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Response of spacing and nitrogen levels on tuberose (*Polianthes tuberosa* L.) cv. Pune Single

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Abstract
An investigation was carried out at Nursery No 4 farm of Horticulture at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during 2017 to 2019 to find out the response of spacing and nitrogen levels on growth and yield of tuberose spikes and bulb production. Among various interactions maximum plant height (33.28 cm), number of leaves (40.66), maximum average spread (34.17 cm) found in S_3N_4 (Wider spacing-30 cm x 30 cm and higher nitrogen level 250:50:50: kg NPK/ha).Closer spacing and higher nitrogen level (S_1N_4) contributed maximum leaf area (38.19 cm^2) and maximum LAI (1.27) in S_1N_4 but early commencement of flowering (81.96), days for 50 percent flowering (101.81) and duration of flowering (39.90) was recorded by in S_2N_4. Closer spacing and higher nitrogen level (S_1N_4) significantly influenced Spike length (82.89 cm), number of florets per plant, diameter of flower (0.75 mm), fresh weight of 100 flowers (125.44 g) also maximum yield of spike per plant (1.27), per plot (90.13), flower yield per plot (3.46 kg) and per hectare (192.36 q) was obtained maximum in. Similarly maximum bulb yield per plant (1.53), bulb yield per plot (4.76 kg) and per hectare (199.95 q) was obtained in same interaction. The available nitrogen from soil (kg ha^{-1}) after harvest of crop was obtained maximum at S_3N_2 (wider spacing and 150:50:50: kg NPK/ha.) interaction (257.42 kg ha^{-1}). Available uptake of nitrogen from plant at final stage was obtained maximum (63.20 kg ha^{-1}) at S_1N_4 interaction. In S_1N_1 interaction it was observed that available phosphorus from soil (7.66 kg ha^{-1}) was maximum while uptake of phosphorus from plant at final stage was obtained maximum (11.96 kg ha^{-1}) in S_1N_4 interaction. In pooled results at S_2N_4 available potassium from soil (383.93 kg ha^{-1}) after harvest of crop was obtained maximum while uptake of potassium from plant (84.99 kg ha^{-1}) at final stage was obtained maximum at S_1N_4 interaction. As S_1N_4 (closer spacing and 250:50:50 NPK kg ha^{-1}) was superior in yield of spikes and bulbs which ultimately generated maximum net returns (Rs.4,36,953.8/-) and recorded highest B:C ratio (2.10).

Keywords: Tuberose, spacing, nitrogen, interaction

Introduction
Among the ornamental bulbous plants which are valued much for their aesthetic, beauty and fragrance of flowers, the tuberose (*Polianthes tuberosa* L.) occupies a very selective and special position for flower loving people, because of their prettiness, elegance and sweet pleasant fragrance. It has a great potential for cut flower trade and essential oil industry (Sadhu and Bose, 1973) [23]. It is among a few flowers, which has got good export potential. The maximum flower yield and quality of flowers can be achieved by adopting standard package of cultural and management practices like spacing, optimum dose of fertilizers, irrigation, plant protection etc. To optimize the Spacing level and nitrogen levels is important as far as production is concerned. Nitrogen and phosphorous plays a vital role in obtaining maximum yield with good quality (Yadav, 1985) [27]. Konkan soils are rich in potash content and according to Chadha, 1986 [5] potash has no role in growth and flowering, therefore study on application of different / graded levels nitrogen levels in tuberose is essential. Agro-climatic conditions and soils of Konkan region are suitable for commercial cultivation of tuberose therefore it can be commercial flower crop of this region in near future. At present no research work has been carried out on optimum spacing, nutrient management under konkan-Agroclimatic condition. This research information will be useful for the florist and research workers in the other region also.

Material and Methods
The experiment was conducted at the Nursery no.4 block of Floriculture at Department of Horticulture, College of Agriculture, Dr. Balasaheb Sawant Krishi Vidyapeeth, Dapoli,

Dist-Ratnagiri (M.S) during 2017-18 and 2018-19 respectively. The experiment was carried out in split plot design with three replications and two factors *viz.*, Spacing levels i.e,. S_1- 30 cm x 10 cm, S_2 - 30 cm x 20 cm, S_3- 30 cm x30 cm and Nitrogen levels (Kg/ha) i.e. N_1 – 100:50:50, N_2 – 150:50:50, N_3 – 200:50:50, N_4 – 250:50:50. The statistical analysis of the data was done by standard methods of analysis of variance as given by Panse and Sukhatme (1985) [17].

Results and Discussion

The effect of different spacing levels and nitrogen levels (Kg/ha) on tuberose cv. Pune Single were studied with respect to growth, flowering and yield parameters. In vegetative parameters (Table 1) among the various interactions S_3N_4 (wider spacing and 250:50:50: kg NPK/ha.) recorded maximum plant height (33.28 cm) while minimum in S_2N_1 (27.05), maximum number of leaves per plant (40.66) recorded in S_3N_4 while minimum in S_1N_1 (31.91), maximum average spread (34.17 cm) found in S_3N_4 while minimum average plant spread (26.14 cm) recorded in S_2N_1, maximum leaf area (38.19 cm^2) recorded in S_1N_4 while minimum leaf area (30.20 cm^2) in S_3N_1 and maximum LAI (1.27) found in S_1N_4 and minimum in S_2N_1 and S_3N_1 (1.01). Desai and Mamatha (2016) [7]. who reported that spacing 30 cm x 30 cm was found to be promising with respect to plant height in tuberose variety Prajwal while, lowest plant height was reported at spacing 30 cm x 15 cm at Tumkur district of Karnataka. Nitrogen levels has promotory effect on plant height in tuberose cv. Pune single, higher doses of nitrogen enhanced rapid vegetative growth which ultimately increased plant height. These results are in close conformity with the results reported by Bharti *et al.* (2016) [3] who noted that increasing levels of NPK up to 250:320:200 kg NPK/ha has showed a significant effect on plant growth. These results are in accordance with Desai and Mamatha (2016) [7]. who reported that the spacing 30 x 30 cm was found to be promising with respect to maximum number of leaves per plant at 360 DAP in tuberose variety of Prajwal in Tumkur district of Karnataka. Singh *et al.* (2014) [24] who noted that number of leaves increased with increasing NPK levels up to 180:360:180 NPK kg/ha. The maximum number of leaves/plant (33.73) at 90 DAP were recorded under the treatment receiving 180:360:180 NPK kg/ha which was at par with 200:400:200 NPK kg/ha. Wider spacing in combination with higher nitrogen levels resulted into more leaf production per plant. Plant spread at a wider spacing was more due to more space available to the plant for its growth. Similar results were obtained by Bhattacharjee *et al*. (1979) [4], Mukhopadhyay *et al*. (1981) [16] and Ambad *et al*. (1997) [2] in tuberose. Wider spacing and maximum nitrogen levels helped in obtaining maximum average spread of plant. Maximum leaf area at medium and wider spacing was contributed by more number of leaves and average spread of the plant. These results are in close conformity with the reports of Suseela *et al.* (2016) [25] who stated effect of spacing levels in tuberose. Maximum leaf area is obtained with increase in level of nitrogen doses. These results are in accordance with Aklade *et al.* (2016) [1] who observed that the leaf area was maximum (305.24 cm^2) in heliconia, where application of nitrogen was at 200 kg $ha.^{-1}$ In Flowering attributes (Table 2) minimum days (81.96 days) for commencement of flowering obtained in S_1N_4 and minimum days for 50 percent flowering (101.81 days) noted in S_1N_4 interaction, maximum duration of flowering (39.90 days) in S_2N_4,maximum spike length (82.89 cm) was obtained in S_1N_4 whereas minimum spike length (71.28 cm) was obtained in S_1N_1 interaction, maximum number of florets per plant (33.34) recorded in S_2N_4 and minimum in S_1N_1 (26.31), maximum diameter of flower obtained in S_1N_4 (0.75 mm) and minimum in S_1N_1 (0.60 mm), maximum fresh weight of 100 flowers (125.44 g) was obtained in S_1N_4 and minimum in S_2N_1 (115.88).Closer spacing produced early flowering and the present investigation is contradictory with the results obtained by Aklade *et al.* (2016) [1] that significantly minimum number of days (214.00) for first flower appearance, was obtained under closer spacing in tuberose. Nitrogen helps in fast vegetative growth which leads to early reproductive phase and also promoted the translocation of phytohormones to the shoot which probably induced early flower initiation. These results are in close association with the Rajwal and Singh (2006) [20]. who studied the effects of various N rates (100, 125 and 150 kg/ha) on the performance of *P. tuberosa* (cv. Double) in Muzaffarnagar, Uttar Pradesh, India, during 2002-03. The minimum (89.87) number of days to the opening of flowers was recorded in 125 kg N/ha. Swetha *et al.* (2018) [26] who reported in Asiatic lily lowest number of days taken to 50% flowering (60.48 days) was recorded at the spacing of 15 cm x 15 cm. Maximum duration of flowering was observed at medium and wider spacing which are in association with Rana *et al.* (2005) [21] in gladiolus at Horticulture Research Farm of C.C.S., University, Meerut, during 2000-2001 and 2001-2002 who reported that medium spacing 30 cm x 20 cm produced the maximum duration of flowering (15.79 days). Priyanka *et al.* (2018) [18] who reported that closer spacing and moderate fertilizer dose exhibited maximum duration of flowering. Kumar *et al.* (2016) [13] who reported that maximum spike length (81.56 cm) in medium spacing 30 cm x 40 cm in gladiolus also Mane *et al* [15]. (2007) who noted that longest spike length was produced (86.79 cm) in treatment wider spacing (20 x 25 cm^2) in tuberose. Maximum level of nitrogen has enhanced the growth of spike and the results are in close conformity with the Dhakal *et al.* (2017) [8] who reported that nitrogen 150 kg/ha and Phosphorous 100 kg/ha produced more spike length (76.54 cm) and less spike length was obtained with control treatment (62.43 cm).Mane *et al.* (2007) [15] who reported that highest number of florets per spike (26.31) in treatment with wider spacing. These results are in accordance with Gowthami *et al.* (2017) [9] who reported that significantly maximum number of florets/spike (576.29) were recorded with 150 kg N + 60 kg K ha^{-1} followed by 100 kg N + 120 kg K ha^{-1} (N_2K_2) in crossandra. Malam *et al.* (2010) [14] who concluded that increased in no. of florets with increase in spacing (45 cm x 45 cm and 45 cm x 30 cm) and produced the maximum diameter of open flowers (4.6 cm) in tuberose. Also Priyanka *et al.* (2018) [18] who concluded that 100 flower weight was found maximum in closer spacing in crossandra. Similar results were obtained by Khalaj (2012) [12]. who reported that increasing doses of nitrogen from 0 to 250 kg/ha increased floret weight. In yield parameters(Table 3) maximum number of spike per plant (1.27) was obtained in S_1N_4 and minimum (1.01) in S_2N_1 and S_3N_1, maximum number of spikes per plot (90.13) was obtained in S_1N_4 and minimum (28.00) in S_3N_1, maximum flower yield per plot (3.46 kg) was obtained in S_1N_4 while minimum (0.73 Kg) in S_3N_1, maximum flower yield per hectare (192.36 q) was obtained in S_1N_4 while minimum

(40.59 q) in S_3N_1, maximum bulb yield per plant (1.56) was obtained in S_2N_4 while minimum (1.12) in S_1N_1, maximum bulb yield per plot (4.76 kg) was obtained in S_1N_4 while minimum (1.20 Kg) in S_3N_1, bulb production per hectare (264.42 q) was obtained in S_1N_4 while minimum (66.88 q) in S_3N_1. In soil and plant analysis (Table 4) The available nitrogen from soil (kg ha^{-1}) after harvest of crop was obtained maximum at S_3N_2 (wider spacing and 150:50:50: kg NPK/ha.) interaction (257.42 kg ha^{-1}). Available uptake of nitrogen from plant at final stage was obtained maximum (63.20 kg ha^{-1}) at S_1N_4 interaction. In S_1N_1 interaction it was observed that available phosphorus from soil (7.66 kg ha^{-1}) was maximum while uptake of phosphorus from plant at final stage was obtained maximum (11.96 kg ha^{-1}) in S_1N_4 interaction. In pooled results at S_2N_4 available potassium from soil (383.93 kg ha^{-1}) after harvest of crop was obtained maximum while uptake of potassium from plant (84.99 kg ha^{-1}) at final stage was obtained maximum at S_1N_4 interaction. The perusal of data presented in table 5 revealed that interaction S_1N_4 (closer spacing and 250:50:50 NPK kg ha^{-1})was superior in yield of spikes and bulbs which ultimately generated maximum net returns (Rs.4,36,953.8/-) and recorded highest B:C ratio (2.10).The number of spikes per plant were observed maximum at closer spacing these results are in close conformity with Suseela *et al.* (2016) [25] who concluded that maximum spikes per plant (3.65) were obtained in spacing 45 cm x 30 cm. These results are in close association with Karuppaia (2019) [10] who observed that the number of spikes per plant (4.55) were observed more in the treatment 25tha^{-1} FYM+ Recommended dose of 200:200:200 kg ha^{-1}NPK+Zinc sulphate @ 0.50%+Borax @ 0.50% on 30, 60 and 90 DAP). From the investigation it could be seen that maximum spike yield in S_1 plot might be due to highest plant population per unit area. These results are in close association with results of Ranchana *et al.,* (2013) [22]. Chandana and Dorajeerao (2014) [6] in gladiolus who reported that highest spike yield per plot (56.34) was recorded by N_4 (400kgha $^{-1}$) which was at par (54.27) with nitrogen-300kg ha $^{-1}$. Maximum flowers yield kg per plot reported by Swetha *et al.* (2018) [26]. Priyanka *et al.* (2017) [19] who reported that treatment F_4 (75:45:45 kg NPK + 18.75 t FYM + 5 t Vermicompost /ha) registered maximum flower yield per hectare (4.82 t). Bharti *et al.* (2016) [3] who reported that highest yield of bulbs (t/ha^{-1}) was recorded in (T_9) 225:290:180 NPK kg ha^{-1} 18.17 followed by (T_{10}) 250:320:200 NPK kg ha^{-1}(18.03). Kejkar and Polara (2015) [11]. who reported that the bulb yield per hectare was significantly increased with addition of nitrogen from 0 to 400 kg ha^{-1}, Nitrogen @ 400kg ha^{-1} (N_3) recorded significantly maximum bulb yield (43.16 t ha^{-1}) as compared to 300kg N ha^{-1} and 200kg N ha^{-1}.

Table 1: Effect of spacing levels and nitrogen levels on vegetative parameters in tuberose cv. Pune Single

Treatments	Plant height (cm)	Number of leaves (No.)	Average plant spread (cm)	Average leaf area (cm^2)	Leaf area index
S_1N_1	29.54	31.91	28.56	31.21	1.04
S_1N_2	30.24	32.91	29.53	31.66	1.06
S_1N_3	30.29	33.78	29.64	35.37	1.18
S_1N_4	31.92	35.48	31.81	38.19	1.27
S_2N_1	27.05	33.86	26.14	30.43	1.01
S_2N_2	28.89	34.39	28.26	31.98	1.07
S_2N_3	31.61	38.67	31.13	34.39	1.15
S_2N_4	32.72	39.29	32.52	35.40	1.18
S_3N_1	29.67	35.66	32.51	30.20	1.01
S_3N_2	31.88	36.34	32.89	31.67	1.06
S_3N_3	32.23	36.66	33.32	33.41	1.11
S_3N_4	33.28	40.66	34.17	34.46	1.15
S.Em.±	0.33	0.42	0.32	0.32	0.01
C.D.@5%	0.46	1.20	0.91	0.92	0.03

Table 2: Effect of spacing levels and nitrogen levels on flowering parameters in tuberose cv. Pune Single

Treatments	Days for commencement of flowering	Days for 50 percent flowering	Duration of flowering (days)	Spike length (cm)	Number of florets per plant	Diameter of flower stalk (mm)	Fresh weight of 100 flowers (g)
S_1N_1	98.88	119.82	30.05	71.28	26.31	0.60	117.13
S_1N_2	96.69	116.85	31.45	75.54	27.42	0.70	119.00
S_1N_3	93.80	112.07	33.79	80.18	30.73	0.73	120.96
S_1N_4	81.96	101.81	39.37	82.89	33.22	0.75	125.44
S_2N_1	96.56	118.83	34.72	74.13	28.95	0.71	115.88
S_2N_2	92.20	119.21	36.08	78.64	30.32	0.71	118.94
S_2N_3	89.82	111.93	37.67	79.06	32.92	0.72	119.63
S_2N_4	83.29	104.60	39.90	81.63	33.34	0.74	122.63
S_3N_1	97.88	117.29	34.74	75.63	29.77	0.71	120.94
S_3N_2	92.84	116.08	36.40	75.48	30.11	0.74	122.63
S_3N_3	87.28	116.98	37.42	78.02	30.36	0.74	122.00
S_3N_4	84.97	114.41	36.68	78.65	31.10	0.73	123.09
S.Em.±	0.68	1.49	0.54	0.75	0.35	0.01	1.12
C.D.@5%	1.95	4.31	1.53	2.14	1.01	0.03	3.25

Table 3: Effect of spacing levels and nitrogen levels on yield parameters in tuberose cv. Pune Single

Treatments	No. of spikes per plant	No. of spikes per plot	Flower yield Kg per plot	Flower yield q ha^{-1}	Bulb production per plant	Number of bulbs per plot	Bulb production Kg per plot	Bulb production q ha^{-1}
S_1N_1	1.04	66.50	1.71	95.09	1.12	68.00	2.96	164.63
S_1N_2	1.06	67.38	1.86	103.57	1.13	67.75	3.06	169.94
S_1N_3	1.18	76.88	2.33	129.40	1.29	77.85	3.61	200.82
S_1N_4	1.27	90.13	3.46	192.36	1.53	92.35	4.76	264.42
S_2N_1	1.01	39.38	1.15	64.00	1.32	38.75	1.53	84.80
S_2N_2	1.07	42.88	1.37	76.12	1.44	43.00	1.88	104.69
S_2N_3	1.15	44.75	1.62	90.18	1.50	44.99	2.06	114.25
S_2N_4	1.18	46.38	1.69	93.99	1.56	46.50	2.22	123.19
S_3N_1	1.01	28.00	0.73	40.59	1.42	28.38	1.20	66.88
S_3N_2	1.06	28.75	0.84	46.94	1.46	29.13	1.28	71.14
S_3N_3	1.11	29.13	0.89	49.22	1.49	29.88	1.43	79.48
S_3N_4	1.15	30.75	1.05	58.15	1.51	30.25	1.53	84.78
S.Em.±	0.01	1.60	0.07	3.98	0.03	1.62	0.09	5.18
C.D.@5%	0.03	4.65	0.21	11.56	0.09	4.70	0.27	15.03

Table 4: Effect of spacing levels and nitrogen levels on available N, P and K in soil and uptake (Kg ha^{-1}) in tuberose cv. Pune Single

Treatments	Available Nitrogen in soil at harvest (Kg ha^{-1})	Uptake of Nitrogen at harvest (Kg ha^{-1})	Available Phosphorus at harvest (Kg ha^{-1})	Uptake of Phosphorus at harvest (Kg ha^{-1})	Available Potassium at harvest (Kg ha^{-1})	Uptake of Potassium at harvest (Kg ha^{-1})
S_1N_1	245.73	42.69	7.66	9.12	305.34	71.59
S_1N_2	253.81	48.37	6.62	10.18	296.66	77.62
S_1N_3	239.49	57.52	7.10	10.14	303.62	64.45
S_1N_4	248.77	63.20	6.80	11.96	302.85	84.99
S_2N_1	248.34	20.79	5.61	5.32	281.66	44.27
S_2N_2	243.71	24.77	6.88	5.15	298.46	33.45
S_2N_3	253.67	28.07	6.98	4.88	365.33	39.08
S_2N_4	240.42	34.80	6.97	5.67	383.93	40.74
S_3N_1	253.14	17.48	6.53	3.55	334.86	27.62
S_3N_2	257.42	20.23	6.71	3.94	338.66	33.65
S_3N_3	236.33	22.19	6.91	5.05	351.50	34.26
S_3N_4	241.60	25.55	6.46	4.29	344.84	33.44
S.Em.±	1.84	0.81	0.05	0.44	4.85	4.41
C.D.@5%	5.35	2.35	0.15	-	14.06	-

Table 5: Economics of Spacing and nitrogen levels in Tuberose cv. Pune Single

Treatment	Yield of flower (q/ha)	Yield of bulb (q/ha)	Total Input cost (Rs)	Gross return (Rs)	Net Return (Rs)	B:C ratio
S_1N_1	95.09	164.63	366467	419864	53397	1.14
S_1N_2	103.57	169.94	394227	455065.6	60838.6	1.15
S_1N_3	129.40	200.82	395087	565796.8	170709.8	1.43
S_1N_4	192.36	264.42	395947	832900.8	436953.8	**2.10**
S_2N_1	64	84.80	388367	276352	-112015	0.71
S_2N_2	76.12	104.69	389227	329605.6	-59621.4	0.84
S_2N_3	90.18	114.25	390087	388140	-1947	0.99
S_2N_4	93.99	123.19	390947	405525.6	14578.6	1.03
S_3N_1	40.59	66.88	383367	187975.2	-195392	0.49
S_3N_2	46.94	71.14	384227	203811.2	-180416	0.53
S_3N_3	49.22	79.48	385087	213953.6	-171133	0.55
S_3N_4	58.15	84.78	385947	251675.2	-134272	0.65

Conclusion

The closer spacing (30 cm x 30 cm) and higher nitrogen dose (250:50:50 NPK kg ha^{-1}) in tuberose cv. Pune single significantly contributed the flower attributing characters and yield parameters like spike length, number of florets per plant, diameter of flower, fresh weight of 100 flowers also maximum yield of spike per plant, per plot, flower yield per plot and per hectare. Also maximum bulb yield per plant (1.53), bulb yield per plot (4.76 kg) and per hectare and benefit: cost ratio.

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