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Effect of bulb size, spacing and planting method on growth and flowering of tuberose (*Polianthes tuberosa* L.) cv. Prajwal

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ABSTRACT
An experiment was laid out with three bulb sizes (0.5-1.5 cm, 1.5-2.5 cm and 2.5-3.5 cm), two spacing (20x20cm and 30x30cm) and two planting methods (flat bed and ridge) in a randomized block design with three replications to study the individual and interaction effects on growth and flowering parameters in tuberose cv. Prajwal during 2016-17 and 2017-18. Results reveal that vegetative growth parameters viz. days taken to initiation of sprouting, days taken to complete sprouting decreased significantly when small size bulb (0.5-1.5 cm) planted at wider spacing (30x30 cm) on ridge while the maximum plant height was observed when large size bulb (2.5-3.5 cm) sown at closer spacing (20x20 cm) on ridge during both the years, respectively. The various flowering parameters viz. days taken to spike initiation and days to flowering decreased significantly when large size of bulb (2.5-3.5 cm) sown at closer spacing (20x20cm) on ridge while duration of flowering increased significantly when large bulb (2.5-3.5 cm) size planted at wider spacing (30x30 cm) on ridge.
Keywords: *Tuberose, Bulb Size, Spacing, Planting Method, Growth, Flowering*

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INTRODUCTION

Tuberose (*Polianthes tuberosa*L.), commonly called as "Rajnigandha, a member of Asparagaceae family is an ornamental bulbous plant native to Mexico. It is one of the most important cut flowers in tropical and subtropical areas. Tuberose occupies a very special position among the ornamental bulbous plants. The slow delightful fragrance and excellent keeping quality are the major characteristics of this crop. It has a great value for economic potential, cut and loose flower trade and essential oil industry. The spikes fragrant in vase for 10-15 days. The tuberose oil one of the most expensive raw material for perfume industry. Tuberose concrete and absolute are great demand due to its expensive and high grade perfumery qualities. The flower spike is used as a cut flower in vases whereas, the individual florets are harvested for making garlands and veins. To meet the increasing demand of domestic market and the value added products from tuberose, there is a need to increase the productivity of this crop. Tuberose grows productively in the warm areas of India. Commercial cultivation of tuberose in India is confined to West Bengal, Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra. The successful cultivation is influenced by various optimum bulb size, spacing and planting method. The plant spacing is one of the most important factors, which influences the yield, quality and quite often the earliness of the respective cultivar [6]. Consequently, the number of plants per unit area indirectly affects the production costs and profitableness. Overcrowding of crops may reduce yields and produces lower quality of the product produced due to competition for light and soil nutrients. Large size bulbs and wider spacing influence the productivity as well as quality of flowers due to more space and sunlight available and maximum reserved food in the big size corms in gladiolus [4].Considering the present situation and above facts, the present investigation was undertaken with the objective to determine the optimum bulb size, spacing and planting method for better growth and flowering of tuberose.

MATERIAL AND METHODS

The experiment was conducted at experimental farm at CCS Haryana Agricultural University, Hisar during 2016-17 and at Botanical Garden of the Department of Plant Physiology, CCS Haryana Agricultural University, Hisar during 2017-18todetermine the optimum bulb size, spacing and planting method on growth and flowering parameters of tuberose cv. Prajwal. The field was prepared well in advance by bringing the soil to a fine tilth by repeated ploughing and planking. Beds were prepared by maintaining plot bed size 1.5 m × 1.5 mfor planting of bulbs. Experiment was laid out in randomized block design having twelve treatments and replicated thrice. Prajwal cultivar was selected to carry out this experiment. In this study three bulb size (0.5-1.5, 1.5-2.5 and 2.5-3.5 cm), two levels of spacing (20×20 and 30×30 cm) and two planting method (flat bed and ridge) were applied. The soil pH was8.10 and 7.05 and E.C. was 1.13 and 1.40 dSm-1 during both the years, respectively. Bulbs of different sizes were selected and treated with Bavistin 0.1 percent solution for 20minutes, a day before planting and allowed to dry overnight under shade. The various observations on growth and floral parameters we rerecorded on five plants randomly selected from net plot are and tagged. The data collected from 2 years were subjected to statistical analysis by' Analysis of Variance' (ANOVA) technique as suggested by Panse and Sukhatme [12].

RESULTS AND DISCUSSION

Plant Growth Characters

Days taken to bulb sprouting

The data presented in Table 1 depict that bulb size, spacing and planting method significantly affecteded the days taken to initiate sprouting of bulb in tuberose plants during 2016-17 and 2017-18. Theminimum number of days taken to bulb sprouting (36.14 and 44.44) was observed in small bulb size (B_1),while themaximum number of days taken to bulb sprouting (39.10 and 48.82) was observed in large bulb size (B_3) irrespective of spacing and planting method. Small bulbs sprouted early due to higher metabolic activity in apical reason of bulbs. These above results are in conformity with the results of Pathak *et al.*1980 and Sandhu and Das [17] in tuberose. The number of days taken to bulb sprouting decreased with increase in the levels of spacing. The minimum number of days taken for bulb sprouting (36.66 and 43.42) was observed in wider spacing (S_2),while the maximum days taken to bulb sprouting (38.92 and 49.57) was recorded in closer spacing (S_1) irrespective of bulb size and planting method.This might be due to less competition among the plants for nutrients, moisture, space and light at wider spacing, which resulted in shortening of sprouting period and early sprouting of bulbs occurred. Further, the minimum days for sprouting of bulb was found (35.91 and 43.68) when planting was done on ridges (P_2), whilethe maximum days taken to bulb sprouting (39.67 and 49.30) was obtained when bulbs sown on flat bed (P_1)during both the years, respectively. This might be due to better aeration in soil of ridges to a large extent [9], which improved the uptake of nutrients because of high rate of root respiration and ultimately health of the plant, which reduced days taken to initiation of sprouting and to complete sprouting

Table 1 Effect of bulb size, spacing and planting method on days taken to initiation of sprouting in tuberose 2016-17 and 2017-18

Planting Method	Bulb size× Spacing × Planting method											
	Bulb size (cm)											
	B_1: 0.5-1.5				B_2: 1.5-2.5				B_3: 2.5-3.5			
	Spacing (cm)											
	S_1: 20×20		S_2: 30×30		S_1: 20×20		S_2: 30×30		S_1: 20×20		S_2: 30×30	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
P_1: Flat bed	36.88	51.79	40.10	44.85	40.04	51.21	39.05	47.09	44.59	52.85	37.34	48.02
P_2: Ridge	34.69	42.96	32.90	38.17	37.51	46.05	35.92	40.52	39.79	52.53	34.68	41.86
	(B1)				(B2)				(B3)			
Overall mean (B)	2016-17		2017-18		2016-17		2017-18		2016-17		2017-18	
	36.14		44.44		38.13		46.22		39.10		48.82	
Overall mean (S)	(S1)				(S2)							
	38.92		49.57		36.66		43.42					
Overall mean (P)	(P1)				(P2)							
	39.67		49.30		35.91		43.68					

Sr. No.		CD at 5% level of significance 2016-17	2017-18
1	Bulb size	0.64	1.38
2	Spacing	0.52	1.13
3	Planting method	1.52	1.13
4	Bulb size x spacing x planting method	1.27	2.77

Bulb size, spacing and planting method interaction (BxSxP) had significant effect on days taken to bulb sprouting. The minimum days required for sprouting of bulbs (32.90 and 38.17) was observed when small size bulb planted in wider spacing on ridge ($B_1S_2P_2$), while the maximum number of days required for sprouting of bulbs (44.59 and 52.85) was recorded when large bulb size bulb planted in closer spacing on flat bed ($B_3S_1P_1$) and during both the years, respectively.

Days taken to complete sprouting

The data concerning to days taken to complete sprouting in Table 2 resulted that bulb size, spacing and planting method significantly affected the days taken to complete sprouting in tuberose plants during 2016-17 and 2017-18. The minimum number of days taken to complete sprouting of bulb (38.32 and 46.68) was observed in small bulb size (B_1), while the maximum number of days taken to complete sprouting (41.37and 50.99) was observed in large bulb size (B_3) irrespective of spacing and planting method. The minimum number of days taken to complete bulb sprouting (38.75 and 45.68) was observed in wider spacing (S_2) whereas, the maximum days taken to complete sprouting (41.09 and 51.96) was recorded in closer spacing (S_1) irrespective of bulb size and planting method. Further, the interpretation data reveal that the minimum days for complete sprouting of bulb was found (37.92 and 46.05) when planting was done on ridges (P_2) and the maximum days taken to complete sprouting (41.92 and 51.59) was obtained when bulbs sown on flat bed (P_1) during both the years, respectively. This might be due to better aeration in soil of ridges to a large extent [9], which improved the uptake of nutrients because of high rate of root respiration and ultimately health of the plant, which reduced days taken to initiation of sprouting and to complete sprouting.

Bulb size, spacing and planting method interaction (BxSxP) had significant effect on days taken to complete sprouting of bulb. The minimum days required for sprouting of bulbs (34.37 and 40.95) was observed when small size bulb planted in wider spacing on ridge ($B_1S_2P_2$), while the maximum number of days required for complete sprouting of bulbs (46.24 and 54.72) was recorded when large bulb size bulb planted in closer spacing on flat bed ($B_3S_1P_1$) and during both the years, respectively.

Plant height (cm)

The perusal of data presented in Table 3 show that bulb size, spacing and planting method significantly influenced the plant height of tuberose plants during 2016-17 and 2017-18. The maximum plant height (70.68 and 92.42 cm) was observed in large bulb size (B_3), while the minimum plant height (63.37 and 86.97) was observed in small bulb size (B_1) irrespective of spacing and planting method.This might be due to the region that larger bulbs had more stored food and moisture, which increased much root formation, thus plant height [5], [20] , [16], [1], [3] in tuberose and [12] in gladiolus.

The plant height decreased with increases the levels of spacing. The maximum plant height (67.77 and 92.04 cm) was recorded in closer spacing (S_1)which might be due to more competition for light. [8] recorded similar results in tuberose.The minimum plant height (65.37 and 86.82 cm) was observed in wider spacing (S_2) irrespective of bulb size and planting method. Further, the maximum plant height (67.70 and 89.78 cm) was obtained when bulbs sown on ridge (P_2).This might be due to better aeration in soil of ridges to a large extent [9], which improved the uptake of nutrients because of high rate of root respiration and ultimately health of the plantwhile, minimum plant height was found (65.43 and 89.09 cm) when planting was done on flat bed (P_1) during both the years, respectively.

The interaction between bulb size and spacing (BxS) significantly affect the plant height during 2016-17 and 2017-18. The plant height (70.92 and 94.81 cm) was maximum in large bulb size with closer spacing (B_3S_1), while the plant height (62.68 and 83.80 cm) was observed minimum in small bulb size with wider spacing (B_1S_2) during the year, respectively.

Likewise, the interaction between bulb size and planting method (BxP) significantly affect the plant height during 2017-18. The maximum plant height (93.83 cm) was recorded when large size bulb planted on ridge (B_3P_2), while minimum plant height (85.54 cm) was observed when small size of bulbs sown on ridges (B_1P_2). No interaction effect was found between the bulb size and planting method during the year 2016-17.

Table 3 Effect of bulb size, spacing and planting method plant height in tuberose 2016-17 and 2017-18

Planting Method	Bulb size × Spacing × Planting method											
	Bulb size (cm)											
	B_1: 0.5-1.5				B_2: 1.5-2.5				B_3: 2.5-3.5			
	Spacing (cm)											
	S_1: 20×20		S_2: 30×30		S_1: 20×20		S_2: 30×30		S_1: 20×20		S_2: 30×30	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
P_1: Flat bed	65.16	88.03	63.65	83.04	70.33	93.70	64.02	86.28	69.85	92.46	71.08	90.48
P_2: Ridge	62.95	92.26	61.71	84.55	66.32	88.71	61.94	86.99	71.99	97.16	69.80	89.59
	(B1)				(B2)				(B3)			
Overall mean (B)	2016-17		2017-18		2016-17		2017-18		2016-17		2017-18	
	63.67		86.97		65.65		88.92		70.68		92.42	
Overall mean (S)	(S1)				(S2)							
	67.77		92.06		65.37		86.82					
Overall mean (P)	(P1)				(P2)							
	65.43		89.09		67.70		89.78					
CD at 5%												

Sr. No.		CD at 5% level of significance 2016-17	2017-18
1	Bulb size	0.85	0.71
2	Spacing	0.69	0.58
3	Planting method	1.20	0.58
4	Bulb size x spacing x planting method	NS	1.42

Flowering characters

Days taken to spike initiation

The data recorded for days taken to spike initiation have been presented in Table 3 show that bulb size, spacing and planting method significantly influenced the days taken to spike initiation of tuberose plants during 2016-17 and 2017-18. The minimum number of days taken to spike initiation (103.81 and 97.55) was observed in large bulb size (B_3), while the maximum number of days taken to spike initiation (112.17 and 109.96) was observed in small bulb size (B_1) irrespective of spacing and planting method. Early spike emergence might be due to more food reserves in larger bulbs. The results of present study were in agreement with [7], [11], [15] and [14].The number of days taken to spike initiation increased with increases the levels of spacing. The minimum days taken to spike initiation (105.48 and 99.14) was recorded in closer spacing (S_1) and the maximum number of days taken to spike emergence (109.74 and 107.12) was observed in wider spacing (S_2) irrespective of bulb size and planting methodwhich might be due to reduction in growth at narrow spaces, which directed the plants toward the reproductive phase earlier than the plant that had more vegetative growth at wider spacing. [10]in tuberose and [2] in gladiolus recorded similar results.

Further, the minimum days taken to spike initiation (105.73 and 101.47) was obtained when bulbs sown on ridge (P_2) and maximum days for spike initiation was found (109.48 and 104.80) when planting was done on flat bed (P_1) during both the years, respectively. Conflicting results were found regarding the flowering parameters *viz.* number of days taken to flowering, duration of flowering, length of spike, length of rachis and number of florets per spike in tuberose [18].

Bulb size, spacing and planting method interaction (BxSxP) had significant effect on days taken to spike initiation. The minimum number of days required for spike initiation (100.41 and 94.32) was recorded when large size bulb planted in closer spacing on ridge ($B_3S_1P_2$) and maximum days required for spike initiation (120.71 and 115.57) was observed when small size bulb planted in wider spacing on flat bed ($B_1S_2P_1$) during both the years, respectively.

Days to flowering

The data on days taken to floweringpresented in Table 4 show that bulb size, spacing and planting method significantly influenced the days taken to flowering in tuberose plants during 2016-17 and 2017-18. The minimum number of days taken to flowering (138.20 and 120.61) was observed in large bulb size (B_3), while the maximum number of days taken to flowering (146.17 and 125.51) was observed in small bulb size (B_1) irrespective of spacing and planting method. Early spike emergence might be due to more

food reserves in larger bulbs. These are in alliance with the results of Khan *et al.,* 2016a. These results are in agreement with the finding of [1], [19] and [3] in tuberose.

The number of days taken to flowering increased with increasing the levels of spacing. The minimum days taken to flowering (137.91 and 119.46) was recorded in closer spacing (S_1) and the maximum number of days taken to flowering (144.42 and 126.08) was observed in wider spacing (S_2) irrespective of bulb size and planting method. It might be due to reduction in growth at narrow spaces, which directed the plants toward the reproductive phase earlier than the plant that had more vegetative growth at wider spacing. [10]in tuberose and [2] in gladiolus recorded similar results.

Further, the minimum days taken to flowering (140.17 and 121.44) was obtained when bulbs sown on ridge (P_2) and maximum days for flowering was found (142.17 and 124.10) when planting was done on flat bed (P_1) during both the years, respectively.

Bulb size, spacing and planting method interaction (BxSxP) had significant effect on days taken to flowering during 2016-17. The minimum number of days required for flowering (134.60) was recorded when large bulb size bulb planted in closer spacing on ridge ($B_3S_1P_2$) and maximum days required for sprouting (156.93) was observed when small size bulb planted in wider spacing on flat bed ($B_1S_2P_1$). No interaction effect was found between the bulb size, spacing and planting method during the year 2017-18.

Duration of flowering

The data concerning to duration of flowering are presented in Table 5 show that bulb size, spacing and planting method significantly affectedthe duration of flowering in tuberose plants during 2016-17 and 2017-18. The maximum duration of flowering (12.90 and 11.89) was observed in large bulb size (B_3), while the minimum duration of flowering (9.50 and 10.72) was observed in small bulb size (B_1) irrespective of spacing and planting method. The duration of flowering increased with increases the levels of spacing. The maximum duration of flowering (11.86 and 12.30) was recorded in wider spacing (S_2) and the minimum duration of flowering (10.60 and 10.11) was observed in closer spacing (S_1) irrespective of bulb size and planting method. Increase in duration of flowering with wider spacing might be due to the fact that the closer spacing hampered intercultural operations and as such more competition arose among the plants for nutrients, moisture, space and light. As a result, the plant became weaker, thinner and consequently affected the flower parameters.

Further, the maximum duration of flowering (11.75 and 12.22) was obtained when bulbs sown on ridge (P_2) and minimum duration of flowering was found (10.71 and 10.20) when planting was done on flat bed (P_1) during both the years, respectively.

Bulb size, spacing and planting method interaction (BxSxP) had significant effect on duration of flowering. The maximum duration of flowering (14.42 and 14.69) was recorded when large size bulb planted in wider spacing on ridge ($B_3S_2P_2$) and minimum duration of flowering (8.80 and 9.35) was observed when small size bulb planted in closer spacing on flat bed ($B_1S_1P_1$) during both the years, respectively.

CONCLUSION

It may be concluded from the present study that days taken to bulb sprouting and complete sprouting decreased significantly when cultivation of tuberose with small bulb size of diameter (0.5-1.5 cm) planted at wider spacing (30x30 cm) on ridge while the maximum plant height (71.99 and 97.16 cm) was observed when large size bulb (2.5-3.5 cm) sown at closer spacing (20x20 cm) on ridge during both the years, respectively. The floral characters viz., days taken to emergence of spike, days to flowering decreased when large bulb (2.5-3.5cm) planted at closer spacing (20x20 cm) on ridge while duration of flowering increased significantly when large bulb (2.5-3.5cm) planted at wider spacing (30x30 cm) on ridge.

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