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Effect of mutagens on vegetative and floral characters in M_1V_2 generation of tuberose (*Polianthes tuberosa* L.)

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ABSTRACT
The present study was carried out at the Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2014-2016 The bulbs were treated with gamma rays, diethyl sulphate (DES) and ethyl methane sulphonate (EMS). The treatments consisted of 0.5, 1.0, 1.5, 2.0 and 2.5 kR of gamma rays; 15, 20, 25 and 30 mM of DES; 30, 45, 60 and 75 mM of EMS and control (untreated). Various morphological and floral characters were observed. In general, the treated population had manifested reduced expression than the control (untreated population) for most of the morphological and floral characters. Higher the dose of mutagens, lower was the expressivity of the traits. Expression of the morphological characters namely plant height, number of leaves, leaf length, leaf width, leaf thickness and floral characters was higher in the lower doses and lower in the higher doses in M_1V_2 generation.
Keywords: *Gamma rays, EMS, DES, tuberose, Prajwal, morphological variations, M_1V_2 generation*

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INTRODUCTION

Floriculture in India is estimated to cover an area of 2.55 lakh ha with a production of 17,54,000 MT of loose flowers. Nearly 77 % of the area under floricultural crops is concentrated in seven states comprising Tamil Nadu, Karnataka, West Bengal, Maharastra, Haryana, Uttar Pradesh and Delhi. Among different states, Tamil Nadu ranks first in area followed by Karnataka, West Bengal and Maharashtra. In Tamil Nadu, 3,43,650 MT of loose flowers are produced in an area of about 55,000 hectares (Anon., 2015). Tuberose (*Polianthes tuberosa* L.*)* is one of the most important flowers used for both cut and loose flower purpose. It is extensively cultivated in many sub-tropical and tropical parts of the world including India. It is a native of Mexico and belongs to the family Amaryllidaceae. It is a bulbous perennial plant with tuberous roots producing long spikes, bearing waxy white fragrant flowers. It is a crop which flowers profusely throughout the year. Due to longer keeping quality of the flower spikes (Benschop, 1993), they are in great demand for making floral arrangements and bouquets in major cities of India. Three types of tuberose which are used in cultivation are single type with one row of corolla segments, semi-double type with two to three rows of corolla segments and double type with more than three rows of corolla segments.

The spikes as a whole in double types can be used as cut flowers whereas the florets of single varieties are used for making garlands, *veni, gajra*, bangles, etc. and also for essential oil extraction. The flower yields a very valuable floral concrete (0.08 – 0.11 per cent) upon solvent extraction (Singh, 1995). The absolute of tuberose (essential oil) extracted from floral concrete is used in the preparation of various high value perfumes and cosmetics.

Mutation breeding stands for the genetic improvement of crop plants for various economic characters by using physical and chemical mutagens. Mutation is the sudden heritable change which may be caused by spontaneous or through artificial induction and the resultant mutant shows change in the gene or chromosomes (De and Bhattacharjee, 2011).

Induced mutagenesis has been most successful in ornamental crops. Both physical and chemical mutagens have been used for improving the desired characters of many ornamental crops including amaryllis, Lilium, bougainvillea, chrysanthemum, dahlia, gladiolus, hibiscus, Lantana, marigold, rose, tuberose, gerbera, narcissus, *etc.* Induced mutations in ornamentals comprise traits such as altered flower characters (colour, size, morphology, fragrance), leaf characters (form, size, pigmentation), growth habit (compact, climbing, branching) and physiological traits such as changes in photoperiodic response, early flowering, free flowering, improved keeping quality and tolerance to biotic and abiotic stresses. The main advantage of mutation breeding in vegetatively propagated crops is the ability to change one or a few characters of an otherwise outstanding variety without altering the unique part of the genotype (Datta, 2014).

In physical mutagens, atoms are the principle source material. Gamma rays are electromagnetic radiations having shorter wavelength than X rays with more energy and penetrating power. Gamma rays are produced by a number of isotopes e.g. ^{14}C, ^{60}Co, ^{137}Cs etc. (De and Bhattacharjee, 2011).

Mutation can also be induced chemically with alkylating agents such as Diethyl sulphate (DES), Ethyl methane sulphonate (EMS), *etc.* The alkyl group of chemical mutagens reacts with DNA which may change the nucleotide sequence and cause a point mutation (Broertijes and Harten, 1988). EMS alkylates are guanine bases and lead to mispairing-alkylated G pairs with T instead of C, resulting in primarily G/C to A/T transitions (Bhat *et al.,* 2007).

Tuberose being a cross pollinated crop, there is need for high yielding variety with improved fragrance to overcome farmer's predicament. Mutation breeding is the most effective and commonly employed tool to induce acceptable variations in the existing cultivars (Bhattacharjee, 2006). The present study was undertaken to induce desirable variations in tuberose using physical and chemical mutagens.

MATERIALS AND METHODS

The present study was conducted at the Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2015-16 in the tuberose var. Prajwal. The experimental site is geographically situated at an altitude of 426.72 metres above mean sea level (MSL) and between 11°02" North Latitude and 76°57" East Longitude. Bulbs of tuberose var. Prajwal (2-3 cm diameter) were subjected to gamma irradiation and chemical mutagen treatments. Prajwal is a hybrid of tuberose (Shringar x Mexican Single) developed by IIHR, Bangalore. It is a single type with greenish white flower buds bearing dark pink tinge at the tips. It yields 18 t/ha/year. It is ideal as loose flower and cut flower.

One physical mutagen (gamma rays) and two chemical mutagens *viz.,* Diethyl Sulphate (DES) and Ethyl Methane Sulphonate (EMS) were used in the study.

For gamma irradiation, the Gamma chamber - 1200 available at the Centre for Plant Breeding and Genetics of Tamil Nadu Agricultural University, Coimbatore (installed and maintained by the Board of Radiation and Isotope Technology (BRIT), DAE, Mumbai) with Cobalt - ^{60}(Co) emitting 5000 rads per minute at the time of irradiation was used. The formula suggested by Kodym and Afza (2003) was used for the calculation of duration of exposure.

Diethyl Sulphate ($C_2H_2O_2$ SO_2) with a molecular weight of 154.19, boiling point of 208° C (lit.), density of 1.777 g/ml at 25°C(lit.) Prior to use, it was removed from refrigerator and placed in a desiccator with calcium chloride until room temperature was reached.

Ethyl Methane Sulphonate (CH_3 SO_2 OC_2 H_5) procured from M/s. Sigma-Aldrich Company, U.S.A was used. It has a Molecular weight of124.16, boiling point of 80/100 mm Hg and Density of D_4^{25} = 1.203 g/ml). It was stored in dry air at 0^0 C to maintain its purity. Prior to use, it was removed from refrigerator and placed in a desiccator with calcium chloride until it reached room temperature.

The treatments consisted of 0.5, 1.0, 1.5, 2.0 and 2.5 kR of gamma rays; 15, 20, 25 and 30 mM of DES; 30, 45, 60 and 75 mM of EMS and control (untreated).

Cultural practices were followed as per the Crop Production Manual, TNAU, 2013. The recommended fertilizer dose of 200:200:200 kg ha^{-1} of NPK was applied. Half of the RDF was applied as basal and the remaining half was applied in two splits at 30 and 45 days after planting respectively. Foliar spray of micronutrients (H_3BO_3 @ 0.1 % + $ZnSO_4$ @ 0.5 % + $FeSO_4$ @ 0.2 %) was given three times at 60, 120 and 180 days after planting (Ganesh, 2010). The entire population of M_1V_1 generation was forwarded to M_1V_2 generation in the field at 45 x 25 cm spacing and flood irrigation was done in the experimental plots at weekly intervals and plants were evaluated from January 2016 to August 2016. Observations were recorded on growth, yield and quality parameters in M_1V_2 generation. For individual plants, the morphological variations were observed up to 200 days after planting.

RESULTS AND DISCUSSION

Data on the time taken for sprouting of bulbs as influenced by the different physical and chemical mutagens are presented in the Table 1. The treatments varied significantly with respect to days taken for sprouting of bulb. Among the treatments, T_1 (control) recorded the least number of days for sprouting (12.21 days) while T_6 (2.5 kR) took the maximum number of days (20.14). Among the chemical mutagen treatments, the longest time (15.33, 14.99 days) for sprouting was recorded in T_{10} (30 mM DES) and T_{14} (75 mM EMS) respectively, as compared to 12.21 days in control.

A reduction in sprouting percentage was noticed corresponding with increase in the dose of gamma rays in treatments T_5 and T_6 (2.0 and 2.5 kR) respectively. Similar results were observed in DES treatments, T_9 and T_{10} (25 and 30 mM) and EMS treatments, T_{13} and T_{14} (60 and 75 mM). The maximum sprouting percentage for gamma rays, DES and EMS was 88.88, 66.66 and 91.11 % respectively as compared to 100 % in control. The higher doses/concentrations reduced the sprouting percentage correspondingly (Table 1).

Data on the effect of gamma rays on survival of the bulbs observed on the 100^{th} day are presented in Table 1. The maximum survival rates for gamma ray, DES and EMS were 83.33, 62.22 and 88.88 % respectively as compared to 97.77 % in control. The higher doses/concentrations reduced the survival percentage in a consistent manner. These findings are in accordance with those of Sambanthamurthi (1983) and Kanagarasu *et al.* (2014). In this study, it was noticed that in the DES treatments were slightly stimulatory to growth compared to EMS. Similar results were also obtained by Sambathamurthi (1983) in tuberose.

In M_1V_2 generation, both DES T_7 (15 mM)(53.46 cm) and EMS T_{11} (30 mM) (57.89 cm) recorded more plant height than control (Table 2). Similar findings were reported by Datta (1990a) in ornamentals. The reduction in plant height could also be attributed to the inhibition of growth due to low rate of cell division, decreased amylase activity and increased peroxidase activity (Cherry and Lessman, 1967 in maize). Besides this, production of diffusible growth retarding substances (Mackey, 1951 in barley), inhibitory action of enzymes concerned with the initial growth processes (Blinks, 1952), delay in the onset of first meiosis (Natarajan *et al.,* 1982 in red gram), change in the specificity of enzymes (Endo, 1967), inhibition of DNA synthesis (Mickaelson, 1968) and reduction of IAA (Miura *et al.,* 1974) have also been attributed as reasons for the retardation of plant height. Reduced growth due to higher doses was also explained differently by different workers. It may be attributed to one or more of the following reasons (i) the increase in growth promoters, (ii) the sudden increase in metabolic status of seeds at certain level of mutagen dose (iii) the increase in destruction of growth inhibitors (iv) drop in the auxin synthesis and (v) decline of assimilation mechanism as reported by Roychowdhury and Tah (2011) in carnation.

The leaf length and width in M_1V_2 generation exhibited negative and positive shifts of mean respectively in both the mutagenic treatments. However, the means recorded significant differences between the treatments. In M_1V_2 generation, maximum leaf length (54 cm in [T_{11}] 30 mM EMS) and leaf width (2.87 cm in [T_7] 15 mM DES) were observed (Table 2). Brock (1965, 1967) in clover and *Arabidopsis thaliana* proposed that in random mutations of characters with definite selection history, each character had varying levels of response for a common mutagen and its doses. The shift in mean values was also found to vary between characters in response to different mutagens (Kawai, 1969). Similar results were obtained by Patil (2014) in gladiolus.

In this study, early spike emergence opening was observed. On the other hand, the duration of flowering had been extended in chemical mutagens compared to control. T_8 (20 mM DES) was observed to have taken only 76.67 days for spike emergence with 21.83 days flowering duration in M_1V_2 generation (Table 3). The higher doses might have affected the physiological process leading to early flowering. As a result, flower bud development must have been delayed and flowering phase within the crop duration was reduced. But the lower doses of mutagens might have caused a stimulatory effect on physiological process of flowering thus inducing early flowering. This is in line with the findings of Kalaivani (1991) and Balakrishnan (1997) in chrysanthemum, (Singh and Saha 2009) in marigold, Mostafa *et al.* (2014) in *Celosia argentea*, Patil (2014) in gladiouls and Singh *et al.* (2015) in tuberose.

In the present study, both physical and chemical mutagens produced more spike length than control. Maximum spike length was observed in T_9 (25 mM DES) (109.80 cm) compared to control (96.37 cm) in M_1V_2 generation. Rachis length was observed maximum in T_7 (15 mM DES) (34.00 cm against 25.50 cm in control) (Table 3). Similar results were obtained by Patil (2014) in gladiolus and Sisodia and Singh (2014) in Gladiolus.

The maximum floret length (6.16 cm) was noticed in T_9 (25 mM DES) which was higher than in T_1 control (5.22 cm). Likewise, floret diameter was maximum (4.36 cm) in T_2 (0.5 kR of gamma ray) whereas it was 3.99 cm in control T_1 () (Table 3). Similarly, large sized flowers were recorded in *Cosmos bipinnatus* by

Bose and Mukherjee (1969) with colchicine treatment and Tonakanjan (1968) in candytuft with X-ray treatments. Nikolova and Vasileva (1979) also recorded larger flowers in *Zinnia elegans* with gamma radiation and Singh *et al.* (2015) in tuberose.

In the present study higher number of spikes was produced in T_9 (25 mM DES) (4.67) whereas minimum was recorded in T_{14} (75 mM EMS (1.00) compared to control T_1 (3.00) (Table 4). But the number of florets per spike was more in chemical mutagen treated plants than gamma ray treated ones and control. Number of flowers present in a spike determines the total yield per plant.

In M_1V_2 generation, higher number of florets per spike was observed in T_7 (15 mM of DES) (44.33) whereas minimum was in T_6 (2.5 kR) of gamma rays (23.33) compared to control T_1 (39.17) (Table 4). Tonakanjan (1968) reported increased number of flowers in candytuft at 125-1000 rad of X-ray treatments. This may be related to the inhibitory effect of ionizing radiations and alkalizing effect of chemical mutagens. Brock (1964) postulated that mutagenic treatments induce differential changes in the polygenic system. Irulappan (1979) and Balakrishnan (1997) also registered such a shift in the mean values towards negative direction. Nikolova and Vasileva (1979) reported increased number of flowers in *Zinnia elegans* with gamma ray treatment and Singh *et al.* (2015) also made similar observations in tuberose.

In this study, the highest number of florets per plant (180.00) was observed in T_9 (25 mM DES) whereas minimum (40.00) was in T_{14} (75 mM EMS) compared to control T_1 (140.32)in M_1V_2 generation. The maximum weight of single floret (1.61 g) was noticed in T_8 (20 mM DES) while minimum (1.06 g) was in T_6 (2.5 kR) as compared to the control T_1 (1.15 g) (Table 5). These results are in accordance with those of Echim and Draganescu (1982) in *Freesisa hybrida* obtained by treating seeds with gamma rays. Similarly, Nikolova and Vasileva (1979) obtained increased number of ligulate flowers of *Zinnia elegans* with gamma irradiation. Patil (2014) in gladiolus and Dhivya, 2015 in crossandra also reported similar observations.

CONCLUSION

As chimerism and genetic variability play a key role in mutation treated plant populations, there is a need to identify solid mutants in the next generation for which it is suggested to forward all the M_1V_2 plants to M_1V_3 generation.

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REFERENCES

1. Anonymous, 2015. Present status and prospects of floriculture in Tamil Nadu. DFR technical Bulletin No. 20.
2. ICAR – Directorate of Floricultural Research, Pune, Maharashtra, India.
3. Balakrishnan, S. 1997. Studies on induced mutations in chrysanthemum (*Dendranthema grandiflora* Tzueleu). **Ph.D. Thesis** submitted to Tamil Nadu Agricultural University, Coimbatore.
4. Benschop, M. 1993. Polianthes, In: De Hertogh A., Le Nard M., (Eds.). The physiology of flower bulbs, Elsevier**,** Amsterdam, The Netherlands, pp. 589- 601.
5. Bhat, R., N. Upadhaya, A. Chaudhury, A. Raghavan, C. Qiu, F.Wang, H.Wu, J. Mcnally, K. Leiung and B. Till. 2007. Chemical and irradiation induced mutants and tilling. Rice functional genomics**,** p 148-180.
6. Bhattacharjee, S. K. 2006. Development and Research on Ornamental Horticulture. In: Advances in Ornamental Horticulture, 1. Pointer Publishers, Jaipur. pp.1-33.
7. Blinks, L. R. 1952. **J. Cell. Com. Physiol., 39:** 11.
8. Bose, S. and R. Mukherjee.1969. Effect of colchicine on *Cosmos bipinnatus*. **Indian J. Hort., 26:** 80-82.
9. Brock, R. D. 1965. Induced mutations affecting quantitative characters. The use of induced mutations in plant breeding. In: **Rep. FAO / IAEA Tech. Meeting**, Pergamon Press, Oxford. pp. 443-450.
10. Brock, R. D. 1967. Quantitative variation in *Arabidopsis thaliana* induced by ionizing radiation. **Radiat. Bot., 10:** 209-233.
11. Broertijes, C. and A.M.V.Harten. 1988. Applied mutation breeding. Elsevier science publishing**. Co.** New York, p. 246-249.
12. Cherry, J. H. and K. J. Lessman. 1967. Comparison on nucleic acids in maize shoot and pea epicotyls. **Am. J. Bot., 54:** 181-188.
13. Datta, S. K. 1990a. Some basic information for induction of somatic mutation in vegetatively propagated ornamentals. **Adv. Hort. For., 1:**261-265.
14. Datta, S.K. 2014. Induced mutagenesis: basic knowledge for technological success. National Botanical Research Institute (NBRI-CSIR), Lucknow, Uttar Pradesh, India. 97-139.
15. De, L.C. and S.K. Bhattacharjee. 2011. Ornamental crop breeding. *Aavishkar Publishers, Distributors, Jaipur, India.* pp. 40-41.

16. Dhivya, M. 2015. Studies on induced mutagenesis in crossandra (*Crossandra infundibuliformis* (L.) Nees). **Ph.D. thesis** submitted to Tamil Nadu Agricultural University, Coimbatore.
17. Echim, T. and I. Draganescu. 1982. Effect of low radiation doses on the growth and development of freesia (*Freesia hybrida*) from seed. **Vidva, 6:** 305-315.
18. Endo, T. 1967. Comparison of the effect of gamma rays and maleic hydrazide on enzyme system of maize seeds. **Radiat. Bot., 7:** 35-40.
19. Ganesh, S. 2010. Influence of growth regulators and micronutrients on growth, yield and quality of tuberose (*Polianthes tuberosa* L.) cv. Prajwal. **M.Sc. (Hort.) Thesis.**
20. Irulappan, I. 1979. Studies on induced mutation in Edward rose (*Rosa bourboniana* Desp.) **Ph.D. Thesis** submitted to Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.
21. Kalaivani, T. 1991. Studies on induced mutagenesis in chrysanthemum. **M.Sc., (Hort.) Thesis** submitted to Tamil Nadu Agricultural University, Coimbatore.
22. Kanagarasu,S. S. Ganeshram and A.John Joel. 2014. Determination of lethal dose for gamma rays and ethyl methane sulphonate induced mutagenesis in cassava (*Manihat esculanta* Crantz.). International Journal of Scientific Research, 3: 3-6.
23. Kawai, T. 1969. Relative effectiveness of physical and chemical mutagens. In: **Induced mutations in Plants. Proc. Symp. FAO / IAEA**, Vienna. pp. 137-151.
24. Kodym, A. and R. Afza. 2003. Physical and chemical mutagenesis. Methods in molecular chrysanthemum biology, 236: 189-204.
25. Mikaelson, K. 1968. Effects of fast neutrons on seedling growth and metabolism in barley. In: Neutron irradiation of seeds. II. Tech. rep. series no 92. IAEA. Vienna. 63:70.
26. Miura, K., T. Hashimota and H. Yamaguchi. 1974. Effect of gamma ray irradiation on cell elongation and auxin level in *Avena Coleoptiles*. **Radiat. Bot.,** 14: 207-215.
27. Mostafa, G. G., A. M. Alfrmawy and H. E. E. Mokadem. 2014. Induction of mutations in *Celosia argentea* using dimethyl sulphate and identification of genetic variation by ISSR markers. **Int. J. Plant Breed. Genet., 8(2):**44-56.
28. Natarajan, N. S., R. S. Ramalingam and N. Sivasamy. 1982. Mutagenic effectiveness and efficiency in *Cajans cajan* (L.) Mill sp. **Madras Agric. J. 69:** 71-75.
29. Nikolova, N. and R.Vasileva. 1979. Effect of gamma rays on growth characteristics and flower quality of *Zinnia elegans*. **Orn. Hort. Abstr., 7(1):** 7926.
30. Patil, S. D. 2014. Induction of mutation in commercial varieties of gladiolus using physical mutagen CO^{60} gamma rays. **Int. J.Adv.Res. Biol. Sci., 1(6):**15-20.
31. Patil, S. D. 2014. Induction of mutation in commercial varieties of gladiolus using physical mutagen CO^{60} gamma rays. **Int. J.Adv.Res. Biol. Sci., 1(6):**15-20.
32. Roychowdhary, R. and J. Tah. 2011. Genetic variability study for yield and associated quantitative characters in mutant genotypes of *Dianthus carophyllus* L. **Int. J. Biosci., 1(5):** 2222-5234.
33. Sambandhamurthi, S. 1983. Studies on induced mutations in tuberose (*Polianthes tuberosa* L.). **Ph.D. Thesis** submitted to Tamil Nadu Agricultural University, Coimbatore.
34. Singh, K. P and T. N. Saha. 2009. Character association and path analysis studies in French marigold. **Annals of Hort., 2(1):** 39-42.
35. Singh, K. P. 1995. Improved production technologies for tuberose (*Polianthes tuberosa* L.). A review of research done in India. **Agric. Rev., 16(3):** 141-166.
36. Singh, P. K., R. Sadhukhan, A. S. Dudhane, V. Kumar and H. S. Sarkar. 2015. Preliminary study on mutagenic effects on EMS on Tuberose (*Polianthes tuberosa* L.). **Environ. Ecol., 33(A):**1386-1390.
37. Sisodia, A. and A.K. Singh. 2014. Influence gamma irradiation on morphological changes, post harvest life and mutagenesis in gladiolus. International Journal of Agriculture, Environment & Biotechnology. 7(3): 535-545.Tamil Nadu Agricultural University, Coimbatore.
38. Tonakanjan, G. A. 1968. The effect of X-ray irradiation of flower crops. **Vezaperelanse Univ., 1 (105):** 110-113. **Hort. Abstr., 39(1):** 1111.

Table 1. Effect of physical and chemical mutagens on days taken for sprouting, Sprouting % and Survival % in M_1V_2 generation (100 days)

Treatments	Days taken for sprouting of bulb (days)	Per cent over control	Sprouting percentage (%)	Per cent over control	Survival percentage (%)	Per cent over control
T_1 – Control	12.21	100.00	100.00	100.00	97.77	100.00
Gamma rays						
T_2- 0.5 kR	17.23	141.11	88.88	88.88	83.33	85.23
T_3 - 1.0 kR	18.21	149.14	77.77	77.77	74.44	76.14
T_4 - 1.5 kR	19.98	163.64	66.66	66.66	61.10	62.49
T_5 - 2.0 kR	20.00	163.80	50.00	50.00	44.44	45.45
T_6 - 2.50 kR	20.14	164.95	33.00	33.00	30.00	30.68
Mean	19.11	-	63.26	-	30.00	-
DES (Diethyl Sulphate)						

T_7 - 15 mM	13.72	112.37	66.66	66.66	62.22	63.64
T_8 - 20 mM	14.11	115.56	61.11	61.11	55.50	56.77
T_9 - 25 mM	14.98	122.69	50.00	50.00	45.55	46.59
T_{10} - 30 mM	15.33	125.55	31.11	31.11	27.77	28.40
Mean	14.54	-	52.22	-	47.76	-
EMS (Ethyl Methane Sulphonate)						
T_{11} - 30 mM	13.56	111.06	91.11	91.11	88.88	90.91
T_{12} - 45 mM	13.85	113.43	83.33	83.33	78.88	80.68
T_{13} - 60 mM	14.32	117.28	50.00	50.00	47.77	48.86
T_{14} - 75 mM	14.99	122.77	33.33	33.33	31.11	31.82
Mean	14.18	-	64.44	-	61.66	-
Grand mean	15.90	-	63.07	-	59.20	-
SE(D)	0.27	-	1.13	-	1.07	-
CD (0.5)	0.56**	-	2.32**	-	2.19**	-

Table 2. Effect of physical and chemical mutagens on plant height, number of leaves, leaf length and leaf width in M_1V_2 generation (200 days)

Treatments	Plant height (cm)	Per cent over control	Number of leaves (nos.)	Per cent over control	Leaf length (cm)	Per cent over control	Leaf width (cm)	Per cent over control
T_1 - Control	48.55	100.00	59.33	100.00	41.00	100.00	1.98	100.00
Gamma rays								
T_2- 0.5 kR	44.12	90.88	47.60	80.23	38.20	93.17	2.02	90.58
T_3 - 1.0 kR	43.42	89.43	83.00	139.90	35.72	87.12	2.14	95.96
T_4 - 1.5 kR	47.17	97.16	67.00	112.93	42.67	104.07	2.17	97.31
T_5 - 2.0 kR	43.98	90.59	49.33	83.15	36.50	89.02	2.33	104.48
T_6 - 2.50 kR	49.67	102.31	68.33	115.17	44.33	108.12	2.53	113.45
Mean	45.67	-	63.05	-	39.48	-	2.24	-
DES (Diethyl Sulphate)								
T_7 - 15 mM	53.46	110.11	44.33	74.72	45.33	110.56	2.87	128.70
T_8 - 20 mM	51.34	105.75	61.00	102.81	44.67	108.95	2.53	113.45
T_9 - 25 mM	46.32	95.41	51.67	87.09	40.67	99.20	2.13	95.52
T_{10} - 30 mM	47.84	98.54	49.20	82.93	41.40	100.98	1.90	85.20
Mean	49.74	-	51.55	-	43.02	-	2.36	-
EMS (Ethyl Methane Sulphonate)								
T_{11} - 30 mM	57.89	119.24	43.33	73.03	54.00	131.71	2.33	104.48
T_{12} - 45 mM	53.20	109.58	77.00	129.78	48.67	118.71	2.22	99.55
T_{13} - 60 mM	48.23	99.34	108.50	182.88	41.50	101.22	2.50	112.11
T_{14} - 75 mM	46.94	96.68	69.50	117.14	39.17	95.54	2.40	107.62
Mean	51.57	-	74.58	-	45.84	-	2.36	-
Grand mean	48.60	-	62.11	-	42.27	-	2.31	-
SE(D)	1.68	-	1.06	-	0.71	-	0.04	-
CD (0.5)	3.44**	-	2.18**	-	1.46**	-	0.08**	-

Table 3. Effect of physical and chemical mutagens on days to spike emergence, floret length, floret diameter, spike length and rachis length in M_1V_2 generation (200 DAP)

Treatments	Days to spike emergence (days)	Per cent over control	Floret length (cm)	Per cent over control	Floret diameter (cm)	Per cent over control	Spike length (cm)	Per cent over control	Rachis length (cm)	Per cent over control
T_1 - Control	85.00	100.00	5.22	100.00	3.99	100.00	96.37	100.00	25.50	100.00
Gamma rays										
T_2- 0.5 kR	86.00	101.18	5.41	103.64	4.36	109.27	103.77	107.68	26.00	101.96
T_3 - 1.0 kR	87.33	102.74	5.67	108.62	4.23	106.02	102.34	106.19	34.67	135.96
T_4 - 1.5 kR	95.00	111.76	5.33	102.11	4.18	104.76	94.34	97.89	25.67	100.67
T_5 - 2.0 kR	95.67	112.55	5.31	101.72	3.79	94.99	85.34	88.55	20.00	78.43
T_6 - 2.50 kR	97.33	114.51	5.23	100.19	3.76	94.24	86.50	89.76	19.33	75.80
Mean	92.27	-	5.39	-	4.06	-	94.46	-	25.13	-
DES (Diethyl Sulphate)										
T_7 - 15 mM	78.67	92.55	4.63	88.70	4.09	102.51	105.73	109.71	34.00	133.33
T_8 - 20 mM	76.67	90.20	5.87	112.45	4.30	107.77	103.10	106.98	27.33	107.18
T_9 - 25 mM	88.33	103.92	6.16	118.01	4.17	104.51	109.80	113.94	24.80	97.25
T_{10} - 30 mM	95.40	112.24	5.32	101.92	3.86	96.74	99.49	103.24	22.17	86.94
Mean	84.77	-	5.50	-	4.11	-	104.53	-	27.08	-
EMS (Ethyl Methane Sulphonate)										
T_{11} - 30 mM	82.50	97.06	5.50	105.36	4.06	101.75	93.33	96.85	27.50	107.84
T_{12} - 45 mM	87.50	102.94	5.44	104.21	4.06	101.75	103.20	107.09	27.00	105.88
T_{13} - 60 mM	86.00	101.18	5.07	97.13	4.01	100.50	104.57	108.51	27.07	105.81
T_{14} - 75 mM	85.67	100.79	5.09	97.51	4.12	103.26	107.80	111.86	22.00	86.27
Mean	85.42	-	5.28	-	4.06	-	102.23	-	25.88	-
Grand mean	87.76	-	5.38	-	4.07	-	99.69	-	25.95	-
SE(D)	1.48	-	0.09	-	0.07	-	1.67	-	0.44	-
CD (0.5)	3.03**	-	0.19**	-	0.14**	-	3.44**	-	0.91**	-

Table 4. Effect of physical and chemical mutagens on flowering duration, number of florets / spike, number of spikes / plant and number of florets per plant in M_1V_2 generation (200 DAP)

Treatments	Flowering duration (days)	Per cent over control	No. of florets / spike (nos.)	Per cent over control	Number of spikes / plant (nos.)	Per cent over control	Number of florets per plant (nos.)	Per cent over control
T_1 - Control	16.38	100.00	39.17	100.00	3.00	100.00	115.00	100.00
Gamma rays								
T_2- 0.5 kR	16.60	101.34	36.60	93.44	3.33	111.11	120.00	104.35
T_3 - 1.0 kR	17.00	103.79	31.25	79.78	3.00	100.00	70.00	60.87
T_4 - 1.5 kR	17.67	107.88	28.33	72.33	3.00	100.00	99.00	86.09
T_5 - 2.0 kR	17.00	103.79	24.67	62.98	2.00	66.67	51.00	44.35
T_6 - 2.50 kR	12.67	77.35	23.33	59.56	1.67	55.56	49.00	42.61
Mean	16.19	-	28.84	-	2.60	-	77.80	-
DES (Diethyl Sulphate)								
T_7 - 15 mM	20.00	122.10	44.33	113.17	3.67	122.22	158.00	137.39
T_8 - 20 mM	21.83	133.27	39.33	100.41	3.33	111.11	109.30	95.04
T_9 - 25 mM	17.00	103.79	37.20	94.97	4.67	155.56	180.00	156.52
T_{10} - 30 mM	16.40	100.12	32.67	83.41	3.30	111.11	123.20	107.13
Mean	18.81	-	38.38	-	3.75	-	142.63	-
EMS (Ethyl Methane Sulphonate)								
T_{11} - 30 mM	17.33	105.80	42.00	107.22	2.67	88.89	101.30	88.09
T_{12} - 45 mM	17.50	106.84	40.00	102.12	2.00	66.67	79.00	68.70
T_{13} - 60 mM	15.50	94.63	39.67	101.28	1.67	55.56	70.00	60.87

T_{14} - 75 mM	16.50	100.73	39.00	99.57	1.00	33.33	40.00	34.78
Mean	16.71	-	40.17	-	1.83	-	72.58	-
Grand mean	17.15	-	35.30	-	2.74	-	97.49	-
SE(D)	0.29	-	0.61	-	0.05	-	1.78	-
CD (0.5)	0.59**	-	1.25**	-	0.10**	-	3.66**	-

Table 5. Effect of physical and chemical mutagens on number of spikes / plant, number of florets per plant, Weight of single floret and Weight of florets per plant in M_1V_2 generation (200 DAP)

Treatments	Number of spikes / plant (nos.)	Per cent over control	Number of florets per plant (nos.)	Per cent over control	Weight of single floret (g)	Per cent over control	Weight of florets per plant (g)	Per cent over control
T_1 - Control	3.00	100.00	115.00	100.00	1.15	100.00	134.23	100.00
Gamma rays								
T_2- 0.5 kR	3.33	111.11	120.00	104.35	1.17	101.74	140.32	104.54
T_3 - 1.0 kR	3.00	100.00	70.00	60.87	1.36	118.26	135.57	101.00
T_4 - 1.5 kR	3.00	100.00	99.00	86.09	1.21	105.22	60.25	44.89
T_5 - 2.0 kR	2.00	66.67	51.00	44.35	1.16	100.87	82.10	61.16
T_6 - 2.50 kR	1.67	55.56	49.00	42.61	1.06	92.17	55.20	41.12
Mean	2.60	-	77.80	-	1.19	-	94.69	-
DES (Diethyl Sulphate)								
T_7 - 15 mM	3.67	122.22	158.00	137.39	1.34	116.52	211.77	157.77
T_8 - 20 mM	3.33	111.11	109.30	95.04	1.61	139.13	176.21	131.27
T_9 - 25 mM	4.67	155.56	180.00	156.52	1.16	100.87	210.21	156.60
T_{10} - 30 mM	3.30	111.11	123.20	107.13	1.18	102.61	145.60	108.47
Mean	3.75	-	142.63	-	1.32	-	185.95	-
EMS (Ethyl Methane Sulphonate)								
T_{11} - 30 mM	2.67	88.89	101.30	88.09	1.34	116.52	129.70	96.63
T_{12} - 45 mM	2.00	66.67	79.00	68.70	1.60	139.13	99.79	74.34
T_{13} - 60 mM	1.67	55.56	70.00	60.87	1.16	100.87	95.32	71.01
T_{14} - 75 mM	1.00	33.33	40.00	34.78	1.18	102.61	46.00	34.27
Mean	1.83	-	72.58	-	1.32	-	92.70	-
Grand mean	2.74	-	97.49	-	1.34	-	125.18	-
SE(D)	0.05	-	1.78	-	1.60	-	2.26	-
CD (0.5)	0.10**	-	3.66**	-	1.16**	-	4.64**	-

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