***INT. J. BIOL. BIOTECH.*, 21 (2): 249-254, 2024.**

EFFECTS OF X-RAYS ON SEED GERMINATION AND SEEDLING GROWTH OF *ZEA MAYS* L.

Ishrat Jahan[1] and S.Tanveer Iqbal[2]

[1]*Fatmiyah Higher Education System, Karachi, Pakistan.*
[2]*Department of physics, Ned University, Karachi-75270, Pakistan*
*Corresponding author: ishratjahanansari878@gmail.com

ABSTRACT

The Present study was carried out to determine the effect of X-rays radiation on exposed to 6MVa dose rate of (20Gy/sec). This dose applied on four different maize varieties viz., FH-793, DK-6724 and KSC-9633, and HC-9091.Exposure to x-ray showed an inhibitory effect on seed germination percentage and seedling growth on maize varieties. The Seedling length and Fresh weight (FW) increased in non-irradiatedseeds(control). No significant effects were found on germination percentage and germination rate(GR)on irradiated maize seeds. Although germination velocity (GV) and germination index (GI) significantly increased in all irradiated varieties while mean germination time decreased as compared to control. The Two varieties DK-6724 and HC-909 showed drastically inhibition in shoot length, root length and fresh weight.Whereas the root length of FH-793 and KSC-9633 were increased. Dry biomass of irradiated varieties was higher in irradiated seeds. The 6mv dosages showed adverse effect on the seedling length and bio mass. This may be cause to earlier death or low productivity of yield of maize crop.

Key-words: X-ray, Irradiated, Variety 1 FH-793 (V1), Variety 2 KSC-9633 (V2), Variety 3 DK-6724 (V3),Variety 4 HC-9091 (V4), Maize seeds, germination, seedling growth.

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crop in the world. In terms of productivity, it is also a leading cereal of the world (Abuzar*et al*., 2011). It is used as food for humans and feed for livestock and poultry. Wide use of Corn as a raw material in textile industries, food, medicine, manufacturing of corn oil, corn flakes, dextrose has been reported(Ali *et al*., 2011; Ali *et al*., 2014). Maize grain constitutes about 9.73 % protein, 4.85% oil, 9.44% crude fibre, 71.96% grain starch, 11.77% embryo. Out of total corn Gross production, 65% used as a fodder and 35% to fulfill nutrient requirement of humans (Banziger *et al.,* 2000; Fawad *et al*., 2015a,b). In Pakistan, maize contributes 2.2% to value addition in agriculture and 0.5% to GDP. Usually major economic loss of maize crop due to several disease like leaf blight, smut, kernel rots and cutworm (Chaudhry, 1994). Nitrogen deficiency and drought also responsible for yield lose (Banziger *et al.*, 2000; Filipovic *et al*., 2014), mutagenic agents such as radiations and certain chemicals can be used for crop improvement. When genes for resistance to a particular disease or tolerance against biotic and a-biotic stress cannot be found in the available gene pool then mutation induction is the best alternative (Novak and Brunner, 1992 and Saif-ul-Malook *et al*., 2014). this trait can be induced to the commercial varieties in which a particular trait is absent (Irfaq and Nawab, 2001). Ionizing radiation is the basic tool of nuclear technology for crop improvement. X-ray is the part of electromagnetic spectrum having wave length of 0.01 – 10nm. Effect of X-ray on growth of plant have been studied (Yang *et al*., 2011). Irradiation have many effects on plant growth as it improves the germination rate. X-ray also known to improve the weight and size of seedling. it is commonly use to quantify and study the edaphic factor of soil and root growth (Karahara *et al*., 2012; Flavel *et al*., 2012) and also used to control the phytopathogens (SpadaroandGullino, 2005). The mechanism, that explain the effect of radiation on plant is still insufficient because X-ray technology is new in plant sciences Moh (1951). Most of studies are mainly based on irradiation of gamma rays.As it is relatively new in plant science, therefore it is important to determine the effect of X-ray radiation. There are number of institutions using x-ray radiation to determine the seed characteristics and how X-ray change the characteristics of seed, flower and fruit. According to physicist, absorption of radiation by substance and ionization of atom produced by photoelectron determine the effect of x-ray. Therefore, long x-ray wave and short x-ray wave show no difference as energy absorb is same.

Moh and Smith (1951)further reported as most of the radiobiological processes, intensity of radiation is also an important factor because dose of radiation is mainly depending on intensity. It effects the growth of plant at certain dose and after certain dose it may become lethal for plant e.g. radiation dose required to improve plant growth is 75r to 300r (in Norway spruce) but above these value i-e 600r (Norway spruce) it harms the plants. There are number of investigations regarding the effect of X-ray dose on growth of plant. but some of the investigator has also stated that, x-ray is harmful for life even at low dose. According to some investigator heavy dose of x-ray are injurious (need research) while some stated that a small dose is much beneficial for growth of plant (need research). It has been studied that, seed of wheat when treated with x-ray resulted in increased in size and foliage. Similarly, no increment in sunflower, tomato was recorded when treated with x-ray (Johnson, 1933). The purpose of present study is to determine the effect of x-ray dose on Maize seed germination.

MATERIALS AND METHODS

Seeds of *Zea maize* (L) varieties viz. V1 (FH-793), V2 (Dk-6724), V3 (KSC-9633) and V4 (HC-9091) were collected from Maize & Millets Research Institute-Yusafwala, Sahiwal and stored at room temperature in dry cabinet. Healthier seeds with similar size and weights were selected for further studies. Seeds were irradiated with X-rays at 6MVat a dose rate of 20 Gy/sec. The experiment and irradiation by an X-Ray emitting source was conducted at Jinnah Post Graduate Medical Center. Seeds were surface sterilized by using 1% bleach (NaOCl) and rinsed with sterilized distilled water. The irradiated seeds and control (non-irradiated) seeds of each variety were placed in sterilized Petri plates (9 cm diameter) containing a moist blotter paper. Five seeds were placed in each glass Petri plate. There were three replicates for each treatment under dark chamber at 30 ^{0}C. Seed germination was recorded every 24 hours (AOSA. 1990) till seeds were fully germinated (5 days). Seeds were considered as germinated when their radicle showed at least 2 mm length. Different parameters of Germination indices, vigor index and Percent inhibition/stimulation over control were calculated according to following formulae. Seedling growth in term of growth, fresh and dry weights of controls and irradiated seedlings were recorded after germination.

1. Germination percentage (GP %) = (number of germinated seeds/total number of seeds) x 100 (till 5 days).
2. Germination Rate (GR) = Number of germinated seeds/ day (till last day of experiment (5 days).
3. Coefficient of velocity of germination (CVG) was evaluated according to Maguire (1962) as follows:

$$CVG = \frac{(G1+G2+G3+\ldots+Gn)}{(1xG1+2xG2+\cdots+nxGn)}$$

Where, G is the number of germinated seeds per day (in this experiment 1 to 5days), and n is the last day of germination (5th day).

4. Means germination time (MGT) is calculated according to Ellis and Roberts (1981) as given below,
MGT = Σ (nd) / Σn
Where ‘n’ is the number of germinated seeds in day d, Σn is the total germinated seeds during experimental period.

5. Germination index (GI) = Σ (Gt / Dt), summation of mean number of germinated seeds per day for t days (AOSA, 1983). Where Gt is the number of germinated seed on day t, and Dt is the total number of days (3days in this experiment).

6. Seedling vigor was computed based on Vashisth and Nagarajan (2010).

7. Vigor index I germination% seedling length (Root + shoot)

8. Vigor index II germination% dry seedling weight (root + shoot)

9. Percent inhibition/stimulation over control was calculated as follows:

$$\frac{\text{Control} - \text{Treatment}}{\text{Treatment}} \times 100$$

Statistical Analysis

The data were subjected to the analysis of variance (ANOVA) along with the calculation of the least significant difference (LSD) were made at P <0.05 (Gomez and Gomez, 1984). The statistical analyses were performed with SPSS version - 12 and COSTAT statistical package.

RESULTS AND DISCUSSION

Germinability

There was no significant effect of x-ray treated seed in germination percentage, 80 % germination was recorded control and irritated seed of variety V1 And V4 *i.e.* germ inability equaled that of the control seed. While V2 and V4 variety showed less germination percentage as compared to control. Among them V2 treated seed having least germination percentage as compared to control. i.e only 40% germination observed. Several studies showed that X-radiation to cause important physiological and morphological changes such as changes in different medicinally important plants spp. (Al-NimerandAbdual-lateef, 2009). Reduction of seed germination percentage was observed in different plant including barley, *Hordeum vulgare* (Joshi and Ledoux, 1970); petunia, *Petunia hybrid* (Gilissen, 1978); jack pine, *Pinusbanksiana*(Rudolph, 2003); Scots pine, *Pinussilvestris* (Zelles, 2003) andwheat, *Triticum aestivum* (Floris and Anguillesi, 2003).

Germination Rate

The untreated seed and exposed to x-rays both showed increased in germination to the maximum level as the at 2^{nd} day, the germination rate is affected at that day before it rises to the maximum. However V1 And V4 variety of maize irritated seed with x-ray having same germination rate as non-treated seed of V1 and V4 followed by V3 treated seed while minimum germination rate was observed in v2 i.e. Only 0.4. Sheppard and Chubey (1990) has been reported as the Seeds were improved at 2 Gy of X-rays but higher doses, 8 and 16 Gy, caused reduction of the germination rate.

Germination velocity

Germination velocity increased in all radiated varietal seed as compare to non-irritated seed means earlier germination observed in treated seed, among all Maximum germination velocity observed in V2 and V3 followed by followed byV1 & V4.

Mean Germination Time

In terms of mean germination time, MGT was decreased of all irritated seeds as compare to non- irritated d seeds, maximum mean germination time decreased in V2 and V3 followed by V1& V4,although V1 & V4 showed highest germination percent (80%) irritated seed showed lower mean germination time is state earlier germination of seed. Borzouei *et al*. (2010) working with wheat (*Triticum aestivum* L.) showed that mean germination time, root and shoot length, and seedling dry weight decreased with increasing radiation.

Germination Index

The present study showed that like germination velocity and MGT germination index also increased as comparison of untreated seeds. Among them V1 showed maximum germination index slightly difference in V3 followed by V4 and least GI was observed in V2 seed of maize.

Effects On shoot length

The effect of studied treatments on shoot length was not significant, but they had a significant effect on shoot and seedling lengths. Shoot length decreased in all irritated seeds as comparison of non-irritated seed. The irritated seeds of V4 & V2 showed maximum length while V1 & V3 showed minimum length. The lowest shoot length was achieved atV3. Shoot elongation was inhibited by-rays -rays exposures. The inhibition range of shoot length 50-56% was induced in V1 and V3.However V4 showed least inhibition of shoot length.

Effects on Root length

X-rays were observed to affect root growth (Scandalios, 1964). Effect of x- rays on the root length of *maize* is shown in Table 1. In this experiment at early stage of root elongation was inhibited by X-rays exposures root length inhibited about 48% in v4 while v3 variety showed less inhibition i.e only 12% only V1 this variety showed improvement in root length followed by V2 variety in root elongation.

Fresh and dry weight of seedling with seed

The present Experimental result haveno significant effect on fresh weight seedling length, dry biomass, vigor index I, and vigor index II. The highest Fresh mass was found in untreated variety of V4 and V1 (2.54g) and (2.33g) although the fresh weight of all variety showed higher value as compare to non-irradiated seeds. But in case of dry weight reverse result found the dry weight of each variety showed higher value as compare to respective non-irradiated seeds; while vigor index 1 show irregular pattern of vigor.

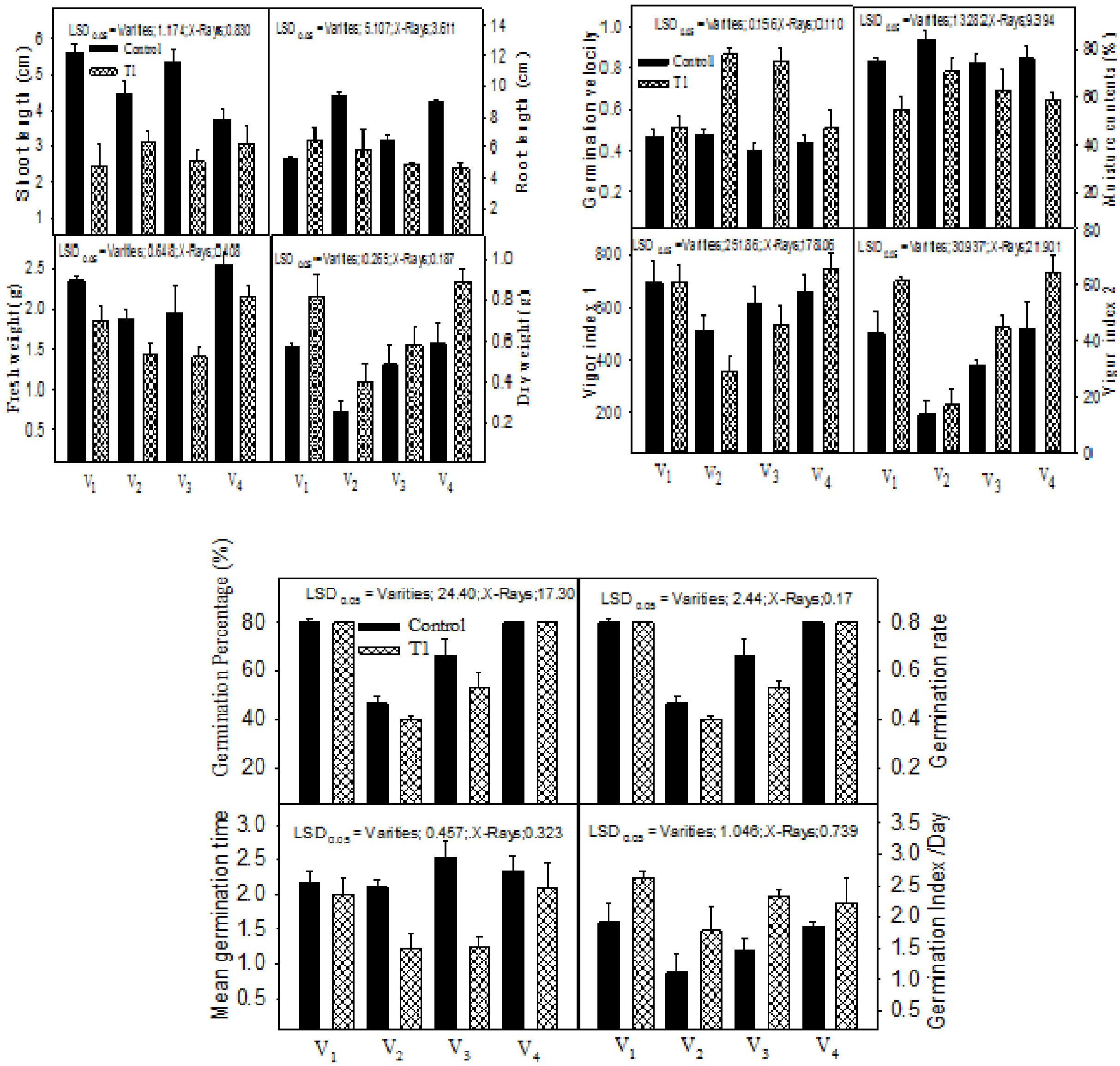

Fig.1. Effect of X-rays on seed germination and seedling growth parameters of *Zea mays*.

Table 1. Effect of X- rays on inhibition or stimulation of shoot and root length of maoze seedlings.

	Shoot Length inhibition/stimulation%	**Root Length inhibition/stimulation%**
	Mean± SE	**Mean± SE**
V1: FH-793	-56.13 ± 9.73	+23.40 ± 19.50
V2: KSC-9633	-31.97 ± 12.61	+11.85 ± 42.17
V3: DK-6724	-50.04 ± 7.04	-24.52 ± 30.08
V4: HC-9091	-17.11 ± 13.66	-48.24 ± 3.53
$LSD_{0.05}$	36.10(variety)	90.45(variety)

The irradiated seeds among them V4 treated variety have high vigor followed by V1, in V1 value of vigor slightly increased as compare to non- irradiated seeds, in case of Vigor index 2 all variety of irradiated seed showed greater value as compare to un irradiated seeds, same pattern observed in moisture content the all irradiated variety showed less moisture content as compare to control. Present study showed that the efficiency of water uptake in irradiated seed effected. The results indicated that seed hydration is a critical factor. Due to irradiation osmotic stress cerate. Osmotic stress indicates that is food reserved such as glucose still available in those seeds but seeds not able to utilize dry weight irradiated of seed mass also showed greater value as compared to control, non-irradiated seed showed maximum seedling length and increased fresh weight because it absorbed sufficient water and utilized mobilize reserved at seedling stage but in irradiated seed of selected variety certain changes occur. Irradiated seeds show lesser seedling length, low fresh weight but dry weight slightly increased might be they were not able to utilize mobilize reserved Since germination is completed before mobilization of the major reserves commences. Since osmotic stress interfere the water uptake of cells, their hydration is lower than when the non-irradiated seeds.The treatment with Ionizing radiations alters hormonal activity the plant growth (Maherchandani, 1975). Changes of membrane permeability may reduce the absorption of some nutrients, especially calcium plays a important role in various stages of seedling growth and development processes of plant (Sanders *et al.*, 2002; Sze *et al*., 2000).

Acknowledgement

Dr. Zeeshan Abbas, Department of Physics, University of Karachi is sincerely acknowleged for x-rays treatment of maize seeds.

REFERENCES

Abuzar, M. R., G. U. Sadozai, M. S. Baloch, A. A. Baloch, I. H. Shah, T. Javaid and N. Hussain (2011). Effect of plant population densities on yield of maize. *JAPS*, 21(4): 692-695.

Ali, Q., M. Elahi, M. Ahsan, M.H.N. Tahirand, S.M.A. Basra (2011a). Genetic evaluation of maize (*Zea mays* L.) genotypes at seedling stage under moisture stress. *IJAVMS*, 5(2): 184-193.8.

Ali, Q., M.H.N. Tahir, M. Ahsan, S.M.A. Q. Basra Ali, A. Ali, M. Ahsan,S. Ali, N. H. Khan, S. Muhammad, H. G. Abbas, I. A. Nasir and T. Husnain (2014b). Line × Tester analysis for morphophysiological traits of *Zea mays* L. seedlings.*Adv. Life Sci*., 1(4): 242-253.

Al-Nimer, S. M. and A. Z. Abdul-lateef (2009). Xrays radiation directly produced favorable and harmful effects on the constituents of different medicinal plants. *Pharm. Res*., 1: 333-335.

AOSA (Association of Official Seed Analyst) (1983). Seed vigor hand testing book. In: Contribution No. 32 to the hand book on seed testing. *Association of Official Seed Analysis*. Springfield, USA. pp. 122-128

AOSA (Association of Official Seed Analyst) (1990). Rules or testing seeds.*Journal of Seed Technology*, 12: 1-112.

Banziger, M., G.O. Edmeades, D. Beck and M. Bellon (2000). *Breeding for drought and nitrogen stress tolerance in maize: From theory to practice*.CIMMYT. Mexico.

Borzouei, A., M. Kafi, H. Khazaei, B. Naseriyan and A. Majdabadi (2010). Effects of gamma radiation on germination and physiologicalaspects of wheat (*Triticumaestivum*L.)seedlings.*Pak. J. Bot*., 42: 2281-2290.

Chaudhry, F.M. (1994). Kharif cereal crops. In: *Crop Production*.Nazir, S., E. Bashir and Bantel, B. (Eds.).National Book Foundation. Islamabad. Pakistan.

Ellis, R. H. and E. H. Roberts (1981).The quantification of ageing and survival in orthodox seeds.*Seed Science and Technology*, 9: 377-409.

Fawad, A., A. Muhammad, N. Kanwal, Q. Ali and N. K.Niazi (2015a). Crop improvement through conventional and non-conventional breeding approaches for grain yield and quality traits in. *Life Sci. J.*, 12(4s):38-50.

Fawad, Ali, N. Kanwal, M. Ahsan, Q. Ali, I. Bibi, and N. K. Niazi (2015b).Multivariate Analysis of Grain Yield and Its Attributing Traits in Different Maize HybridsGrown under Heat and Drought Stress.*Scientifica*, vol. 2015, Article ID563869, 6 pages.

Filipovic, M., M. Babic, N. Delic, G. Bekavac and V. Babic (2014). Determination of relevant breeding criteria by the path and factor analysis in maize.*Genetika*, 46: 41-49.

Flavel, R. J., C. N. Guppy, M.Tighe, M. Watt and A. McNeill (2012). Non-destructive quantification of cereal roots in soil using high-resolution X-ray tomography. *Journal of Experimental Botany*: Online present.

Floris, C. P. and M. C. Anguillesi (2003). Response to X-rays of dormant and non-dormant seeds of *Triticum durum* desf.*Mut. Res. Fund. Mol. Mech. Mutag*., 28: 63-67.

Gilissen, L. J. W. (1978). Post-x-irradiation effects on petunia pollen germinating *in vitro* and *in vivo*. *Env. Exp. Bot*., 18:81-86.

Gomez, K.A. and A. A. Gomez (1984). *Statistical procedure for Agricultural Research 2nd edition*. Willey, New York, 680 pp.

Irfaq, M. and K. Nawab (2001). Effect of gamma irradiation on some morphological characteristics of three wheat (*TriticumaestivumL*.) cultivars.*Journal of Bolological Sciences*, 1(1): 935-937.

Johnson, E. L. (1933). The Influence of X-Radiation on Atriplex hortensis L. *New Phytologist*, *32*(4):, 297-307.

Joshi, R. K. and L. Ledoux (1970). Influence of Xirradiation and seed-moisture on nucleic-acid and protein metabolism in barley. *Rad. Bot*., 10: 437-443.

Karahara, I., K. Umemura,Y. Soga, Y. Akai and T. Bando (2012) Demonstration of osmotically dependent promotion of aerenchyma formation at different levels in the primary roots of rice using a 'sandwich'method and X-ray computed tomography. *Annals of Botany,* 110: 503–509.

Maguire, J. D. (1962). Speed of germination-aid in selection and evaluation for seedling emergence and vigor. *Crop Sci*., 2: 176-177.

Maherchandani, N. (1975). Effects of gamma radiation on the dormant seed of Avena fatua L. *Radiation Botany*, *15*(4), 439-443

Moh, C. C. and L. Smith (1951). An Analysis of Seedling Mutants (Spontaneous, Atomic Bomb-Radiation-, and X Ray-Induced) in Barley and Durum Wheat.*Genetics,*36: 629-640.

Novak, F.J. and H. Brunner (1992). Plant Breeding: Induced mutation technology for crop improvement. *International Atomic Energy Agency, Bulletin*.*Nat Sci.*,12 (9): 36- 49.

Rudolph, T. D. (2003). Effects of X-irradiation of seed on X1 and X2 generations in *Pinusbanksiana*Lambert.*Rad. Bot*., 7:303-312.

Saif-ul-malook, M. Ahsan, Qurban Ali, and Aamer Mumtaz (2014). Inheritance of yield related traits in maize (*Zea mays*) under normal and drought conditions. *An overview of Nature and Science*, 14(5): http://www.sciencepub.net/nature

Sanders, D., J. Pelloux, C. Brownlee and J. F. Harper (2002). Calcium at the crossroads of signaling. *The Plant Cell*, 14(suppl 1): S401-S417.

Scandalios, J. G. (1964). Some effects of X-rays on root primordia in the poplar.*Rad. Bot*., 4:355-359.

Sheppard, S. C. and B. B. Chubey (1990). Radiation hormesis of field-seeded broccoli, parsnip and cauliflower.*Can. J. Plant Sci*., 70:369-373.

Spadaro, D. and M. L.Gullino (2005). Improving the efficacy of biocontrol agents against soilborne pathogens.*Crop Prot*., 24: 601-613.

Sze, H., F. Liang, L. Hwang, A. C. Curran and J.E. Harper (2000). Diversity and regulation of plant Ca2+ pumps: insights from expression in yeast. *Annual review of plant biology*, 51(1): 433-462.

Vanish, A. and S. Nagarajan (2010). Effect on germination and early growth characteristics in sunflower (*Helianthus annuus*) seeds exposed to static magnetic field. *Journal of plant physiology,* 167: 149-156.

Yang, W.N., X. C. Xu, L. F. Duan, Q. M. Luo and S. B. Chen (2011). High-throughput measurement of rice tillers using a conveyor equipped with x-ray computed tomography. *Review of Scientific Instruments*, 82: 025102.

Zelles, L. (2003). Effect of X-ray and UV-light onthe levels of NAD(P), NAD(P)H and hydroxyl proline in *Pinussilvestris*pollen. *Environ. Exp. Bot*., 18:39-45.

(*Accepted for publication April 2024*)