalities.

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REFERENCES

Amin R, Wani MR, Raina A, Khursheed S, Khan S (2019). "Induced morphological and chromosomal diversity in the mutagenized population of black cumin (*Nigella sativa* l.) using single and combination treatments of gamma rays and ethyl methane sulfonate", Jordan J. Biol. Sci., Vol.12, No.1, pp.23-30 .

Ballare, Carlos L, Martyn M, Caldwell, Stephen D, Flint, Sharon A, Robinson, Janet F, Bornman (2011). "Effects of solar ultraviolet radiation on terrestrial ecosystems. Patterns, mechanisms, and interactions with climate change", Photochem. Photobiol. Sci., Vol. 10, No. 2 , pp. 226-241.

Chatterji A (2015). "Impact of UV-B radiations on morphology of *Ocimum* and Mentha (*Family-Lamiaceae*) by ascorbic acid", International Journal of Advanced Research, Vol.1, pp.347-351.

Gohl B (1982). "Tropical feeds. FAO animal production and health"; Food and AgricultureOrganization, Rome. Series, No. 12.

Hackney B, Dear B, Crocker G (2007). "Berseem clover: New South Wales Department of Primary Industries", Primefacts, N°388.

Han R, Zheng YF, Wang, CH (2007). "Effects of enhanced UV-B radiation on the growth of aerial parts and root of maize", Journal of Ecology and Environmental Science**,** Vol.2, pp.323-326.

Hannaway DB, Larson C (2004). "Berseem Clover (*Trifolium alexandrinum* L.)". Oregon State University, Species Selection Information System.

Heisler GM, Richard H, Grant WG (2003). "Ultraviolet radiation and its impacts on agriculture and forests", Agricultural and Forest Meteorology*,* Vol.120, pp. 3-7.

Hopkins L, Bond MA, Tobin AK (2002). "Ultraviolet-B radiation reduces the rates of cell division and elongation in the primary leaf of wheat (*Triticum aestivum* L. cv Maris Huntsman)", Plant, Cell and Environment, Vol.25, No.5, pp.617-624.

Khan M, Musharaf S (2014). "*Foeniculum vulgare* Mill- A medicinal herb", Med.l Plant Res.Vol. 4, pp.46-54.

Koppula S, Kumar H (2013). "*Foeniculum vulgare* Mill. (Umbelliferae) attenuates stress and improves memory in wister rats", Tropical J. Pharm. Res, Vol.12, No. 4, pp.553-558.

Kumar G, Srivastava A (2017). "Studies on the effect of temperature variation on chromosomal changes in buckwheat (Fagopyrum esculentum Moench)". J.Environ. Biol., Vol.*38*, No.3, pp.471.

Kumar G, Bhardwaj M (2019). "Induced genetic variations in Cuminum cyminum through supplemental UV-B radiation". J. Environ. Biol., Vol. 40*,* No. 3, pp. 342-348.

Kumar G, Rai PK (2007). "EMS induced karyomorphological variations in maize (*Zea mays* L.) inbreds", Turkish Journal of Biology, Vol.31, No.4, pp.187-195.

Kumar G, Srivastava A (2015). "Comparative genotoxicity of herbicide ingredients glyphosate and atrazine on root meristem of buckwheat *(Fagopyrum esculentum* Moench)", Jordan J. Biol. Sci.**,** Vol.8, No.3, pp.1-6.

Liu F, Chen H, Han R (2015). "Different doses of the enhanced UV-B radiation effects on wheat somatic cell division", CellBio, Vol**.**4, No 2, pp.30-36.

Mishra V, Srivastava G, Prasad SM (2009). "Antioxidant response of bitter gourd (Momordica charantia L.) seedlings to interactive effect of dimethoate and UV-B irradiation". Scientia Horticulturae, Vol.120, No.3, pp.373-378.

Mohajer S, Taha RM , Mohajer M. & Javan IY (2015). "UV-B irradiation effects on biological activities and cytological behavior of sainfoin (Onobrychis viciifolia Scop.) grown in vivo and in vitro". *Pak. J. Bot*, vol.47, No.5, pp1817-1824.

Musil CF, Chimphango SB, Dakora FD (2002). "Effects of elevated ultraviolet-B radiation on native and cultivated plants of southern Africa." Annals of botany*,* Vol.90, No. 1, pp.127-137.

Ozbek H, Uğraş S, Dulger H, Bayram I, Tuncer I, Oztürk G, Oztürk A (2003). "Hepatoprotective effect of *Foeniculum vulgare* essential oil" Fitoterapia,Vol.74, pp.317-319 .

Parejo I, Viladomat F, Bastida J, Codina C (2004). "Development and validation of a high–performance liquid chromatographic method for the analysis of antioxidative phenolic compounds in fennel using a narrow pore reversed phase C_{18} column", Analytica chimica Acta, Vol**.**519, pp**.** 271–280.

Paul A, Nag S, Sinha K (2013). "Cytological effects of Blitox on root mitosis of Allium cepa L." Int. J. Sci. Res., Vol.*3,* No.5, pp.1-6.

Sudhakar R, Venu G (2001). "Mitotic abnormalities induced by silk dyeing industry effluents in the cells of *Allium cepa*", Cytologia, Vol.6**6,** No. 3**,** pp**.**235-239.

Suttie JM (1999). "Berseem clover (*Trifolium alexandrinum*)" A searchable mcatalogue of grass and forage legumes, FAO.

Tabazadeh A, Santee ML, Danilin MY, Pumphrey HC, Newman PA, Hamill PJ, Mergenthaler JL (2000). "Quantifying denitrification and its effect on ozone recovery", Science, Vol.*288* No.5470, pp.1407-1411.

Tahir NA, Lateef DD, Omer DA, Kareem SH, Ahmad DA, Khal LH (2018). "Genetic Diversity and Structure Analysis of Pea Grown in Iraq Using Microsatellite Markers", Jordan J. Biol. Sci., Vol.11, No.2**,** pp.201-207.

World Meteorological Organization Global Ozone Research and Monitoring Project—Report No. 52.
Zeeshan M, Prasad SM (2009). "Differential response of growth, photosynthesis, antioxidant enzymes and lipid peroxidation to UV-B radiation in three cyanobacteria", South African Journal of Botany. Vol.75, No.3, pp.466–474

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