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Effect of bulb size and soaking treatment on growth, yield and quality of tuberose (*Polianthes tuberosa* L.) hybrid Suvasini under North Gujarat condition

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Abstract
The present investigation "Effect of bulb size and soaking treatments on growth, yield and quality of tuberose (*Polianthes tuberosa* L.) hybrid Suvasini under North Gujarat condition" was carried out during April 2022-2023 at College of Horticulture, SDAU, Jagudan (Gujarat). The two factors of experiment was laid out with Factorial Randomized Block Design with three replications. Factor A comprises of three size of bulb, i.e. small (1.25-1.75 cm), medium (3.00-3.50 cm) and large (4.00-4.50 cm) and Factor B includes the application of soaking treatments, *i.e.* control (water soaking), Thiourea @ 500 ppm, Paclobutrazol @ 10 ppm, GA_3 @ 200 ppm, NPK Consortium @ 10 ppm and Novel @ 5 ppm. It was observed that large bulb size with the treatment of GA_3 resulted in vigorous growth, maximum yield and greater quality as compared to other treatments.

Keywords: Bulb size and soaking treatment, growth, yield, tuberose, *Polianthes tuberosa* L.

Introduction
Tuberose (*Polianthes tuberosa* L.) commonly called as "Rajnigandha", a member of Asparagaceae family is an ornamental bulbous plant native to Mexico. The etymology of *polianthes* is *poly*, meaning several and *anthes*, meaning flowers– "bearing or contains several flowers." (Khan *et al.*, 2016) [8]. In tropical and subtropical regions, it is one of the most important cut flower. Commercial cultivation of tuberose in india is confined to West Bengal, Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra (Nain *et al.*, 2019) [11]. The florets of tuberoses are used in making creative garlands, ornaments and buttonholes, while the long spikes are utilised for vase decoration and bouquet creation.

The successful cultivation is influenced by various bulb size and different soaking treatment. Raja and Palanisamy reported that in bulbous flowers, variable bulb sizes had variable effects on the production and quality of the flowers. Bulb size influences the sprouting of bulb and the time required is inversely proportional to size of bulb (Sadhu and Das, 1978; Pathak *et al.*, 1980) [15, 13]. Larger bulbs normally have more stored food than smaller ones and capable of producing more side shoots. Growth hormones also regulates the development and growth of bulbous plants. At ideal concentrations, it is known that the different growth chemicals can coordinate several stages of growth and development that includes flowering. The importance of tuberose and unavailability of limited information regarding the optimum bulb size and soaking treatments, the present research was undertaken to explore the optimum size of bulbs which can produce good quality flowers.

Materials and Methods
In April 2022–2023, a field experiment on tuberose was carried out at College Farm, College of Horticulture, S.D. Agricultural University, Jagudan, Gujarat. It has hot and dry windy summer, warm and humid monsoon and cold winter. The soil at the experimental site had a texture similar to loamy sand, was non-saline, had a low organic carbon content and accessible nitrogen, was moderately alkaline in reactivity, and had a medium amount of potassium and phosphorus available. Bulbs of tuberose variety Suvasini were planted on the raised beds (1.5 m × 1.5 m) at a spacing of 30 cm × 30 cm. The experiment was designed with two factors. Eighteen treatment combinations with three replications are included in the factorial concept with Randomised Block Design. There were three different sizes of bulbs that is small B_1 = 1.25-1.75 cm, medium B_2 = 3.00-3.50 cm and large size B_3 = 4.00-4.50 cm and six different soaking treatments S_1 = Control, S_2 = Thiourea @ 500 ppm, S_3 = Paclobutrazol @ 10 ppm,

S_4 = GA_3 @ 200 ppm, S_5 = NPK Consortium @ 10 ppm and S_6 = Novel @ 5 ppm. The diameter of the bulb was measured using a Vernier calliper to determine its size. The time of the soaking treatments was six hours for Thiourea @ 500 ppm and Paclobutrazol @ 10 ppm, and twelve hours for GA_3 @ 200 ppm, NPK consortium @ 10 ppm, and Novel @ 5 ppm. A small amount of ethyl alcohol was used to dissolve GA_3. Separate solutions of Thiourea, Paclobutrazol, NPK Consortium and Novel were prepared using distilled water. When these substances were completely dissolved, volume was made with measured quantity of water and stirred gently while adding water to keep material in solution. Using urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) as the basal, the prescribed amount of manure (FYM @ 15t/ha), 50% nitrogen, and 100% of each of phosphorus and potassium of RDF (200:200:200 kg ha^{-1}) were applied. Remaining 50 percent nitrogen of recommended dose was applied in three splits at 30, 45 and 60 days after planting.

Results and Discussion

Effect of bulb size and soaking treatments on growth parameters

The vegetative growth parameters were significantly influenced by different bulb size and soaking treatments. Small sized bulbs (1.25-1.75 cm) sprouted significantly earlier (13.19 days) than large sized bulb. Larger sized bulbs took more time for sprouting due to the presence of more layers of membranous scales which interfered in the exchange of gases and inhibited metabolic process (Raja and Palanisamy, 2000) [14]. 4.00-4.50 cm diameter sized bulbs recorded maximum plant height (24.27 cm) at the stage of 45 days which was found at par with treatment B_2 (23.83 cm) and (44.56 cm) at 90 days after planting. The taller plants with large sized bulbs in tuberose might be due to presence of more reserves photosynthates in planting material *i.e.*, large sized bulbs. The highest number of leaves $clump^{-1}$ (33.73 and 55.60, respectively) observed in large sized bulbs (4.00-4.50 cm). Similar variation were reported by Sadhu and Das (1978) [15], Dhua *et al.* (1987) [5], Raja and Palanisamy (2000) [14], Ahmad *et al.* (2009) [1], Akand *et al.* (2016) [2], Khan *et al.* (2016) [8], Nain *et al.* (2019) [11] and Islam *et al.* (2022) [7] in tuberose.

The soaking treatments had significant influence on vegetative growth parameters. The minimum days taken to bulb sprouting (12.62) was recorded in S_2 treatment (Thiourea @ 500 ppm) closely followed (12.76) by treatment S_4 and it was at par with treatment S_5 (13.98), S_1 (13.89) and S_3 (13.84). It seems that treating thiourea causes early sprouting because it breaks the dormancy of tuberose bulbs. The maximum plant height (25.82 cm and 44.74 cm) was recorded under treatment S_4 at the stage of 45 and 90 days after planting. Plant height was increased at the soaking treatment which might be due to enhancement of cell in terms of division and elongation occurring at shoot tips and this effect was due to increase in photosynthetic efficiency, improvement in mobilization of photosynthates, rapid increase in reducing sugars which leads to change in membrane permeability. Maximum number of leaves (24.08) at 45 days after planting was recorded in treatment S_4, which was at par with treatment S_6, S_2 and S_5 (22.86, 22.72 and 22.67, respectively) and (46.87) recorded under the treatment S_4 (GA_3 @ 200 ppm) at 90 days after planting followed by treatment S_6 (43.13). Gibberellic acid has beneficial effect on vegetative growth, which include boosting cambial activity, cell elongation, and activating RNA and protein synthesis, allowed for the maximum amount of leaves to be produced. Similar variation was observed by Dhua *et al.* (1987) [5], Tak and Nagda (1999) [18], Raja and Palanisamy (2000) [14], Singh *et al.* (2008) [16], Tyagi and Singh (2008) [19] and Dhumal *et al.* (2018) [6] in tuberose.

Table 1: Effect of different bulb size and soaking treatments on growth parameters

Treatments	Days taken to germination of bulb	Plant height (cm)		Number of leaves per clump	
		45 Days	90 Days	45 Days	90 Days
Bulb size (B)					
B_1	13.19	19.94	33.59	10.01	24.84
B_2	13.70	23.83	41.63	24.27	44.99
B_3	13.97	24.27	44.56	33.73	55.60
S.Em±	0.22	0.40	0.96	0.39	1.00
C.D.(P = 0.05)	0.62	1.14	2.74	1.11	2.84
Soaking treatments (S)					
S_1	13.89	20.87	35.79	21.30	38.42
S_2	12.62	23.01	39.88	22.72	40.59
S_3	13.84	22.58	40.07	22.40	40.99
S_4	12.76	25.82	44.74	24.08	46.87
S_5	13.98	22.64	39.21	22.67	40.86
S_6	14.62	21.17	39.88	22.86	43.13
S.Em±	0.31	0.56	1.36	0.55	1.41
C.D.(P = 0.05)	0.87	1.61	3.88	1.58	4.01
Interaction (B × S)					
S.Em±	0.53	0.98	2.36	0.96	2.44
C.D.(P = 0.05)	NS	NS	NS	NS	NS
C.V. (%)	6.75	7.47	10.24	7.32	10.11

Effect of bulb size and soaking treatments on flowering characters

The data presented in Table 2 shows significant influence in flowering characters of different bulb size. The minimum days taken to emergence of first spike was (77.46 days) recorded in large sized bulb (4.00-4.50 cm), being at par with treatment B_3 (79.48) and earliest opening of first floret (97.94 DAP) recorded in treatment B_3 closely followed by B_2 (102.87 DAP). The maximum longevity of intact spike (18.81 days) was found under the B_3 treatment, being at par with treatment B_2 (18.41 days). This could be the result of plants from small bulbs not producing enough nutrients, enzymes or hormones for flowering. The longest duration of flowering was recorded under large sized bulb B_3 (187.82 days) being at par with treatment B_2 (185.24 days). Similar findings were earlier reported by Dhua *et al.* (1987) [5], Raja and Palanisamy (2000) [14], Ahmad *et al.* (2009) [1], Akand *et al.* (2016) [2], Khan *et al.* (2016) [8], Nain *et al.* (2019) [11], Islam *et al.* (2022) [7] in tuberose.

Table 2: Effect of bulb size and soaking treatments on flowering characters

Treatments	Days taken for emergence of first spike	Days taken for opening of first florets	Longevity of intact spike	Duration of flowering
Bulb size (B)				
B_1	175.24	199.79	15.91	94.76
B_2	79.48	102.87	18.41	185.24
B_3	77.46	97.94	18.81	187.82
S.Em±	1.57	1.52	0.24	1.62
C.D.(P = 0.05)	4.46	4.33	0.67	4.62
Soaking treatments (S)				
S_1	115.74	139.94	16.89	150.70
S_2	110.74	133.48	18.31	156.48
S_3	111.23	134.56	17.00	155.43
S_4	105.36	126.68	18.96	161.31
S_5	108.69	131.93	17.21	157.98
S_6	112.61	134.60	17.89	153.72
S.Em±	2.22	2.15	0.33	2.29
C.D.(P = 0.05)	6.31	6.13	0.95	6.53
Interaction (B × S)				
S.Em±	3.84	3.73	0.58	3.97
C.D.(P = 0.05)	NS	NS	NS	NS
C.V. (%)	6.00	6.84	5.67	4.41

The soaking treatment had significant influence on flowering characters of tuberose. Minimum days taken for first spike initiation (105.36 days) recorded in treatment S_4 and this can be due to early flower primordial development, cell differentiation and early utilization of nutrients. The minimum days required for opening of first floret (126.68 DAP) reported with treatment S_4, being at par to treatment S_5 (131.93 DAP). The maximum longevity (18.96 days) recorded under the treatment S_4 being at par to treatment S_2 (18.31 days). Maximum duration (161.31 days) was recorded with treatment S_4, being at par to treatment S_5 (157.98 days), S_2 (156.48) and S_3 (155.43) treatments. Gibberellic acid treatment results in a continuous supply of photosynthetic assimilate for a longer period of time. Similar results were observed by Panwar *et al.* (2006) [12], Singh *et al.* (2008) [16], Singh *et al.* (2010) [17], Kurve *et al.* (2018) [10] and Dhumal *et al.* (2018) [6] in tuberose.

Effect of bulb size and soaking treatments on yield attributes

The results given in Table 3 exhibited that the effect of bulb size on yield attributes was observed significant. The maximum number of florets (41.81 spike^{-1}) recorded in large sized bulb B_3, which was found at par to treatment B_2 (40.75). The weight of spike (156.39 g) number of spikes (52.78 plot^{-1} and 651.58 thousand ha^{-1}), florets yield (3.13 kg plot^{-1} and 38.68 t ha^{-1}) and total number of harvesting of spike (5.22) were higher in large sized bulbs (4.00-4.50 cm diameter) followed by medium sized bulbs. Larger bulbs produced more flowers than smaller bulbs, because larger bulbs contain more stocks of metabolites. These results are in agreement with the finding of Sadhu and Das (1978) [15], Raja and Palanisamy (2000) [14], Ahmad *et al.* (2009) [1], Akand *et al.* (2016) [2], Khan *et al.* (2016) [8] and Islam *et al.* (2022) [7] in tuberose.

Table 3: Effect of bulb size and soaking treatments on yield attributes

Treatments	No. of florets spike^{-1}	Weight of spike (g)	Spike yield (number)		Florets yield		Weight of 100 florets (g)	No. of harvestings of spike
			Plot^{-1}	in '000 ha^{-1}	kg plot^{-1}	tonne ha^{-1}		
Bulb size (B)								
B_1	32.36	121.50	37.67	465.02	2.87	35.49	206.04	2.89
B_2	40.75	149.89	50.50	623.46	2.95	36.44	207.38	4.50
B_3	41.81	156.39	52.78	651.58	3.13	38.68	209.79	5.22
S.Em±	0.54	1.99	0.68	8.39	0.04	0.50	2.54	0.15
C.D.(P = 0.05)	1.55	5.66	1.93	23.87	0.12	1.43	NS	0.44
Soaking treatments (s)								
S_1	35.70	136.22	44.67	551.44	2.87	35.40	200.00	3.33
S_2	37.49	140.56	47.00	580.25	2.91	35.97	204.67	4.22
S_3	37.94	144.78	46.22	570.64	2.96	36.57	214.39	4.33
S_4	42.38	149.56	49.44	610.43	3.28	40.55	204.88	5.00
S_5	37.57	142.67	46.67	576.13	2.96	36.52	212.63	4.11
S_6	38.78	141.78	47.89	591.22	2.93	36.20	209.87	4.22
S.Em±	0.77	2.81	0.96	11.86	0.06	0.71	3.59	0.22
C.D.(P = 0.05)	2.19	8.00	2.73	33.76	0.16	2.03	NS	0.62
Interaction (B × S)								
S.Em±	1.33	4.87	1.66	20.54	0.12	1.23	6.21	0.38
C.D.(P = 0.05)	NS	NS	4.74	58.47	0.28	3.50	NS	NS
C.V. (%)	6.02	5.92	6.13	6.13	5.79	5.79	5.18	15.49

It is evident from the Table 3 that soaking treatments showed significant effect on yield attributes of tuberose. The maximum number of florets (42.38), total number of harvesting of spike (5.00) and maximum weight of spike (149.56 g) was recorded with treatment S_4, found at par to treatment S_3 (144.78 g) S_5 (142.67) and S_6 (141.78). This could be because of enhanced mobilisation and photosynthates to the spike, which led to the buildup of respirable substrates in the spike and possibly increased fresh weight of cut spikes. The highest number of spikes (49.44 plot^{-1} and 610.43 thousand ha^{-1}) and florets yield (3.28 kg plot^{-1} and 40.55 t ha^{-1}) was recorded in treatment S_4, which can be due to the action of GA, stimulating the conversion of storage polymers (polysaccharides, proteins and fats) into sucrose or mobile amino acids to facilitate their translocation via phloem into and throughout the young root and shoot system and thus influencing spike production. Similar findings was earlier reported by Panwar *et al.* (2006) [12], Singh *et al*. (2008) [16], Kumar and Gautam (2011) [9], Dhumal *et al*. (2018) [6] and Kurve *et al.* (2018) [10] in tuberose**.** The maximum number of spikes (57.33 plot^{-1} and 707.82 thousand ha^{-1}) and florets yield per plot (3.80 kg plot^{-1} and 46.87 t ha^{-1}) was obtained in treatment combination of B_3S_4.

The data presented in Table 4 shows significant influence on bulblets yield of different bulb size. The maximum number of bulblets (31.04 clump^{-1}, 288.40 plot^{-1} and 3560.49 thousand ha^{-1}) was recorded with large sized bulbs (4.00-4.50 cm). An increase in bulb size was shown to correspond with an increase in bulblets. These results are in harmony with those obtained by Sadhu and Das (1978) [15], Reddy and Singh (1997) [21], Arya *et al*. (2006), Ahmad *et al.* (2009) [1], Choudhury *et al*. (2010) [4], Wagh *et al*. (2012) [20], Khan *et al*. (2016) [8] and Islam *et al.* (2022) [7] in tuberose.

Table 4: Effect of bulb size and soaking treatments on bulblets yield

Treatments	Number of bulblets		
	Clump^{-1}	Plot^{-1}	in '000 ha^{-1}
Bulb size (B)			
B_1	22.80	214.20	2644.44
B_2	29.11	271.00	3345.68
B_3	31.04	288.40	3560.49
S.Em±	0.53	4.78	59.03
C.D.(P = 0.05)	1.51	13.61	168.01
Soaking treatments (S)			
S_1	25.96	242.60	2995.06
S_2	28.30	263.70	3255.56
S_3	28.40	264.60	3266.67
S_4	30.01	279.10	3445.68
S_5	26.87	250.80	3096.30
S_6	26.38	246.40	3041.98
S.Em±	0.75	6.76	83.48
C.D.(P = 0.05)	2.14	19.25	237.61
Interaction (B × S)			
S.Em±	1.30	11.71	144.59
C.D.(P = 0.05)	NS	NS	NS
C.V. (%)	8.15	7.87	7.87

The tuberose plants from treatment S_4 responded maximum number of bulblets (30.01 clump^{-1}, 279.10 plot^{-1} and 3445.68 thousand ha^{-1}) being at par to treatment S_3 (28.40 clump^{-1}, 264.60 plot^{-1} and 3266.67 thousand ha^{-1}) and S_2 (28.30 clump^{-1}, 263.70 plot^{-1} and 3255.56 thousand ha^{-1}). These results are in harmony with those obtained by Choudhury *et al.* (2010) [4], Kumar and Gautam (2011) [9] and Dhumal *et al*. (2018) [6] in tuberose.

Effect of bulb size and soaking treatments on quality parameters

The bulb size had significant influence on quality parameters of tuberose. Significantly longer spike length (78.19 cm), rachis length (56.05 cm) and vase life (9.06 days) reported with treatment B_3, being at par with treatment B_2 (8.72 days). Better vegetative development of the plant was most likely the cause of the increased spike length from the large bulb. Similar finding was earlier reported by Sadhu and Das (1978) [15], Dhua *et al.* (1987) [5], Ahmad *et al.* (2009) [1], Akand *et al.* (2016) [2] and Islam *et al.* (2022) [7] in tuberose.

The data given in Table 5 exhibits the maximum length of spike (73.68 cm) with the treatment S_4, was at par to S_2 (69.88) and S_6 (69.54). The reason for the increased spike length could be attributed to the rapid elongation of internodes resulting from enhanced cell proliferation and elongation in the intercalary meristem. Maximum length of rachis (56.58 cm) was found with treatment S_4 was found at par to S_6 (53.68). Because GA3 enhanced the conversion of storage polymers into sucrose or mobile amino acids to ease their transportation via vascular bundles to various regions such as root and shoot system and dry matter accumulation, taller plants were produced, which also resulted in higher rachis lengths. Maximum vase life of tuberose spike (9.33 days) was recorded with treatment S_4. This might be due to accumulation of more food materials in spike due to mobilization and translocation of photosynthates from increased number of leaves and leaf area in treated bulbs. Similar results were earlier reported in tuberose Panwar *et al*. (2006) [12], Singh *et al*. (2008) [16], Kumar and Gautam (2011) [9], Dhumal *et al.* (2018) [6] and Kurve *et al.* (2018) [10] in tuberose.

Table 5: Effect of bulb size and soaking treatments on quality parameters

Treatments	Spike length (cm)	Rachis length (cm)	Vase life (days)
	`		
B_1	53.93	44.47	8.44
B_2	74.97	54.41	8.72
B_3	78.19	56.05	9.06
S.Em±	1.18	0.75	0.13
C.D.(P = 0.05)	3.36	2.14	0.36
Soaking treatments (S)			
S_1	65.78	48.48	8.67
S_2	69.88	51.81	8.78
S_3	68.54	50.12	8.44
S_4	73.68	56.58	9.33
S_5	66.77	49.21	8.44
S_6	69.54	53.68	8.78
S.Em±	1.67	1.06	0.18
C.D.(P = 0.05)	4.75	3.02	0.51
Interaction (B × S)			
S.Em±	2.89	1.84	0.31
C.D.(P = 0.05)	NS	NS	NS
C.V. (%)	7.25	6.16	6.19

Conclusion

Based on the result of the study, it can be concluded that treatment of bulb size and soaking treatment, large sized bulb 4.00-4.50 cm along with the application of soaking treatment GA_3 @ 200 ppm was found superior in terms of growth, yield and quality of tuberose.

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