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Influence of spacing and fertilizer levels on growth, flowering, yield and quality of crape jasmine (*Tabernaemontana divaricata* (L.) R. Br. ex Roem. & Schult.)

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Abstract
A field experiment was conducted during the year 2023-24 at the Floriculture block, MHREC (Main Horticultural research and extension center), College of Horticulture, University of Horticultural Sciences, Bagalkot. The experiment was laid out in a factorial RCBD with three replications, comprising three levels of fertilizer and three different spacings, resulting in 09 treatment combinations. The highest fertilizer level F_3, recorded maximum growth, flowering, yield and quality parameters. Among various spacing levels, the maximum growth, flowering, yield and quality parameters were observed at optimum spacing S_2, with the exception of plant height (137.41 cm), internodal length (5.19 cm), which were reported at closer spacing S_1. In terms of different treatment combinations, the growth, flowering, yield and quality attributes were maximum in the treatment combination of S_2F_3, except for plant height (140.35 cm), internodal length (5.50 cm), which was recorded in the S_1F_3 treatment combination.

Keywords: Crape Jasmine, *Tabernaemontana divaricata* (L.) R. Br. ex Roem. & schult, fertilizer, spacing

Introduction
Tabernaemontana divaricata (L.) R. Br. ex Roem. & Schult, also known as Crape Jasmine, is a perennial shrub native to India and extensively cultivated throughout South East Asia and warm regions of continental Asia. Belonging to the family Apocynaceae, it thrives in tropical climates and is known for its ornamental value worldwide. With its distinctive white flowers, approximately 120 species of *Tabernaemontana* found across tropical countries like Brazil, Egypt, India, Sri Lanka, Vietnam, Malaysia and Thailand (Samanta *et al*., 2015) [18]. The plant exudes milky latex from its stem when broken, hence its nickname "milk flower". It is vernacularly known as East Indian rosebay/Pinwheel flower/Moonbeam (English), Chandini (Hindi), Ananta/Tagar (Konkani/Marathi), Nanthiyar vattam (Malayalam), Nanthiyar vattai (Tamil), Nandi battallu (Kannada), Nandi Vardhanam (Telugu), Sagar (Gujarati) and Nandivrksah (Sanskrit).

Plant typically grows up to height of 5-6 feet (1.5-1.8 m) with large, shiny, deep green leaves measuring about 15 cm in length and 5.0 cm in width. Its single-type flowers exhibit the characteristic 'pinwheel' shape, similar to other genera in the Apocynaceae family such as Vinca and Nerium. There is notable variation in petal shapes and flower types, with both single and double-flowered forms cultivated, all of which are white in color. While the single-flowered variety is unscented, the double-flowered form emits a pleasant fragrance. Crape jasmine blooms primarily in spring but can produce flowers sporadically throughout the year. The wax-like blossoms, arranged in small clusters at tips of stems, consist of five-petalled white pinwheels.

Flowers are commonly used for pooja in north and south India. It is an excellent evergreen and ornamental bush for lawns and gardens. Abundance of dazzling white flowers justifies the name ‘Moonbeam’ - the amazing beauty of its small white flowers under moonlight. It is commonly propagated from stem cuttings and is relatively low-maintenance. Thriving in well-drained sandy loam soil with an acidic to neutral pH, this plant prefers sunny locations in tropical and subtropical climates, where increased sunlight tends to promote more abundant blooming.

It requires moderate watering consistently throughout the year and occasional light pruning to ensure it maintains an appropriate size and shape.

The major nutrients especially nitrogen, phosphorous and potassium have important roles for plant growth and development. There is wide scope to improve and increase the *Tabernaemontana* production and productivity by enhancing its nutritional requirement. Therefore, this study was carried out with the following objectives.

- To study the influence of spacing on growth, flowering, yield and quality of *Tabernaemontana divaricata*.
- To study the response of *Tabernaemontana divaricata* to different level of fertilizers for growth, flowering, yield and quality parameters.

Materials and Methods

A field experiment was conducted during year of 2023-24 at Floriculture block, MHREC (Main Horticultural research and extension center), College of Horticulture, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India. For this experiment 5-month-old *T. divaricata* plot was selected. The treatment comprises 3 levels of fertilizer (F_1: 20:40:40, F_2: 30:60:60 and F_3: 40:80:80 g of NPK/plant/year) and 3 different spacings (S_1: 1.5 x 1.2 m, S_2: 2.0 x 1.5 m and S_3: 2.5 X 1.8 m) in 09 treatment combinations. These treatment combinations were replicated thrice and laid out in a Factorial RCB design. Nitrogen, phosphorus and potash were applied in the form of urea, di ammonium phosphate and muricate of potash, respectively. Fertilizer distribution occurred in four stages at two-month intervals (during month of May, July, September and November). Other cultural operations were carried out as per recommendations.

All vegetative growth, flowering, quality and yield attributes such as plant height, plant spread (North-South and East-West direction), number of primary and secondary branches per plant, leaf area, chlorophyll content, internodal length, number of inflorescences per plant, number of flowers per inflorescence, flower bud yield per plant, diameter of flower and flower bud, corolla tube length, individual flower bud weight and shelf life of flower buds was recorded. For growth and flowering parameters, observations were recorded at 2 months interval from the days after treatment imposition until 240 DAT (Days after treatment imposition) and quality parameters were recorded at 240days. Here results are provided for 240 DAT. Quality parameters was taken at 240 DAT and yield data was recorded from 2023 to 2024 by harvest flowers in alternative days.

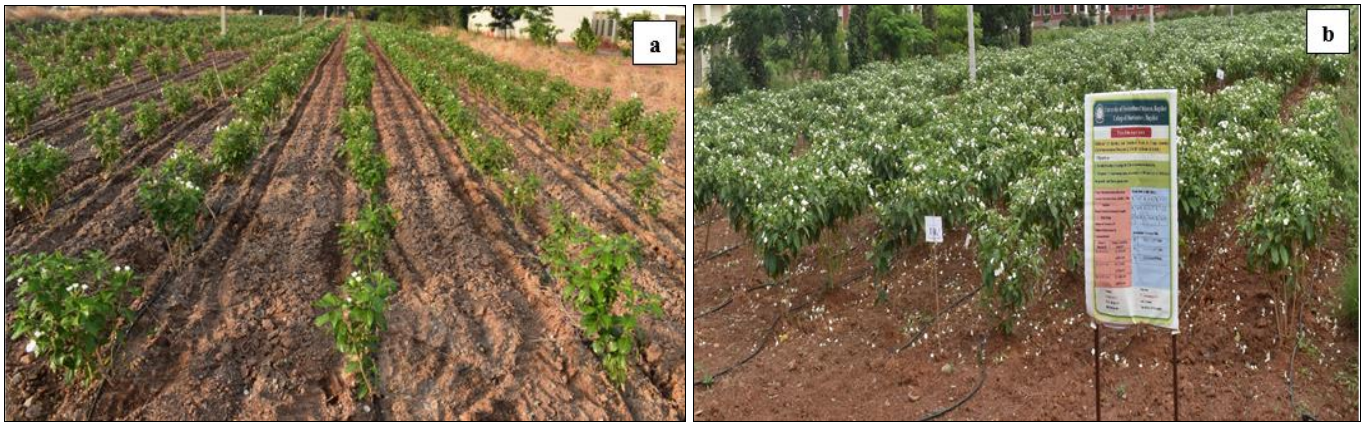

Plate 1: General view of the Experimental site at initial (a) and flowering stage (a)

Results and Discussion

Influence of different spacings and fertilizer levels on growth parameters of *Tabernaemontana divaricata*

Plant height (cm), plant spread (North-South and East-West direction), number of primary and secondary branches per plant, leaf area (cm^2), chlorophyll content and internodal length (cm)

The maximum plant height (137.41 cm) and internodal length (5.19 cm) was recorded at plant spacing of S_1 (1.5 X 1.2 m) and minimum (122.60 cm and 4.60 cm) was in S_3 (2.5 X 1.8 m) (Table 1). The variation in plant height was due to proper utilization of nutrition, moisture and light. Manjula *et al.* (2023) [15] observed that plant height was increased by decreasing plant spacing, an antagonistic relationship was found between vegetative growth and plant spacing in nerium. The maximum plant spread at E-W and N-S directions (134.15 cm and 134.24 cm, respectively), primary and secondary branches per plant (5.04 and 9.96, respectively), leaf area (44.30 cm^2) and chlorophyll content (49.65) of the plant were recorded at plant spacing of S_2 (2.0 X 1.5 m) and minimum (126.28 cm, 126.17 cm, 3.87, 7.42, 35.70 cm^2 and 41.62, respectively) was in S_1 (1.5 X 1.2 m) (Table 1). The rise in vegetative traits was linked to reduced competition among plants for the necessary environmental conditions, leading to more metabolite production, increased in biomass and resulted in higher spread, branches, leaf area and chlorophyll content. Similar findings were observed by Sumangala *et al.* (2013) [21], Manimaran and Ganga (2022) [14] in Jasmine and Kanchana (2021) [10] in nerium.

Table 1: Influence of various spacings on growth parameters of *Tabernaemontana divaricata*

Treatments	Plant height (cm)	Plant spread (E-W)	Plant spread (N-S)	Internodal Length (cm)	Primary branches per plant	Secondary branches per plant	Leaf area (cm^2)	Chlorophyll content
S_1	137.41	126.28	126.17	5.19	3.87	7.42	35.70	41.62
S_2	130.83	134.15	134.24	5.00	5.04	9.96	44.30	49.65
S_3	122.60	132.80	131.20	4.60	4.82	9.47	42.38	47.50
S.EM. ±	0.41	0.68	0.39	0.043	0.05	0.07	0.33	0.39
C.D. at 5%	1.24	2.04	1.17	0.128	0.14	0.21	1.00	1.18

There is a significant variation on growth parameters at different fertilizer levels in *Tabernaemontana divaricata*. The maximum growth parameters like plant height (134.17 cm), plant spread at E-W and N-S directions (134.56 cm and 132.96 cm, respectively), primary and secondary branches per plant (5.11 and 10.13, respectively), internodal length (5.10 cm), leaf area (43.17 cm^2) and chlorophyll content (49.69) of the plant, significantly influenced by higher fertilizer level F_3 (40:80:80 g of NPK/plant/year) and minimum (127.56 cm, 127.83 cm, 127.85 cm, 4.22, 8.00, 4.73, 37.46 cm^2 and 43.79, respectively) was in F_1 (20:40:40 g of NPK/plant/year) (Table 2). It might be attributed to a beneficial influence on the proper absorption of nutrients, a greater function of photosynthesis, reduced transpiration and stimulation of the root system, accelerated cell division, cell enlargement and metabolism. The growth attribute was increase with macronutrient dosages. The macronutrient functions are dependent on amount of them in the root zone and its uptake by plant roots and that effect on the plant growth. Shoram *et al*. (2012) [19], Chamakumari *et al*. (2017) [5] and Mangroliya *et al*. (2021) [13] in Jasmine, Aboyeji and Abayomi (2013) [1] in *Thevetia peruviana* J. and Gopitha *et al*. (2021) [9] in nerium.

The combined effect of different spacings and fertilizer levels proved significant differences on growth parameters in *Tabernaemontana divaricata* (Table 3). The maximum plant height (140.35 cm) and internodal length (5.50 cm) was recorded at treatment combination of S_1F_3 and minimum (118.08 cm and 4.50 cm) was in S_3F_1. Increase in plant height was due to suppression of lateral branches and increases in apical dominance with closer spacing, as well as mutual shading (Plate 2). The maximum plant spread at E-W and N-S directions (140.60 cm and 139.62 cm, respectively), primary and secondary branches per plant (5.80 and 11.33, respectively), leaf area (48.49 cm^2) and chlorophyll content (55.55) of the plant were recorded in treatment combination of S_2F_3 and minimum (125.23 cm, 125.20 cm, 3.60, 6.77, 34.63 cm^2 and 41.12, respectively) was in S_1F_1. Generally, optimum spacing and fertilizer level increases the growth and development of plant. It was due to better penetration of light, more soil moisture and more availability of nitrogen. These findings were parallel with those of Azharuddin *et al*. (2017) [3] in sweet William and Manjula *et al*. (2023) [15] in nerium.

Table 2: Influence of different fertilizer levels on growth parameters of *Tabernaemontana divaricata*.

Treatments	Plant height (cm)	Plant spread (E-W)	Plant spread (N-S)	Internodal Length (cm)	Primary branches per plant	Secondary branches per plant	Leaf area (cm^2)	Chlorophyll content
F_1	127.56	127.83	127.85	4.73	4.22	8.00	37.46	43.79
F_2	129.12	130.84	130.79	4.95	4.40	8.71	41.22	45.29
F_3	134.17	134.56	132.96	5.10	5.11	10.13	43.71	49.69
S.EM. ±	0.41	0.68	0.39	0.043	0.05	0.07	0.33	0.39
C.D. at 5%	1.24	2.04	1.17	0.128	0.14	0.21	1.00	1.18

Table 3: Influence of various spacings and fertilizer levels on growth parameters of *Tabernaemontana divaricata*

Treatments	Plant height (cm)	Plant spread (E-W)	Plant spread (N-S)	Internodal Length (cm)	Primary branches per plant	Secondary branches per plant	Leaf area (cm^2)	Chlorophyll content
S_1F_1	134.86	125.23	125.20	4.80	3.60	6.27	34.63	41.12
S_1F_2	137.04	125.70	126.10	5.26	3.73	7.47	35.63	41.48
S_1F_3	140.35	127.90	127.20	5.50	4.27	8.53	36.83	42.26
S_2F_1	129.73	128.53	128.79	4.90	4.60	9.07	38.88	45.72
S_2F_2	129.36	133.33	134.32	5.00	4.73	9.47	45.53	47.68
S_2F_3	133.40	140.60	139.62	5.10	5.80	11.33	48.49	55.55
S_3F_1	118.08	129.73	129.57	4.50	4.47	8.67	38.86	44.54
S_3F_2	120.95	133.50	131.95	4.60	4.73	9.20	42.49	46.70
S_3F_3	128.78	135.17	132.07	4.70	5.27	10.53	45.80	51.26
S.EM. ±	0.72	1.18	0.67	0.074	0.08	0.12	0.58	0.68
C.D. at 5%	2.15	3.54	2.02	0.222	0.24	0.36	1.73	2.04

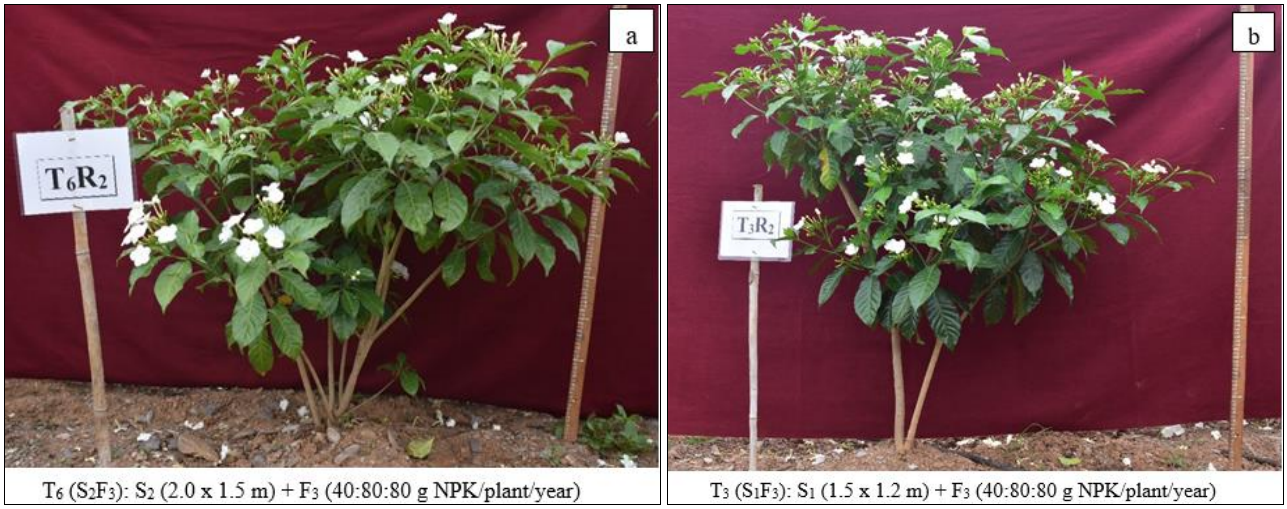

Plate 2: Best treatments for flower bud yield per plant (kg) (a) and per plot (kg) (b) of *Tabernaemontana divaricata* as influenced by spacing and fertilizer levels

Influence of different spacings and fertilizer levels on flowering and yield parameters of *Tabernaemontana divaricata*

Number of inflorescences per plant, number of flowers per inflorescence and flower bud yield per plant

The different plant spacing showed significant effect on flowering and yield parameters (Table 4). The maximum number of inflorescences per plant (43.49), number of flowers per inflorescence (39.20) and flower bud yield per plant (1.27 kg) was recorded at spacing of S_2 (2.0 × 1.5 m) and minimum (37.21, 33.09 and 1.00 kg, respectively) was in S_1 (1.5 X 1.2 m). The optimum spacing received adequate plant nutrients, no inter competition among plants, favorable growing atmosphere which contributed maximum number of inflorescence and flowers per inflorescence and flower bud yield per plant (kg). The result achieved from the present study was in conformity with the findings of Kanchana (2021) [10] in nerium, Ansar *et al*. (2014) [2] in rose.

Table 4: Influence of various spacings on flowering and yield parameters of *Tabernaemontana divaricata*.

Treatments	inflorescence per plant	Flowers Per Inflorescence	Flower Bud Yield Per Plant (Kg)
S_1	37.21	33.09	1.00
S_2	43.49	39.20	1.27
S_3	41.20	38.02	1.20
S.EM. ±	0.37	0.38	0.01
C.D. at 5%	1.11	1.13	0.03

Table 5: Influence of different fertilizer levels on flowering and yield parameters of *Tabernaemontana divaricata*

Treatments	inflorescence per plant	Flowers Per Inflorescence	Flower Bud Yield Per Plant (Kg)
F_1	38.17	34.40	1.03
F_2	40.78	35.87	1.17
F_3	42.96	40.04	1.27
S.EM. ±	0.37	0.38	0.01
C.D. at 5%	1.11	1.13	0.03

The different levels of fertilizers (N, P_2O_5 and K_2O) had significant influence on flowering and yield parameters. The maximum number of inflorescence per plant (42.96), number of flowers per inflorescence (40.04) and flower bud yield per plant (1.27 kg), were recorded at higher fertilizer level F_3 (40:80:80 g of NPK/plant/year) and minimum (38.17, 34.40 and 1.03 kg, respectively) was in F_1 (20:40:40 g of NPK/plant/year) (Table 5). NPK is an essential nutrient for plants, which enhances flowering capacity. Available phosphorous in the soil for plants could be resulted in higher number of inflorescences per plant, number of flowers per inflorescence, flower bud yield per plant, per plot and per hectare. The results obtained from the present study was similar with the findings of Shoram *et al*. (2012) [19], Diwivedi *et al*. (2018) [8] and Bilji *et al*. (2018) [4] in Jasmine.

Among combination of spacing and fertilizers (Table 6). The maximum number of inflorescences per plant (46.00), number of flowers per inflorescence (43.47) and flower bud yield per plant (1.40 kg) were significantly maximum in treatment combination of S_2F_3 and minimum (35.38, 29.93 and 0.90 kg, respectively) was in S_1F_1. In optimum spacing with higher fertilizer doses no inter competition among plants, which contributed maximum number of inflorescences, flowers and yield per plant (kg). This type of achievement might be due to higher plant population. The trend is same as that of Manjula *et al.* (2023) [15] in nerium, Azharuddin *et al*. (2017) [3] in sweet William and Kurabet (2015) [12] in crossandra.

Table 6: Influence of various spacings and fertilizer levels on flowering and yield parameters of *Tabernaemontana divaricata*

Treatments	Inflorescence Per Plant	Flowers Per Inflorescence	Flower Bud Yield Per Plant (Kg)
S_1F_1	35.38	29.93	0.90
S_1F_2	36.87	32.33	1.00
S_1F_3	39.40	37.00	1.10
S_2F_1	41.67	35.73	1.10
S_2F_2	42.80	38.40	1.30
S_2F_3	46.00	43.47	1.40
S_3F_1	37.47	37.53	1.10
S_3F_2	42.67	36.87	1.20
S_3F_3	43.47	39.67	1.30
S.EM. ±	0.64	0.66	0.02
C.D. at 5%	1.92	1.97	0.05

Influence of different spacings and fertilizer levels on quality parameters of *Tabernaemontana divaricata*

Diameter of flower bud and flower, corolla tube length, individual flower bud weight and Shelf life of flower buds

The different plant spacing showed significant effect on quality parameters in *Tabernaemontana divaricata* (Table 7). The maximum diameter of flower bud and flower (10.30 mm and 15.75 mm, respectively), corolla tube length (2.37 cm), individual flower bud weight (1.03 g) and shelf life of flower buds (2.57 days) were recorded at plant spacing of S_2 (2.0 X 1.5 m) and they are statistically on par with S_3 (2.5 X 1.8 m) except for individual bud weight and shelf life, while minimum (8.60 mm, 14.44 mm, 2.10 cm, 0.89 g and 2.03 days, respectively) was in S_1 (1.5 X 1.2 m). optimum spacing were provided more nutrients to the plants compared to closer spacing with same nutrient status in the soil that was provided and resulted in increased in the quality attributes of flowers. Similar results were also reported by Sumangala *et al.* (2013) [21] in Jasmine, Kavya *et al* (2023) [11] in Lupin and Dali *et al* (2023) [11] in crysanthamum.

Table 7: Influence of various spacings on quality parameters of *Tabernaemontana divaricata*

Treatments	Bud Diameter (Mm)	Flower Diameter (Mm)	Corolla Tube Length (Cm)	Individual Bud Weight (G)	Shelf Life (Days)
S_1	8.60	14.44	2.10	0.89	2.03
S_2	10.30	15.75	2.37	1.03	2.57
S_3	10.14	15.54	2.34	0.99	2.47
S.EM. ±	0.07	0.09	0.01	0.01	0.02
C.D. at 5%	0.22	0.28	0.04	0.02	0.06

The different fertilizer levels (N, P_2O_5 and K_2O) had significant influence on quality parameters in *Tabernaemontana divaricata* (Table 8). Application of 40:80:80 g of NPK/plant/year at F_3 treatment showed the maximum diameter of flower bud and flower (10.24 mm and 16.19 mm, respectively), corolla tube length (2.37 cm), individual flower bud weight (1.05 g) and shelf life of flower buds (2.73 days) and minimum (9.05 mm, 14.33 mm, 2.20 cm, 0.90 g and 1.93 days, respectively) was in F_1 (20:40:40 g of NPK/plant/year). Increase in quality parameters of flowers with the increase in nutrient doses. These findings are in agreement with those of Shoram *et al*. (2012) [19] and Bilji *et al*. (2022) [4] in Jasmine.

Table 8: Influence of different fertilizer levels on quality parameters of *Tabernaemontana divaricata*

Treatments	Bud Diameter (Mm)	Flower Diameter (Mm)	Corolla Tube Length (Cm)	Individual Bud Weight (G)	Shelf Life (Days)
F_1	9.05	14.33	2.20	0.90	1.93
F_2	9.74	15.20	2.25	0.97	2.40
F_3	10.24	16.19	2.37	1.05	2.73
S.EM. ±	0.07	0.09	0.01	0.01	0.02
C.D. at 5%	0.22	0.28	0.04	0.02	0.06

Table 9: Influence of various spacings and fertilizer levels on quality parameters of *Tabernaemontana divaricata*.

Treatments	Bud Diameter (Mm)	Flower Diameter (Mm)	Corolla Tube Length (Cm)	Individual Bud Weight (G)	Shelf Life (Days)
S_1F_1	7.98	13.41	1.94	0.79	1.70
S_1F_2	8.81	14.64	2.07	0.89	1.90
S_1F_3	9.00	15.27	2.30	0.99	2.50
S_2F_1	9.32	14.88	2.33	0.98	2.10
S_2F_2	10.27	15.36	2.35	1.01	2.70
S_2F_3	11.32	17.00	2.44	1.10	2.90
S_3F_1	9.85	14.69	2.33	0.92	2.00
S_3F_2	10.16	15.62	2.34	1.00	2.60
S_3F_3	10.40	16.31	2.36	1.05	2.80
S.EM. ±	0.12	0.16	0.02	0.01	0.03
C.D. at 5%	0.37	0.48	0.07	0.03	0.10

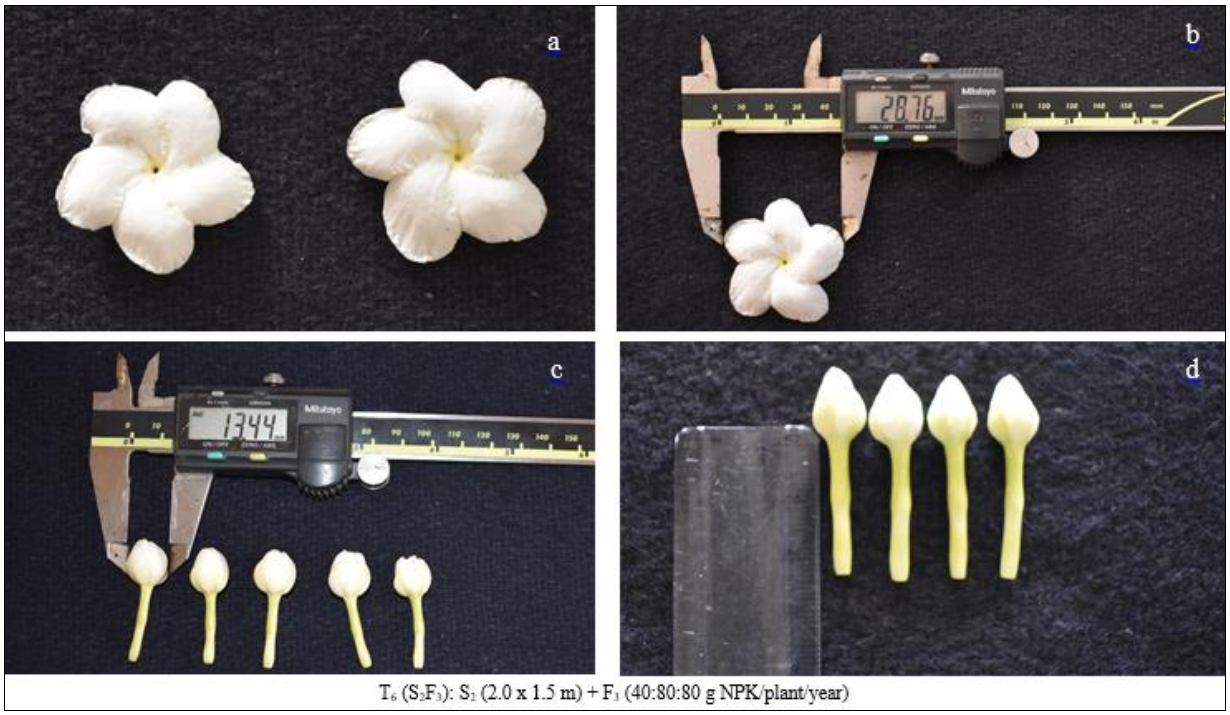

Plate 3: Flower diameter (mm) (a&b), bud diameter (mm) (c) and corolla tube length (cm) (d) of *Tabernaemontana divaricata* as influenced by spacing and fertilizer levels

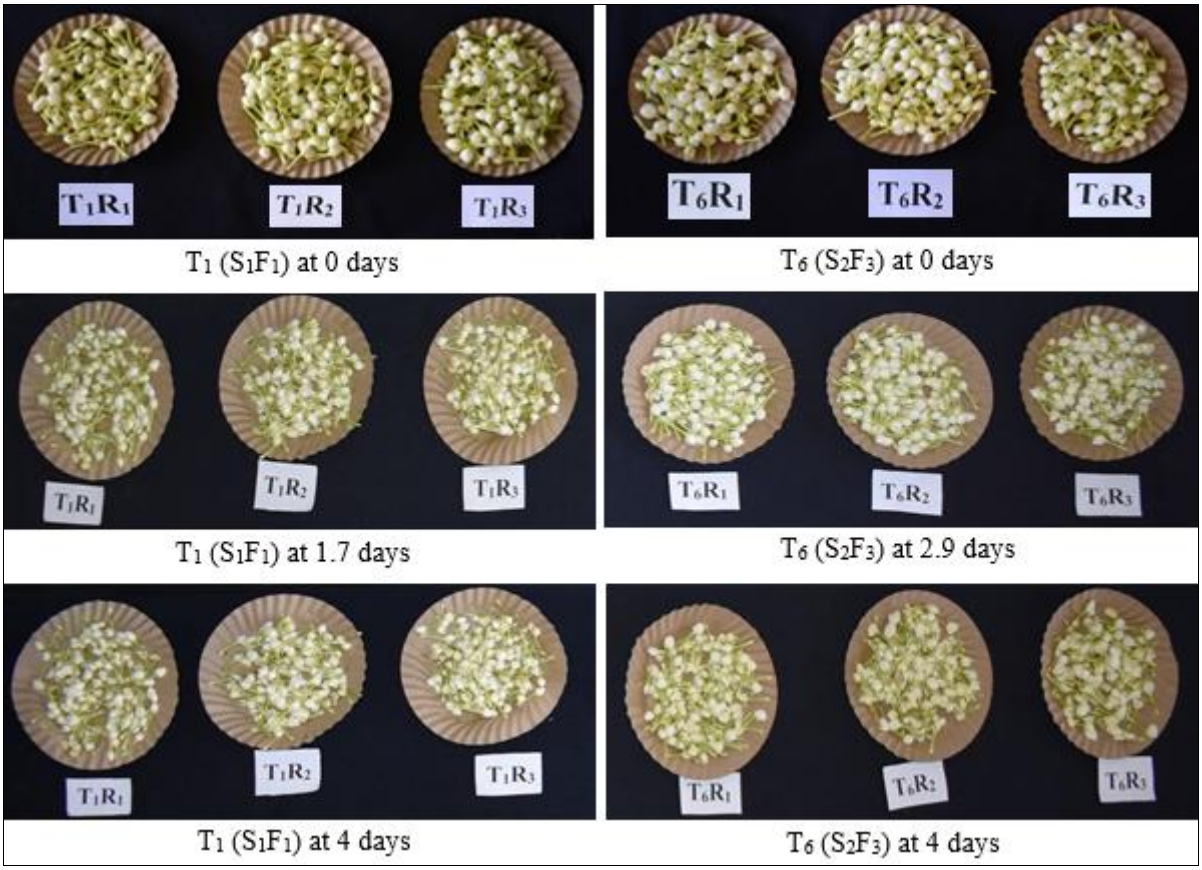

Plate 4: Flower buds shelf life (days) of *Tabernaemontana divaricata* as influenced by spacing and fertilizer levels

The combined effect of different spacings and fertilizer levels proved significant differences on quality parameters in *Tabernaemontana divaricata* (Table 9). The maximum diameter of flower bud and flower (11.32 mm and 17.00 mm, respectively), corolla tube length (2.44 cm), individual (1.10 g) and shelf life of flower buds (2.90 days) were recorded in treatment combination of S_2F_3 (2.5 X 1.8 m and 40:80:80 g of NPK/plant/year) and minimum (7.98 mm, 13.41 mm, 1.94 cm, 0.79 g and 1.70 days, respectively) was in S_1F_1. Due to adequate supply of nutrients to the plants and less competition for food, water and light between the plants in optimum spacing was observed (Plate 3 & 4). Parallel results were examined by Divyashree *et al*. (2016) [7] in gaillardia, Manjula *et al*. (2023) [15] in nerium and Paramagoudar (2015) [16] in spider lilly.

Conclusion

In the experimental study, finally concluded that the combination of closer spacing S_1 (1.5 x 1.2 m) and a higher dosage of 40:80:80 g NPK/plant/year (F_3) was beneficial for promoting maximum plant height and internodal length. Meanwhile, optimum spacing S_2 (2.0 x 1.5 m) with 40:80:80 g NPK/plant/year (F_3) was identified as beneficial for achieving good vegetative growth in term of maximum plant spread in both direction (north-south and east-west), greater number of primary and secondary branches with superior quality of flower buds and maximum yield of flower buds per plant in crape jasmine.

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