PLANT SCIENCE TODAY
Vol x(x): xx–xx
https://doi.org/10.14719/pst.7606

eISSN 2348-1900

RESEARCH ARTICLE

Impact of physical and chemical mutagenesis on growth and flowering parameters in tuberose variety Arka Prajwal

Malepati S N V S Sripriya Bhargavi[1], R Chitra[1*], M Ganga[1], R Kalaiyarasi[2], N Manikanda Boopathi[3], D Uma[4], S P Mirunalini[1] & M Arun Kumar[1]

[1]Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural College, Coimbatore 641 003, Tamil Nadu, India

[2]Department of Genetics and Plant Breeding, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

[3]Department of Plant Biotechnology, Centre for Plant Molecular Biology and Biotechnology, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

[4]Department of Biochemistry, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

*Correspondence email - chitra.varadharaj@gmail.com

Received: 05 February 2025; Accepted: 25 April 2025; Available online: Version 1.0: 14 July 2025

Cite this article: Malepati SNVSSB, Chitra R, Ganga M, Kalaiyarasi R, Manikanda BN, Uma D, Mirunalini SP, Arun KM. Impact of physical and chemical mutagenesis on growth and flowering parameters in tuberose variety Arka Prajwal. Plant Science Today (Early Access). https:/doi.org/10.14719/pst.7606

Abstract

The present study evaluated the effects of physical (gamma radiation) and chemical (ethyl methane sulphonate, EMS) mutagens on the growth and flowering parameters of Arka Prajwal in the M_1V_1 generation. Uniform-sized bulbs were subjected to gamma radiation (1.5 kR, 2.0 kR and 2.5 kR) and EMS treatments (0.3%, 0.4% and 0.5%) to induce variability. Growth parameters, including sprouting time, plant height, number of leaves, leaf dimensions and plant spread, exhibited significant variation across treatments. Gamma radiation delayed bulb sprouting (21.27-25.83 days) compared to control (12.53 days), while EMS treatments showed intermediate sprouting times (14.75-20.13 days). Plant height and leaf dimensions were highest in 0.4% EMS-treated plants, with notable increases in leaf width and plant spread. Flowering parameters demonstrated that EMS treatments accelerated spike emergence and floret opening compared to gamma irradiation. EMS-treated plants (0.3%) showed the earliest flowering, with reduced days to spike emergence (73.47 days) and first floret opening (90.38 days). Spike length and rachis length were slightly reduced in gamma-treated plants, while EMS-treated plants maintained longer spikes and rachis. The number of florets per spike was highest under EMS treatment (44.93 florets for 0.3%), accompanied by improved floret dimensions and weight. The study highlights that EMS enhanced growth and flowering performance in Arka Prajwal, while higher doses of gamma radiation adversely affected these parameters. This research provides insights into the potential of mutagenesis for improving floricultural traits in tuberose.

Keywords: flowering parameters; growth parameters; M_1V_1; tuberose

Introduction

Tuberose (*Agave amica* (Medik.) Thiede & Govaerts), previously known as *Polianthes tuberosa*, is a significant ornamental geophyte recognised for its aesthetic appeal and distinctive fragrance. Native to Mexico and a member of the Asteraceae family, it is extensively cultivated in India across states such as West Bengal, Karnataka, Tamil Nadu, Maharashtra and Andhra Pradesh, where it is vernacularly referred to as Rajanigandha, Nishigandha, Sambangi, Sugandharaja and Gulcheri (1). Its wide adaptability, low cultivation input requirements and economic profitability, coupled with its year-round flowering potential, have made it a commercially valuable crop.

As of 2023-24, tuberose cultivation in India spans 20920 hectares, yielding 101760 metric tonnes of loose flowers, an increase of 11.31% from the previous year. Cut flower production was reported at 101180 metric tonnes. West Bengal ranks highest in cut flower production (89170 metric tonnes), whereas Tamil Nadu leads in loose flower production with 101760 metric tonnes cultivated over 70200 hectares.

The genetic variability in tuberose remains limited, with commercial cultivation primarily focusing on the species *Agave amica*. Breeding efforts are hindered by its self-incompatibility and dichogamous nature (2), necessitating the adoption of advanced breeding techniques, including hybridisation, molecular breeding and mutation breeding. Mutation breeding, utilising physical or chemical mutagens, offers an efficient and cost-effective approach for inducing genetic variation, particularly in vegetatively propagated crops like tuberose. India's prominence in this field is evident as it ranks third globally in the release of mutant varieties, as per the International Atomic Energy Agency's Mutant Varieties Database.

Mutation breeding accelerates the development of desirable traits by enhancing the mutation rate, enabling the creation of superior cultivars within shorter timeframes. Advances in ornamental crop improvement through this technique include the development of compact growth habits, novel variegated foliage and innovations in flower morphology, colour and yield potential (3). Hence, the present research was taken with the objective of evaluating the M_1V_1 generation of Arka Prajwal to identify putative mutants.

Materials and Methods

The present study was carried out in Tamil Nadu Agricultural University, Coimbatore, India. The tuberose types selected for the study were Arka Prajwal, which is a leading commercial variety that was grown and Nilakottai Local, which is an important variety that is popular in the districts of Dindugul. The LD50 of Arka Prajwal was analysed to be 2.0 kR for gamma irradiation and 0.4% for EMS treatments and for Nilakottai Local, the LD50 was seen to be 2.0 kR for gamma irradiation and 0.3% for EMS treatments. The selected treatments, based on LD50 assessment, were advanced to the M1V1 generation to screen putative mutants. 300 bulbs for each treatment were mass irradiated at the NRC of Banana and sown in M1V1 generation. The treatment details are given in Table 1.

The field preparation involved levelling and raising beds measuring 1 m in width and 40 m in length. *Trichoderma viride* (100 g) was incorporated into each bed and incubated for two days, followed by the application of 100 kg vermicompost, which was thoroughly mixed into the soil. Black polyethylene mulch sheets (50-micron thickness) with perforations were laid over the beds. Treated bulbs were planted in a double-row pattern with 45 cm spacing between rows and 30 cm between plants (Fig. 1). The field was equipped with a drip irrigation system to maintain optimal moisture levels and planting was completed in June 2023.

Growth parameters

Days to bulb sprouting

The sprouting process was observed until all bulbs in each treatment had sprouted. The time taken for complete sprouting was recorded in days.

Plant height

Plant height was measured from the ground level to the tip of the leaf at the spike emergence stage. The average height was calculated and expressed in centimeters.

Number of leaves per plant

The total number of leaves on each plant was counted and the mean number was determined.

Leaf length

Leaf length was measured from the base to the tip of the leaf and the average length was expressed in centimeters.

Leaf width

The width of leaves was measured and the average value was recorded in centimeters.

Flowering parameters

Days to spike emergence

The time taken for spike emergence was recorded from the date of bulb planting and the number of days was documented for each plant.

Days to first floret opening

The days required for the first floret to open in a spike were recorded from the date of bulb planting.

Spike length

Spike length was measured from its base to the tip and the average length was expressed in centimeters.

Rachis length

Rachis length was determined by measuring the distance from the base of the basal floret to the tip of the spike. The mean value was recorded in centimeters.

Floret characteristics

Number of florets per spike

The total number of florets on each spike was counted and the mean number was calculated.

Floret length and diameter

The length of fully developed florets was measured from the base to the tip and the mean values were calculated. The diameter of florets at full bloom was also measured and the average diameter was determined.

Table 1. Treatment details

Arka Prajwal	Nilakottai local
Physical mutagens (Gamma rays)	
1.5 kR	1.5 kR
2.0 kR	2.0 kR
2.5 kR	2.5 kR
Control	Control
Chemical mutagens (EMS)	
0.4%	0.3%
0.5%	0.4%
0.6%	0.5%
Control	Control

Fig. 1. Field view of M1V1 generation

Floret weight
The weight of individual florets was recorded and the average weight was expressed in grams.

Weight of florets per spike
The total weight of all florets on a spike was measured and the mean weight was calculated and expressed in grams.

Weight of 100 florets
The weight of 100 randomly selected, fully developed florets was measured and the average weight was expressed in grams.

Weight of florets per plant
Fully developed but unopened florets were harvested to determine the weight of florets per plant, which was expressed in grams.

Number of spikes per plant
The total number of spikes produced during the observation period was counted for each plant and the average value was determined.

Number of florets per plant
The total number of florets produced by each plant was recorded and the mean value was computed.

Floret yield per plot
The floret yield per plant was used to calculate the yield for the entire plot area, with the results expressed in kilograms per plot.

Statistical analysis

The data was collected and analysed statistically by using Randomised Block Design (RBD) with seven treatments with three replications at a 5% probability level (4).

Results and Discussion

The present study assessed the influence of gamma radiation and ethyl methane sulphonate (EMS) treatments on key growth parameters, including days to sprouting, plant height, number of leaves, leaf length, leaf width and plant spread as presented in Table 2.

Days to sprouting

The number of days taken for sprouting was significantly affected by the treatments. Control plants exhibited the shortest sprouting time (12.53 days), indicating that untreated plants were free from stress-induced delays. In contrast, gamma radiation treatments delayed sprouting progressively with increasing doses. The highest dose of gamma rays (2.5 kR) caused the maximum delay, requiring 25.83 days for sprouting. This trend suggests that higher doses of gamma rays impair physiological and metabolic processes, possibly due to DNA damage or oxidative stress. EMS treatments also delayed sprouting, but to a lesser extent compared to gamma rays. Among EMS concentrations, 0.4% EMS induced sprouting in 14.75 days, while 0.6% EMS caused a more pronounced delay (20.13 days). Similar results were observed on tuberose (5).

Plant height

Plant height varied significantly across treatments. Control plants reached a mean height of 52.36 cm, while gamma-ray-treated plants showed a reduction in height with increasing radiation doses. The shortest plants were observed at 2.5 kR (44.87 cm), reflecting the inhibitory effects of higher gamma radiation on cell division and elongation. EMS treatments, however, demonstrated a contrasting pattern. Plants treated with 0.4% EMS were the tallest (54.28 cm), exceeding even the control. This result suggests that lower EMS concentrations might stimulate growth, possibly due to enhanced gene expression or stress-induced metabolic activation, expressing the hormesis phenomenon. Higher EMS concentrations (0.6%) resulted in shorter plants (47.56 cm), indicating growth inhibition at elevated mutagen levels. The results are in accordance with earlier findings (6).

Number of leaves

The number of leaves also exhibited significant variation among treatments. Control plants had 75.03 leaves on average, whereas gamma-ray treatments reduced leaf numbers, with the lowest count observed at 2.5 kR (61.38 leaves). This reduction might result from radiation-induced damage to meristematic tissues. EMS treatments, on the other hand, led to an increase in the number of leaves, with 0.4% EMS producing the highest count (78.15 leaves). This suggests that lower EMS concentrations may enhance leaf proliferation, possibly due to stress-induced hormonal changes. Similar results were observed in earlier findings (7).

Leaf length and width

Both leaf length and width were significantly affected by the treatments. Control plants exhibited a leaf length of 41.26 cm and a width of 1.65 cm. Gamma-ray treatments reduced leaf size, with the most pronounced effect at 2.5 kR (32.24 cm

Table 2. Effect of physical and chemical mutagens on growth parameters in M_1V_1 generation of Arka Prajwal

Treatment	Days taken to sprout	Plant height (cm)	No. of leaves	Leaf length (cm)	Leaf width (cm)	Plant spread (E-W)	Plant spread (N-S)
Control	12.53	52.36	75.03	41.26	1.65	27.79	29.05
			Gamma rays				
1.5Kr	21.27	49.48	70.23	38.21	1.86	25.62	25.65
2.0Kr	22.54	47.15	65.15	35.45	1.59	24.94	24.39
2.5Kr	25.83	44.87	61.38	32.24	1.31	22.68	23.16
Mean	23.21	47.16	65.59	35.30	1.59	24.41	24.40
			Ethyl Methane Sulphonate				
0.4%	14.75	54.28	78.15	43.32	1.98	30.57	27.53
0.5%	16.21	51.95	71.64	37.26	2.06	27.64	26.19
0.6%	20.13	47.56	66.48	35.69	1.52	24.56	24.61
Mean	17.03	51.26	72.09	38.75	1.85	27.59	26.11
Grand Mean	**19.03**	**50.26**	**69.72**	**38.43**	**1.71**	**26.26**	**25.79**
C.D	**1.02**	**2.67**	**3.16**	**2.11**	**0.08**	**2.42**	**1.95**
SE(d)	**0.50**	**1.31**	**1.54**	**0.97**	**0.04**	**1.20**	**0.97**

length and 1.31 cm width). These reductions reflect the inhibitory effects of gamma radiation on cellular expansion and development. EMS treatments, particularly 0.4%, resulted in the longest (43.32 cm) and widest (1.98 cm) leaves, highlighting the potential of lower EMS concentrations to enhance leaf growth. Higher EMS concentrations (0.6%) reduced leaf size, aligning with the inhibitory effects observed at higher mutagen levels.

Plant spread

Plant spread, measured in both east-west and north-south directions, showed a similar pattern of significant variation. Control plants had a spread of 27.79 cm (E-W) and 29.05 cm (N-S). Gamma radiation reduced plant spread across all doses, with the lowest values recorded at 2.5 kR (22.68 cm E-W and 23.16 cm N-S). This reduction could be attributed to stunted growth resulting from radiation stress. EMS treatments increased plant spread with 0.4% EMS showing the maximum spread (30.57 cm E-W and 27.53 cm N-S). Higher EMS concentrations reduced plant spread, reflecting the inhibitory effects at elevated mutagen levels.

Flowering and spike parameters

The data presented reveals the effects of gamma rays and ethyl methane sulphonate (EMS) treatments on various floral and spike characteristics in tuberose compared to the control and presented in Table 3.

Days to spike emergence and first floret opening

Control plants recorded 75.94 days for spike emergence and 92.50 days for the first floret opening. Gamma irradiation showed a gradual delay in both parameters with increasing doses. The highest delay was observed at 2.5 kR (85.89 and 101.73 days, respectively), likely due to stress-induced physiological changes. EMS-treated plants exhibited earlier spike emergence and floret opening than gamma-treated plants. The shortest duration for both parameters was recorded at 0.3% EMS (73.47 and 90.38 days, respectively). The results were in accordance with earlier research on gladiolus (7).

Spike length and rachis length

Control plants had a spike length of 85.43 cm and a rachis length of 24.31 cm. Gamma irradiation caused a reduction in spike and rachis length, with the lowest values recorded at 2.5 kR (76.27 cm and 20.27 cm, respectively). EMS treatments exhibited less pronounced reductions with the longest spike length observed at 0.5% EMS (83.69 cm). This suggests that EMS may have a less inhibitory effect on elongation compared to gamma rays. Similar results were given in earlier works on Gladiolus (8).

Number of florets per spike

The highest number of florets per spike was observed in EMS-treated plants at 0.3% (44.93), which exceeded the control (39.49). Gamma irradiation reduced the floret count, with the lowest number at 2.5 kR (37.44). EMS treatments, particularly at lower concentrations, appear to stimulate floral differentiation. Similar observations were in tuberose (9).

Floret length and width

The control recorded a floret length of 5.41 cm and a width of 4.63 cm. The largest florets were observed in 0.3% EMS-treated

Table 3. Effect of physical and chemical mutagens on flowering parameters in M_1V_1 generation of Arka Prajwal

Treatment	Days to spike emergence	Days to first floret opening	Spike length (cm)	Rachis length (cm)	No. of florets per spike	Floret length (cm)	Floret width (cm)	Weight of single floret (g)	Weight of florets/ spike	Weight of hundred florets (g)
Control	75.94	92.50	85.43	24.31	39.49	5.41	4.63	1.14	29.19	119.52
Gamma rays										
1.5kR	80.23	97.53	81.77	23.20	40.87	5.49	4.61	1.21	50.79	123.45
2.0kR	82.73	98.48	79.74	21.82	38.76	5.32	4.57	1.12	45.12	114.83
2.5kR	85.89	101.73	76.27	20.27	37.44	5.02	4.23	1.04	40.19	106.12
Mean	82.95	99.25	79.26	21.76	39.02	5.28	4.47	1.12	45.37	114.80
Ethyl Methane Sulphonate										
0.3%	73.47	90.38	78.61	26.25	44.93	5.53	4.65	1.37	63.28	141.26
0.4%	76.93	95.77	80.26	23.96	42.86	5.24	4.31	1.26	55.95	129.27
0.5%	78.87	98.25	83.69	22.95	39.72	5.06	4.48	1.19	49.87	121.48
Mean	76.42	94.80	80.85	24.39	42.50	5.28	4.48	1.27	56.36	130.67
Grand Mean	**78.44**	**95.52**	**81.85**	**23.49**	**40.34**	**5.32**	**4.53**	**1.18**	**43.64**	**121.66**
CD	2.24	2.87	2.46	1.67	1.94	0.87	0.65	0.21	1.74	5.69
SE(d)	1.11	1.42	1.29	0.83	0.95	0.43	0.31	0.11	0.81	2.79

plants (5.53 cm length and 4.65 cm width), while gamma irradiation at higher doses (2.5 kR) resulted in the smallest florets (5.02 cm and 4.23 cm). These results indicate that EMS at lower concentrations enhances floral dimensions, while gamma irradiation suppresses them.

Weight of single floret and florets per spike

Control plants exhibited a single floret weight of 1.14 g and a total floret weight per spike of 29.19 g. EMS-treated plants, particularly at 0.3%, significantly improved these parameters, recording the highest weights (1.37 g and 63.28 g, respectively). Conversely, gamma irradiation reduced floret weight with increasing doses. Similar observations were reported in Crossandra (7, 10).

Weight of hundred florets

EMS treatments resulted in the heaviest florets, with the maximum weight of 141.26 g observed at 0.3% EMS. Gamma irradiation reduced the weight, with the lowest value at 2.5 kR (106.12 g). The grand mean revealed that EMS treatments generally outperformed gamma irradiation in enhancing floral and spike characteristics. The 0.3% EMS treatment emerged as the most effective, promoting earlier flowering, higher floret counts and improved floral dimensions and weights. Gamma rays, particularly at higher doses, adversely impacted growth and flowering attributes, possibly due to radiation-induced stress.

Conclusion

The study demonstrates the significant influence of gamma radiation and ethyl methane sulphonate (EMS) on the growth and flowering characteristics of Arka Prajwal in the M_1V_1 generation. EMS treatments were most effective in enhancing key growth parameters, such as plant height, leaf dimensions and plant spread, while also accelerating flowering by reducing days to spike emergence and first floret opening. In contrast, gamma radiation delayed sprouting and flowering while causing reductions in spike and rachis lengths, particularly at higher doses. Notably, EMS-treated plants produced more florets per spike with improved floret dimensions and weight, contributing to superior floral yield. These findings underscore the potential of EMS as a mutagen to induce beneficial variations for floricultural improvement in tuberose. Gamma radiation, while useful for generating variability, may require lower doses for optimal results. This study provides a foundation for selecting appropriate mutagens to enhance tuberose performance.

Acknowledgements

The financial support was extended by UGC through the SJSGC fellowship to carry out the research. I express my special gratitude to my chairperson, Dr. R Chitra and the advisory committee for the immense support in implementing this work.

Authors' contributions

MSNVSSB carried out the experiment, took observations and analysed the data. RC guided the research by formulating the research concept, helped in securing research funds and approved the final manuscript. MG developed the ideas, reviewed the manuscript and helped in procuring research grants. RK contributed by imposing the experiment, helped in editing, summarizing and revising the manuscript. NMB helped in editing, summarising and revising the manuscript.

DU helped in summarising and revising the manuscript. SPM helped in carrying out the experiment and analysing the data. MA helped in carrying out the experiment and analysing the data.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

Declaration of generative AI and AI-assisted technologies in the writing process

During the process of this work the author(s) did not use AI tools and the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

References

1. Sirohi U, Kumar M, Chauhan P, Kumar N, Prakash S, Chand P, et al. Genetic diversity in tuberose (*Polianthes tuberosa* L.) germplasm using Inter Simple Sequence Repeat (ISSR) markers. Int J Curr Microbiol Appl Sci. 2017;(6):1313–21. https://doi.org/10.20546/ijcmas.2017.605.142
2. Sreethramu GK, Bhat RN, Ranjanna KM. Studies on pollen viability, pollen germination and seed germination in tuberose hybrids and cultivars. South Indian Hortic. 2000;48(1):78–82. https://www.cabidigitallibrary.org/doi/full/10.5555/20013163047
3. Pooja K, Ranjan S, Manish K. Effect of physical and chemical mutagens on different cultivars of tuberose (*Polianthes tuberosa* Linn.) with particular reference to induction of genetic variability. Int J Agric Sci. 2016;8(56):3183–6.
4. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. New Delhi: Indian Council of Agricultural Research Publication. 1985;87–9.
5. Kayalvizhi K, Kannan M, Ganga M. Effects of gamma irradiation and chemical mutagens in tuberose *Polianthes tuberosa* L. Res Environ Life Sci. 2016;9(8):1030–2.
6. Datta SK. Induction and analysis of somatic mutations in garden chrysanthemum. Adv Hortic For. 1990;31:231–54.
7. Patil S. Induction of mutation in commercial varieties of gladiolus using physical mutagen, Co^{60} gamma rays. Int J Adv Res Biol Sci. 2014;1(6):15–20.
8. Sisodia A, Singh A. Influence of gamma irradiation on morphological changes, postharvest life and mutagenesis in gladiolus. Int J Agric Environ Biotechnol. 2014;7(3):535. https://doi.org/http://dx.doi.org/10.5958/2230-732X.2014.01358.8
9. Singh PK, Sadhukhan R, Dudhane AS, Kumar V, Sarkar HS. Preliminary study on mutagenic effects of EMS on tuberose (*Polianthes tuberosa* L.). Environ Ecol. 2015;33(A):1386–90.
10. Dhivya M, Balakrishanan S, Thangaselvabai T. Sensitivity and mutagenic effects of ethyl methane sulphonate on the growth of *Crossandra infundibuliformis* L. Nees. Int J Agric Sci Res. 2015;5(3):199–203.

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.