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Effect of Gamma Irradiation on Growth, Flowering and Postharvest Characters in Tuberose Varieties

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A B S T R A C T

An experiment was conducted to find out the influence of gamma rays dose *i.e*. 2 kR and 4 kR along with untreated (control) in different varieties of tuberose *viz*., Shringar, Calcutta Double, Vaibhav, Pune Local Single, Arka Nirantra, Sikkim Selection, Prajwal, Hyderabad Single, Phule Rajani Single, Calcutta Single, Mexican Single, ACC No.7, GKTC-4 and ACC No. 9. Experiment was laid down in Randomized Block Design with three replications. 4 kR dose of gamma ray does not sprout due to lethal effect. Early sprouting was recorded with 2 kR treatment as compared to control. Maximum number of leaves per plant was recorded with control followed by 2 kR. Maximum width of longest leaf was noticed in control which was significantly higher than 2 kR. Maximum leaf area index and plant height was observed with control which was at par with 2 kR treatment. Early spike emergence was recorded with 2 kR dose of gamma irradiation. Maximum length of spike was noticed in control. Maximum number of florets/spike was recorded with control when compared to 2 kR dose of gamma irradiation. Maximum diameter of floret was noticed in control as compare to 2 kR. Control plants resulted maximum duration of flowering. Maximum number of spikes m^2 was recorded with control. Interaction of gamma doses and different varieties found non- significant on number of spike per m^2. Maximum days taken to first floret withered was noticed in control as compare to 2 kR treatment of gamma dose. Earliest 50% flowering was noticed due to gamma irradiation dose at 2 kR. The highest percentage of opened floret was noticed in control. Maximum water uptake and vase life was found in control.

Introduction

Tuberose (*Polianthes tuberosa* Linn.) is one of the most important bulbous perennial flowering plant of tropical and sub-tropical areas belonging to monocots (Rose 1903, Bailey, 1939). It occupies second position in area and production after gladiolus in India (Desh Raj, 2006). It is found to be originated at Mexico. It belongs to family Amarylladaceae. There are very few cultivars of tuberose in production worldwide. In all the existing varieties, flower colour is limited to white, although some varieties show pinkish tinge at bud stage. To develop more variation in biotic and abiotic traits such as disease resistance, flower shape, vase life, etc. in tuberose, there is an urgent need of well-planned breeding programmes using conventional and non-conventional breeding techniques. Among the commercially grown bulbous plants which are valued much for aesthetic world and fragrance, tuberose occupies a very selective and special position,

because of their prettiness, elegance and pleasantly sweet fragrance. Tuberose (*Polianthes tuberosa* Linn.) popularly known as Rajnigandha. It has great economic potential for cut flower trade and essential oil industry due to their greet demand. Tuberose is cultivated on large scale in France, Italy, South Africa, Southern State of America, Egypt, Israel, and India, and in many tropical and sub-tropical countries (Singh, 2006). The spike of tuberose has longer vase life and can be transported for long distance. Whereas, for local markets spike are harvested when basal floret is fully opened. Post-harvest quality of flowers also influenced by various doses of gamma irradiation and electron-beam irradiation. Generally biocide and sucrose are used for enhancing post-harvest life of cut spikes of tuberose because biocides remove the microorganism which present in the spikes and sucrose provide energy.

Materials and Methods

The present investigation was conducted at the Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P. during Summer season March 2016 to April 2017. Banaras Hindu University is situated at a distance of about 10 km away from Varanasi Railway Station in South-East direction. The geographical situation is 25º02' North latitude and 83º 03' East longitude. The latitude of the location is 128.93 meter the mean sea level. Fourteen cultivars *viz.*, Shringar, Calcutta Double, Vaibhav, Pune Local Single, Arka Nirantra, Sikkim Selection, Prajwal, Hyderabad Single, Phule Rajani Single, Mexican Single, ACC No.7, GKTC-4 and ACC No.9 were used as experimental material. The bulbs of tuberose were irradiated with gamma rays at 2 kR and 4 kR at the dose rate of 6.08 KGY per 11 sec and 23 sec in Gamma chamber with 60Co source at the gamma irradiation facility of National Botanical Research Institute, Lucknow. Healthy and uniform size of bulbs were treated with gamma radiation at treatments 2.00 kR, 4 kR and control (0.00 kR) and planted with a spacing of 25×25 cm. The experiment was laid out in Randomized Block Design with 3 replications. Various parameters were observed on growth, flowering and post-harvest stages.

Results and Discussion

Growth parameters

Doses of gamma irradiation at 2 kR gave lethal effect and five varieties could not produce any sprout. Whereas, higher doses of gamma irradiation (4 kR) failed to produce any sprout in different varieties. Irradiated bulbs at 2 kR took longer time to sprout in all treatments than respective control. Early Sprouting was recorded with 2 kR dose of gamma irradiation and late sprouting was observed in control (Table 1). Among the varieties, delayed sprouting was observed in GKTC-4 which was statistically higher than other varieties. Interaction of cultivar Phule Rajani Single with 2 kR doses resulted in early sprouting. Similar observations were also made by Singh and Sisodia (2015) in gladiolus. At 2 kR doses, number of leaves was drastically reduced. Maximum number of leaves per plant was recorded in germplasm Sikkim Selection, whereas, number of leaves per plant decreased in all the cultivars with increased dose of mutagen when compared to control. Significant effect due to gamma irradiation was observed on width of the leaf and in general, width of leaf decreased as doses of gamma irradiation at 2kR. Maximum width of longest leaf was recorded in germplasm Vaibhav. Similarly, leaf area index was decreased at 2 kR treatment of gamma dose. Similar results were also found by Sisodia *et al.,* (2015) in gladiolus. Maximum leaf area index was recorded in control. Similar results on leaf area index

have been reported by Singh and Sisodia (2015) in gladiolus. Pandey and Gaur (1984) recorded that cormels of cv. Scarlet irradiated with the low dose generally exhibited slight earliness in sprouting because of 38% increase in O_2 uptake, stimulation of alpha-amylase enzyme prior to sprouting and a rise in sugar content. The higher doses delayed sprouting by decreased O_2 uptake and inhibited alpha-amylase activity although it induced a slight rise in sugar content. Srivastava *et al.,* (2007) stated that, delayed sprouting might be due to the lower levels of mutagens which are themselves not responsible for stimulating sprouting but the substances such as enzymes that are set free by irradiation at low doses causes stimulation of enzymes which play pivotal role in plant metabolism. Maximum plant height was recorded with control. Results of present experiment are also in the line with the observation made by Rather and Jhon (2000) who recorded less plant height due to application of gamma doses in the Dutch iris. Similar results were reported earlier by Banerji *et al.,* (1994) in gladiolus. This may be caused by the reduced amount of endogenous growth regulators, especially the cytokinin, because of breakdown or lack of synthesis due to irradiation.

Different varieties of tuberose (Shringar, Calcutta Double, Vaibhav, Pune Local Single, Arka Nirantra, Sikkim Selection, Prajwal, Hyderabad Single, Phule Rajani Single, Calcutta Single, Mexican Single, ACC No.7, GKTC-4 and ACC No.9) were treated with gamma doses (at 2 kR, 4 kR) along with control (untreated). Sprouting of bulbs varied significantly in different varieties. Cultivar GKTC-4 resulted in late sprouting whereas, early sprouting was recorded in cultivar ACC No.7. Different varieties showed significant response on width of leaves. Maximum width of longest leaf was recorded in germplasm Vaibhav. Different varieties responded significantly on number of leaves and cultivar Sikkim Selection produced more leaves than other varieties. Cultivar Sikkim Selection registered more height. Cultivar Prajwal registered more leaf area index followed by Vaibhav, Sikkim Selection and Calcutta Double.

Flowering parameters

Various flowering attributes influenced significantly due to various gamma doses. Gamma irradiation at 2 kR resulted in late spike emergence, whereas, all untreated bulbs (control) produced early spike. Gamma dose at 2 kR were found lethal in case of four varieties *i.e.* Shringar, Prajwal, Hyderabad Single and Phule Rajani Single whereas, control plants produced spike. Similar results were found by Sisodia and Singh (2015) in gladiolus. The results are in conformity with the work of Patil and Dhaduk (2009), who reported earlier spike initiation in three cultivars of gladiolus when treated with 2 Krad gamma rays whereas further increase in dose delayed spike emergence in all the cultivars. Delay in spike emergence might be due to disturbance in biochemical pathways which assisted in flower induction pathway. Influence of gamma irradiation on length of spike was recorded in which length of spike reduced due to gamma doses in comparison to untreated (control). Maximum length of spike was recorded in control. Diameter of floret was decreased due to gamma doses at different level. Similar results were also found by Sisodia *et al.,* (2015) in gladiolus. It was also observed that at 2 kR dose of gamma irradiation, number of florets/spike were reduced which was statistically lower than control. These results are in conformity with the findings of Sisodia and Singh (2015), who recorded maximum number of florets per spike in untreated plants and reduction in florets at higher doses of gamma rays in gladiolus. Cultivar ACC No.7 resulted in early spike emergence whereas, cultivar GKTC-4 produced late spike (Tables 2 and 3).

Table.1 Effect of gamma irradiation on growth characters in tuberose varieties

Treatment / Variety	Days to sprouting			Number of leaves/plant			Width of longest leaf (cm)			Leaf area index			Plant height (cm)		
	Control	2 kR	Mean	Control	2 kR	Mean	Control	2 kR	Mean	Control	2 kR	Mean	Control	2 kR	Mean
Shringar	23.50	14.50	19.00	66.16	4.00	35.08	1.38	0.45	0.91	6.66	0.53	3.59	61.33	-	30.66
Calcutta Double	30.66	30.50	30.58	132.00	43.33	87.66	1.23	0.86	1.05	13.89	1.58	7.73	73.25	55.61	64.43
Vaibhav	35.83	47.50	41.66	114.33	61.33	87.83	1.31	1.26	1.29	12.25	5.76	9.01	72.53	34.75	53.64
Pune Local Single	26.33	-	13.16	84.83	-	42.41	1.16	-	0.58	10.17	-	5.08	66.58	-	33.29
Arka Nirantra	23.83	-	11.91	58.33	-	29.16	1.23	-	0.61	6.26	-	3.13	108.83	-	54.41
Sikkim Selection	28.66	38.50	33.58	113.00	81.83	97.41	1.41	0.73	1.07	11.56	6.37	8.96	99.83	76.21	88.02
Prajwal	29.66	15.66	22.66	105.00	4.50	54.75	1.68	0.55	1.11	18.53	0.86	9.70	93.70	11.33	52.51
Hyderabad Single	34.50	24.00	29.25	95.00	22.16	58.58	1.26	0.70	0.98	11.20	2.09	6.64	70.41	-	35.20
Phule Rajani Single	29.00	7.83	18.41	128.00	10.83	69.41	1.36	0.16	0.76	13.80	1.66	7.73	63.00	-	31.50
Calcutta Single	30.66	-	15.33	112.00	-	56.00	1.23	-	0.61	8.80	-	4.40	68.58	-	34.29
Mexican Single	32.33	-	16.16	81.66	-	40.83	1.23	-	0.61	7.21	-	3.60	87.95	-	43.97
ACC No.7	18.00	-	9.00	49.33	-	24.66	0.83	-	0.41	7.14	-	3.57	33.56	-	16.78
GKTC-4	42.83	47.00	44.91	43.16	53.33	48.25	1.31	1.05	1.18	5.56	5.56	5.56	65.40	49.38	57.39
ACC No.9	16.16	39.00	27.58	34.00	51.16	42.58	0.58	0.75	0.66	4.19	5.36	4.78	54.40	79.08	66.72
Mean	28.71	18.89		86.91	23.75		1.23	0.46		9.80	2.12		72.81	21.88	
C.D. (0.05)															
Treatment	4.75			11.60			0.13			1.11			8.00		
Variety	12.59			30.69			0.36			2.94			21.17		
Treatment × Variety	17.80			43.40			0.52			4.16			29.94		

Table.2 Effect of gamma irradiation on flowering characters

Treatment / Variety	Days to spike emergence			Length of spike (cm)			Number of florets/spike		
	Control	2 kR	Mean	Control	2 kR	Mean	Control	2 kR	Mean
Shringar	177.16	-	88.58	44.40	-	22.20	38.66	-	19.33
Calcutta Double	265.00	87.16	176.08	53.36	43.33	48.35	36.66	11.16	23.91
Vaibhav	221.33	93.83	157.58	57.26	25.50	41.38	24.66	15.33	20.00
Pune Local Single	167.50	-	83.75	48.91	-	24.45	36.00	-	18.00
Arka Nirantra	246.50	-	123.25	89.50	-	44.75	37.33	-	18.66
Sikkim Selection	208.00	199.83	203.91	78.13	56.71	67.42	38.66	20.33	29.50
Prajwal	239.33	54.33	146.83	74.36	6.00	40.18	43.00	5.66	24.33
Hyderabad Single	240.83	-	120.41	46.16	-	23.08	63.33	-	31.66
Phule Rajani Single	197.50	-	98.75	44.90	-	22.45	32.66	-	16.33
Calcutta Single	236.66	-	118.33	47.08	-	23.54	34.00	-	17.00
Mexican Single	195.00	-	97.50	68.66	-	34.33	41.33	-	20.66
ACC No.7	149.66	-	74.83	23.46	-	11.73	28.66	-	14.33
GKTC-4	276.00	252.16	264.08	44.20	30.50	37.35	40.66	33.16	36.91
ACC No.9	112.33	205.00	158.66	41.91	61.66	51.79	28.00	23.00	25.50
Mean	209.48	63.73		54.45	15.98		37.40	7.76	
C.D. (0.05)									
Treatment	24.69			6.62					
Variety	65.32			17.53					
Treatment × Variety	92.38			24.79					

Table.3 Effect of gamma irradiation on flowering characters

Treatment / Variety	Diameter of floret (cm)			Weight of spike (g)			Number of spikes/m^2		
	Control	2 kR	Mean	Control	2 kR	Mean	Control	2 kR	Mean
Shringar	3.16	-	1.58	44.66	-	22.33	29.33	-	14.66
Calcutta Double	3.50	2.50	3.00	99.66	33.13	66.40	16.00	13.33	14.66
Vaibhav	3.48	2.30	2.89	64.28	19.33	41.80	29.33	13.33	21.33
Pune Local Single	3.60	-	1.80	33.66	-	16.83	13.33	-	6.66
Arka Nirantra	3.33	-	1.66	66.76	-	33.38	26.66	-	13.33
Sikkim Selection	2.96	3.03	3.00	60.50	36.16	48.33	93.33	96.00	94.66
Prajwal	3.45	0.91	2.18	78.90	-	39.45	18.66	2.66	10.66
Hyderabad Single	3.66	-	1.83	82.00	-	41.00	16.00	-	8.00
Phule Rajani Single	3.15	-	1.57	60.83	-	30.41	16.00	-	8.00
Calcutta Single	3.26	-	1.63	96.16	-	48.08	18.66	-	9.33
Mexican Single	3.20	-	1.60	72.16	-	36.08	37.33	-	18.66
ACC No.7	3.10	-	1.55	28.33	26.73	14.16	13.33	-	6.66
GKTC-4	3.43	2.60	3.01	58.50	30.33	42.61	21.33	16.00	18.66
ACC No.9	2.15	2.83	2.49	29.50	10.40	29.91	18.66	48.00	33.33
Mean	3.24	1.01		62.56			26.28	13.52	
C.D. (0.05)									
Treatment	0.33			7.18			10.84		
Variety	0.88			18.99			28.69		
Treatment × Variety	1.24			26.86			N/A		

Table.4 Effect of gamma irradiation on post-harvest characters

Treatment / Variety	Days to first floret withered			Days to 50% flowering			Percentage of opened florets			Total water uptake (ml)			Vase life (days)		
	Control	2 kR	Mean	Control	2 kR	Mean	Control	2 kR	Mean	Control	2 kR	Mean	Control	2 kR	Mean
Shringar	4.66	-	2.33	5.33	-	2.66	44.85	-	22.42	39.00	-	19.50	10.66	-	5.33
Calcutta Double	5.33	3.00	4.16	5.00	2.33	3.66	42.25	31.78	37.02	27.00	14.00	20.50	11.66	6.00	8.83
Vaibhav	4.66	1.66	3.16	3.66	1.00	2.33	35.85	11.85	23.85	29.33	9.00	19.16	11.33	3.00	7.16
Pune Local Single	3.00	-	1.50	3.66	-	1.83	25.49	-	12.74	20.00	-	10.00	7.00	-	3.50
Arka Nirantra	4.66	-	2.33	4.33	-	2.16	54.48	-	27.24	26.66	-	13.33	8.00	-	4.00
Sikkim Selection	6.00	4.66	5.33	5.00	4.33	4.66	58.04	46.01	52.02	33.33	30.66	32.00	11.00	7.33	9.16
Prajwal	4.33	-	2.16	5.00	-	2.50	49.50	-	24.75	37.33	-	18.66	9.66	-	4.83
Hyderabad Single	4.33	-	2.16	5.33	-	2.66	39.14	-	19.57	41.66	-	20.83	10.33	-	5.16
Phule Rajani Single	5.33	-	2.66	4.33	-	2.16	45.56	-	22.78	38.66	-	19.33	11.66	-	5.83
Calcutta Single	5.33	-	2.66	4.33	-	2.16	55.38	-	27.69	35.66	-	17.83	9.66	-	4.83
Mexican Single	5.00	-	2.50	4.66	-	2.33	54.34	-	27.17	35.33	-	17.66	10.33	-	5.16
ACC No.7	1.33	-	0.66	1.33	-	0.66	13.19	-	6.59	8.33	-	4.16	2.66	-	1.33
GKTC-4	5.33	3.66	4.50	4.00	3.66	3.83	54.19	33.54	43.86	47.33	23.33	35.33	11.66	6.33	9.00
ACC No.9	3.66	5.33	4.50	3.00	4.33	3.66	31.64	46.03	38.84	26.33	47.33	36.83	7.33	9.33	8.33
Mean	4.50	1.31		4.21	1.11		43.13	12.08		31.85	8.88		9.50	2.28	
C.D. (0.05)															
Treatment	0.59			0.59			5.46			4.49			1.28		
Variety	1.57			1.57			14.45			11.87			3.39		
Treatment × Variety	2.23			2.22			20.44			16.79			4.80		

These results were also in congruence with the observations of Anu *et al.,* (2003) who reported that spike emergence was influenced due to various gamma doses in different varieties of tuberose. Cultivar GKTC- 4 resulted in more number of florets/spike followed by cultivar Hyderabad Single and Sikkim Selection. Maximum diameter of floret was recorded in germplasm GKTC- 4. Cultivar Sikkim Selection resulted in more length of spike and also recorded maximum number of spikes/ m^2.

Post-harvest parameters

Post-harvest studies were done to see the response of gamma irradiation in tuberose during its post-harvest life. Maximum days taken to first floret withered was noticed in control as compare to 2 kR treatment of gamma dose. Maximum days taken to first floret withered were recorded in germplasm Sikkim Selection. Interaction of control with cultivar Sikkim Selection exhibited maximum number of days taken to first floret withered.

Earliest 50% flowering was noticed due to gamma irradiation dose at 2 kR which was significantly earlier than control. Earliest 50% flowering was recorded in germplasm ACC No.7. The highest percentage of opened floret was noticed in control which was significantly higher than 2 kR. Highest percentage of opened florets was recorded in germplasm Sikkim Selection. Whereas, more water uptake was recorded in control which was significantly more than 2 kR. In vase life study, more florets opened in untreated plants; however, it was at par with 2 kR dose of gamma irradiation. The results are in close conformity with findings of Anu *et al.,* (2003) who carried out an experiment on gamma irradiation in different varieties of tuberose and found that vase life of cut spikes increased at lower doses of gamma irradiation and reduced at higher doses of gamma rays. Interaction effect of gamma rays and varieties were also found non-significant (Table 4).

Pandey and Gaur (1984) reported that low irradiation exhibited slight earlier sprouting. They further observed a rise in sugar content due to gamma irradiation which probably played some role in augmenting some metabolic processes in the plant and resulted in increased vase life and longevity of flower in gladiolus. Sugar is directly related to the flower quality, longevity and vase life in general. The results of Hayashi and Todoriki (1996) suggested that sugar solution following irradiation prolonged the vase life of cut chrysanthemum. Present findings are also lent credence with the observation made by several earlier workers. Life of tuberose flower increased significantly due to gamma irradiation and a dose of 5 rad irradiations was found most beneficial over other treatments (Kumar *et al.,* 2003). Beneficial effect of lower doses (2.5 kR) was also observed in the post-harvest life of cut roses in which maximum opening of flower bud was observed and longevity was found better than untreated flowers (De *et al.,* 1997). Post-harvest study of tuberose flowers was done in some varieties because few varieties was highly influenced due to gamma doses and failed to produce spikes Cultivars Shringar, Pune Local Single, Arka Nirantra, Prajwal, Hyderabad Single, Phule Rajani Single, Calcutta Single, Mexican Single and ACC No.7 were not included in post-harvest studies and rest of cultivar produced less spike with 2 kR dose of gamma irradiation. Cultivar ACC No.9 recorded more water uptake. More vase life was recorded in germplasm Sikkim Selection. These studies are in congruence with the observations made by Anu *et al.,* (2003) who carried out experiment on gamma irradiation in different varieties of tuberose. They observed that vase life influenced significantly due to gamma doses and less influenced due to varieties.

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