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Original Research Paper

Effect of gamma rays and colchicine on morphology, flowering and yield attribute of tuberose (*Agave amica* (Medik.) Thiede & Govaerts)

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ABSTRACT

The genetic enhancement of tuberose is hindered by limited genetic variability, self-incompatibility and seed sterility in double type tuberose; therefore, an attempt was made to harness the potential of induced mutations, using both physical (gamma rays 1.0 to 3.5 kR) and chemical (colchicine 0.01 to 0.11%) mutagens to diversify the genetic makeup of double type tuberose var. BRH 19. Results revealed that minimum days to 50% sprouting was recorded with colchicine (0.11%), whereas, least days to first flower opening, maximum survival percentage and number of florets open at a time were noted in control. Maximum plant height and spike longevity were recorded with colchicine (0.07%), while, number of leaves per clump noted maximum with colchicine (0.05%). Maximum leaf area, spike length, rachis length, length of floret, floret diameter, number of spikes per clump, number of bulbs per clump and weight of bulbs per clump were recorded with 3.5 kR gamma rays. Bulbs irradiated with 1.00 kR recorded maximum number of florets per spike, however, maximum number of bulblets and weight of bulblets/clump were found maximum with colchicine (0.01%).

Keywords: BRH 19, colchicine, gamma rays, mutants, tuberose

INTRODUCTION

Tuberose is one of the most important tropical ornamental bulbous flowering plants, cultivated for production of long-lasting flower spikes. It is an important commercial cut as well as loose flower crop due to pleasant fragrance, longer vase-life, higher returns and wide adaptability to varied climate and soil. Its flower is very popular for its strong fragrance and its essential oil is important component of high-grade perfumes. Double cultivars are infertile and used as cut flower. Seed setting is not observed in double cultivars. The genetic variability available in tuberose is very limited and available named varieties are very few in India. Non-availability of genetic variability has become a major constraint in conventional breeding of tuberose.

Genetic variability is an essential component of any plant breeding program aimed at crop improvement. However, the conventional breeding of tuberose faces a significant challenge due to a lack of available genetic variability (Anu Krishnan et al., 2003). The genetic enhancement of tuberose is hindered by limited genetic variability, self-incompatibility and seed sterility. The induction of mutations proves to be a well-established, efficient and cost-effective technique for creating novel ornamental cultivars with commercial significance in tuberose. The var. BRH 19 is released from Bidhan Chandra Krishi Viswavidyalaya, Kalyani, India and is a cross between Phule Rajani x Arka Vaibhav. It is important high yielding double type variety, has good fragrance and bright white flower.

MATERIALS AND METHODS

The present investigation was conducted at Floriculture Research Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India during 2022 and 2023, in randomized block design with three replications. One hundred forty-four tuberose bulbs (3.0±0.25 cm diameter) of var. BRH 19 were selected per treatment per replication and treated with chemical and physical mutagens. For physical mutagenic treatment (gamma rays), bulbs were treated at Bhabha Atomic Research Station, Trombay, Mumbai. The ^{60}Co used as a source of gamma rays (1.0, 1.5, 2.0, 2.5, 3.0. 3.5 and 4.0 kR). For chemical mutagenic treatment, bulbs were treated with various concentrations of colchicine (0.01, 0.03, 0.05, 0.07, 0.09 and 0.11%) by immersing

Table 1 : Effect of various physical and chemical mutagen on vegetative characters of tuberose var. BRH 19

Mutant	Days to 50% sprouting	Survival (%)	Plant height (cm)	Leaves/ plant	Leaf area (cm^2)
Gamma rays (kR)					
T_1: 1.00	44.00	95.82	26.83	32.52	35.43
T_2: 1.50	60.33	87.49	20.71	23.06	30.62
T_5: 3.00	72.33	71.52	10.55	32.47	39.04
T_6: 3.50	86.67	67.36	11.11	28.25	42.05
Colchicine (%)					
T_8: 0.01	31.67	88.19	38.87	32.54	35.09
T_9: 0.03	35.33	95.83	34.72	29.20	31.95
T_{10}: 0.05	35.67	93.06	34.96	33.10	38.46
T_{11}: 0.07	45.33	95.83	41.83	30.96	33.87
T_{12}: 0.09	84.00	86.11	35.27	31.98	33.92
T_{13}: 0.11	27.67	93.06	33.65	32.62	32.67
T_{14}: Control	28.33	100.00	31.62	31.98	34.16
SEm±	4.34	4.47	2.57	1.70	1.67
C.D. at 5 %	12.79	13.18	7.58	5.02	4.92

in the chemical solution overnight. Chemical solution of above-mentioned concentrations was prepared by diluting colchicine powder of 1, 3, 5, 7, 9 and 11 g, respectively in 10 liters of water and kept overnight, after that these bulbs were washed in running tap water for 20 minutes while, bulbs were soaked in water overnight in control.

Raised beds (90 cm width, 20 cm height and 40 cm paths) were prepared using a tractor-operated ridger, followed by manual leveling with a garden rake. Well-decomposed FYM at a rate of 15 tons per hectare, along with 300 kg of nitrogen, 200 kg of phosphorus (P_2O_5) and 100 kg of potassium (K_2O) per hectare, were applied as per the recommended dose. Nitrogen was applied in four equal doses at three-month intervals, while the full dose of phosphorus and potassium was applied as a basal treatment. A drip irrigation system with 16 mm laterals, equipped with inline drippers discharging at 4.0 liters per hour, was utilized. Three rows of plants were accommodated per bed, with two laterals installed per bed before applying a 25-micron silver-black plastic mulch. Observations were recorded at various growth stages from all treated plants across all replications, focusing on nineteen key quantitative traits.

RESULTS AND DISCUSSION

Among the different vegetative parameters, days to 50% sprouting (27.67) recorded minimum in T_{13} (0.11% colchicine), while, survival percentage (100) was maximum in T_{14} (control). Maximum plant height (41.83 cm) was recorded in T_{11} (0.07% colchicine), number of leaves per clump (33.10) in T_{10} (0.05% colchicine) and leaf area (33.10) in T_6 (Table 1). Colchicine-treated bulbs may undergo physiological changes that facilitate dormancy break and promote early sprouting, whereas gamma rays-treated bulbs may experience delays in growth due to DNA damage and cellular stress. High doses of colchicine induce more pronounced genetic changes, including polyploidy, which can impact plant physiology and stress responses. Despite the potential cytotoxic effects of high colchicine doses, certain genetic alteration induced by these doses may confer beneficial traits that enhance survival under specific environmental condition. Riviello Flores et al. (2022) and Mangena & Pirtunia (2023) also reported similar results.

Flowering parameter *viz.,* number of petals per floret and weight of 10 florets were found non-significant. Least days to first flower opening (140.45) and maximum number of florets open at a time (14.87) was recorded in T_{14} (control). Maximum spike length

Table 2 : Effect of various physical and chemical mutagen on flowering characters of tuberose var. BRH 19

Mutant	Petals/ floret	Days to first floret opening	Spike length (cm)	Rachis length (cm)	Florets/ spike	Length of floret (cm)	Weight of 10 florets (g)	No. of florets open at a time	Floret diameter (cm)	Spike longevity (days)
Gamma rays (kR)										
T1: 1.00	16.49	155.79	71.10	29.65	50.46	5.56	24.22	12.54	4.22	32.63
T2: 1.50	14.73	204.56	70.78	26.78	33.04	5.52	23.15	12.45	4.26	30.87
T5: 3.00	16.15	232.15	63.11	33.50	48.14	6.38	25.34	13.51	4.55	30.64
T7: 4.00	16.07	164.46	75.85	35.33	48.16	6.45	29.98	13.89	5.54	35.11
Colchicine (%)										
T8: 0.01	16.17	217.39	73.69	30.43	45.60	5.24	23.03	12.66	4.60	29.54
T_{9}: 0.03	16.65	148.72	74.14	35.23	44.98	6.01	25.31	14.16	3.87	32.19
T_{10}: 0.05	13.80	191.51	75.23	32.66	47.57	5.66	25.23	13.18	4.42	32.52
T_{11}: 0.07	14.37	155.69	73.61	32.77	41.24	5.46	26.86	11.55	3.62	36.60
T_{12}: 0.09	16.05	237.00	74.87	33.38	35.59	5.46	23.97	12.42	4.60	28.69
T_{13}: 0.11	16.20	232.41	71.94	27.54	36.89	5.07	22.95	12.22	4.33	29.27
T_{14}: Control	14.67	140.45	74.59	32.77	40.26	6.12	24.61	14.87	4.96	31.32
SEm±	1.07	5.04	1.74	1.66	1.72	0.23	1.50	0.60	0.29	1.31
C.D. at 5 %	NS	14.87	5.14	4.88	5.08	0.67	NS	1.77	0.85	3.88

(75.85 cm), rachis length (35.33 cm), length of floret (6.45 cm) and floret diameter (5.54 cm) were noted in T_6 (3.5 kR gamma rays). Maximum number of florets per spike (50.46) was recorded in T_1 (1.00 kR gamma rays) whereas, spike longevity (36.60 days) was found maximum in treatment T_{11} (0.07% colchicine) (Table 2).

Generally, mutation induced by lower doses of gamma rays can profoundly impact floral development by altering genes involved in cell division, cell enlargement, and overall growth regulation. These genetic changes contribute to the development of larger and more robust floral structures, including florets with greater diameter. The interaction between mutagenic effects, genetic responses, and environmental factors shapes the final floral morphology observed in plants subjected to gamma ray treatment, as also reported by Sudha Patil et al. (2017) in gladiolus, Singh & Kumar (2013), Ayesha Manoor (2019) in ornamental plant and Sharavani et al. (2019) in tuberose. However, floral parameters were recorded with superior result at higher doses of gamma rays in this study. This might be due to genetic make-up of the variety and environmental condition of south Gujarat region.

Number of spikes per clump (8.50), number of bulbs per clump (35.68) and weight of bulbs per clump (863.45 g) were found maximum in T_6 (3.5 kR gamma rays). Maximum number of bulblets per clump (19.28) and weight of bulblets per clump (43.90 g) were found maximum in treatment T_8 (0.01% colchicine) (Table 3).

Mutations may disrupt normal regulatory pathways, leading to enhanced branching and increased formation of axillary buds, ultimately resulting in the production of more spikes per plant. Gamma ray mutagenesis can stimulate adventitious bud formation, enhance branching and tillering, induce polyploidy and genetic variation, and influence bulb development of which contribute to an increased number of bulbs per plant (Riviello Flores et al., 2022). Higher doses of gamma rays can reach an optimal level of mutagenic exposure that induces beneficial mutation related to bulb development and growth. This optimal mutation frequency may lead to variation in bulb structure and physiology that result in larger and heavier bulbs. These findings are in conformity with the results of Singh & Kumar (2013) and Sharavani et al. (2019) in tuberose. Fig. 1 showed stable mutants from var. BRH 19.

Table 3 : Effect of various physical and chemical mutagen on yield characters of tuberose var. BRH19

Mutant	Spikes/ clump	Bulbs/ bulb	Bulblets/ bulb	Weight of bulbs/clump (g)	Weight of bulblets/clump (g)
Gamma rays (kR)					
T_1: 1.00	6.2	18.31	13.77	550.53	36.22
T_2: 1.50	4.82	19.81	13.7	508.34	29.34
T_3: 2.00	2.46	33.02	13.34	836.29	21.43
T_6: 3.50	8.5	35.68	16.76	863.45	36.57
Colchicine (%)					
T_8: 0.01	5.35	17.89	19.28	405.67	43.9
T_9: 0.03	5.41	23.03	12.28	546.31	14.67
T_{10}: 0.05	5.33	32.52	12.53	756.31	14.36
T_{11}: 0.07	5.37	14.59	8.84	322.3	8.98
T_{12}: 0.09	3.6	22.68	13.38	450.14	17.24
T_{13}: 0.11	4.95	20.53	8.57	454.31	10.43
T_{14}: Control	5.34	26.01	8.36	638.36	8.63
SEm±	0.43	1.37	0.84	40.32	1.61
C.D. at 5%	1.27	4.05	2.49	118.94	4.74

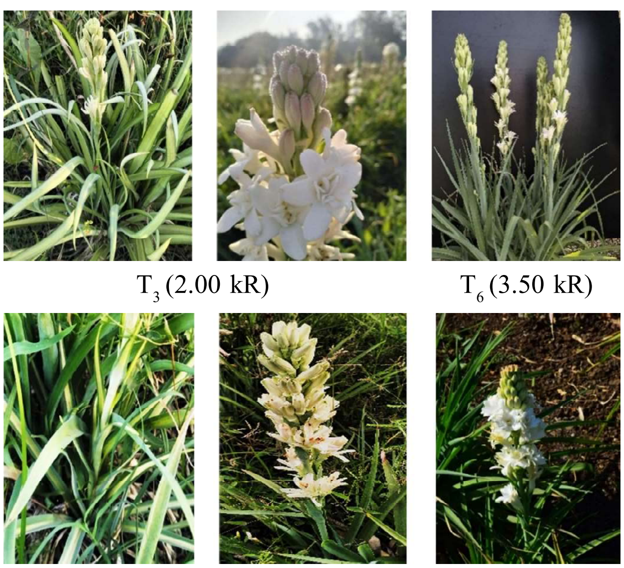

Fig. 1 : Stable mutants from var. BRH 19 in M_2 generation

CONCLUSION

The gamma rays (1.0 kR and 3.5 kR) and colchicine (0.01, 0.05, 0.07 and 0.11%) are comparatively effective among all other treatments. Few plants selected from treatments T_1 (1.00 kR gamma rays), T_2 (1.50 kR gamma rays), T_3 (2.00 kR gamma rays), T_6 (3.50 kR gamma rays) and T_{13} (0.09 % colchicine) showed unique characteristics like semi-double type flower, dwarf, long and bold floret, bulky and flat top, leaves with yellow strip in middle, greenish, dwarf and thin spike with pink tinge on bud, multiple spike per plant, cluster or petals in middle of flower, light green leaves, earliness, greenish buds and compact spike with bold florets, multiple spikes per plants, compact rachis and bold floret, dwarf, bold spike and floret with round petal.

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